The relationship between antenatal food insecurity, maternal depression and birthweight and stunting: results from the National Income Dynamics Study (NIDS)

Academic thesis completed by published work.
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Declaration

I, **Abigail Joan Harper, student number 1689822,** declare that this thesis is my own work conducted under the supervision of Dr. Sumaya Mall, Prof Alan Rothberg and Dr. Esnat Chirwa. The work is being submitted for the Degree of Doctor of Philosophy (PhD) in the School of Public Health at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

I have read the sections on referencing and plagiarism in the WITS Plagiarism Policy. I am aware that the plagiarism is wrong and that the University of the Witwatersrand may take disciplinary action should plagiarism be found in this work. I have followed the required conventions in referencing the thoughts and ideas of others. I confirm that all the work submitted in this thesis is my own unaided work except where I have explicitly indicated otherwise.

Signature

Date: July 14, 2023

Dedication

I dedicate this work to my beloved daughters Lena and Anna.

Publications arising from this study

1. **Harper, AJ**., Rothberg, A., Chirwa, E., Mall., S., Examining maternal depression, birthweight and linear growth: Findings from the South African National Income Dynamics Study. Published in the *South African Journal of Child Health.* 2022.

   https://www.ajol.info/index.php/sajchh/article/view/240981

2. **Harper, AJ**., Goudge, J., Chirwa, E., Rothberg, A., Sambu, W., Mall., S., Dietary diversity, food insecurity and the double burden of malnutrition among children, adolescents and adults in South Africa: findings from a national survey. Published in *Frontiers in Public Health.* 2022.

   https://www.frontiersin.org/articles/10.3389/fpubh.2022.948090/full

3. **Harper, AJ**., Mall., S., Chirwa, E., Sambu, W., Rothberg, A., Maternal food insecurity and demographic factors, low birth weight and stunting in early childhood: findings from a longitudinal study in South Africa. Published in Maternal *Child Health Journal*. 2022.

   https://link.springer.com/article/10.1007/s10995-022-03555-7

Manuscripts under review

1. **Harper, AJ**., Burger, R. Swart, EC., Sayed, N., "*Giving my baby the life she deserves and protecting her from COVID-1"*: Household shocks, food insecurity and maternal depressive symptoms amongst South African mothers. Under review with *BMC Pregnancy and Childbirth.*

2. **Harper, AJ**., Mall., S., Rothberg, A., Maternal depression and dietary diversity: a scoping review. Under review with *Public Health Nutrition journal*.

Abstract

Background

Maternal food insecurity is an important social determinant of health and has been associated with adverse birth and pregnancy outcomes as well as depressive symptoms. Pregnant women and new mothers are vulnerable to both food insecurity and depression. This thesis investigated the relationships between maternal food insecurity, depressive symptoms and low birthweight and stunting using nationally representative longitudinal data from the National Income Dynamics Study (NIDS). In addition, the thesis also examined the association between various food security indicators and adult and child anthropometry.

Methods

The NIDS data included three experiential indicators of food security (adult and child hunger in the household in the past twelve months and household food sufficiency in the past 12 months) as well as household dietary diversity in the past thirty days and household food expenditure in the past thirty days. Three of the included studies utilised NIDS data.

a) Chapter 4 was a scoping review that examined dietary diversity and maternal depression.

b) Chapter 5 gives a broad overview by using cross-sectional data from wave 1 to examine food security indicators in relation to adult and child anthropometry.

c) Chapter 6 used maternal data from Wave 1 of NIDS and child data from wave 3 of NIDS to longitudinally examine maternal depression and food insecurity during the periconceptional and antenatal period in relation to a continuous measure of birthweight and children's height-for-age scores. In this vein, Chapter 6 employs different statistical measures to achieve longitudinal perspectives.

d) Chapter 7 used the same dataset as Chapter 6 to examine various maternal exposures in more depth including food security indicators, alcohol use and other maternal characteristics in relation to binary measures of low birthweight and stunting among children born during the reference period.

e) The final article used mobile survey data from the MomConnect database, a government database of pregnant and postnatal women.

Results

a) For the scoping review, a total of 813 records were screened and 11 articles from 13 different studies met the inclusion criteria. The findings on maternal depression and maternal dietary diversity were mixed; The findings on maternal depression and children's dietary diversity were also mixed. In the studies that examined maternal depression and dietary diversity as predictor variables for child outcomes, the findings on depression were mixed but dietary diversity was consistently associated with both cognitive and linear growth outcomes among children.

b) Among children, the prevalence of stunting was 18.4% and the prevalence of wasting and overweight was 6.8% and 10.4% respectively. Children <5 and adolescents with medium dietary diversity were significantly more likely to be stunted than children with high dietary diversity. None of the indicators were associated with stunting in children aged 5-9. Among stunted children, 70.2% lived with an overweight or obese adult, the double burden of malnutrition. Among adults, increased dietary diversity increased the risk of adult overweight and obesity.

c) Maternal food insecurity significantly increased the risk of depression among periconceptional and pregnant women but there was no association between maternal depression, food insecurity and mean birthweight or height-for age scores among children.

d) Women who reported a child going hungry in the household in the past 12 months were significantly more likely to give birth to a low birthweight infant during the reference period. Low dietary diversity among periconceptional and pregnant women was associated with stunting among children five years later. Low birthweight significantly increased the risk of stunting among children.

e) The prevalence of depression in the sample was 16% and pregnant women and new mothers who reported hunger in the household were significantly more likely to be depressed. The qualitative component of the study revealed that women's main worries could be broadly divided into three categories; worries about hunger and food

insecurity, fears that they or their children would be infected with Covid 19 and concerns about unemployment during the lockdown.

Conclusion

The studies included in this PhD study demonstrate that food insecurity is an important social determinant of both physical and mental health and a potentially modifiable risk factor for low birthweight and stunting. In both studies that examined maternal depression, food insecurity significantly increased the risk of depression among periconceptional women as well as pregnant women and new mothers. In addition, food insecurity is associated with adverse child health outcomes (low birthweight, stunting and wasting). However, experiential measures of food insecurity are not associated with stunting among young children or adolescents while dietary diversity is. Dietary diversity consistently emerged as an important indicator for children's linear growth as well as cognitive development in the scoping review. Holistic interventions that focus on the social determinants of health such as food security may improve maternal depressive symptoms among women in resource poor settings. Dietary diversity tools could be refined to also include a category for processed foods given the nutrition transition occurring in many LMICS. More longitudinal research with repeated measurements is required to elucidate the relationship between maternal depression and child health outcomes.

Acknowledgements

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For now we see through a glass, darkly, but then face to face. Now I know in part; but then shall I know, even as also I am known. 1 Corinthians 13:12

List of Abbreviations

ANH – Agriculture, Nutrition and Health Academy

ASF – Animal source foods

BMI – Body mass index

CATI – Computer assisted telephonic interview

CCHIP – Community Childhood Hunger Identification Project

CCT – Conditional Cash Transfer

CESD-R – Centre for Epidemiological Studies Depression Scale – Revised

CHW – Community health worker

CMD – Common mental disorders

CSG – Child Support Grant

DALY – Disability adjusted life years

DBM – Double burden of malnutrition

DDS – Dietary diversity score

DRC – Democratic Republic of Congo

EPDS – Edinburgh Postnatal Depression Scale

FAO – Food and Agriculture Organization

FIES – Food Insecurity Experience Scale

GHS – General household survey

GLM – Generalized Linear Mixed

GWG – Gestational weight gain

GWP – Gallup World Poll

HAZ – Height-for-age Z score

HDDS – Household dietary diversity score

HDRS – Hamilton Depression Rating Scale

HFIAP – Household Food Insecurity Access Prevalence

HFIAS – Household Food Insecurity Access Scale

HID – Household ID

HIV – Human Immunodeficiency Virus

HREC – Health Research Ethics Committee

IFPRI – International Food Policy Research Institute

IPV – Intimate partner violence

IUGR- Intrauterine growth restriction

JAM – Joint Aid Management Organization

LAZ – Length-for-age Z score

LBW – Low birthweight

LMIC – Low- and middle-income countries

MDE – Major Depressive Episode

MINI – The Mini International Neuropsychiatric Interview

MMD – Minimum dietary diversity

MMF – Minimum meal frequency

MMS – Multiple micronutrient supplementation

MPI – Multidimensional poverty indicator

NCD – Non-communicable disease

NFCS – National Food Consumption Survey

NGO – Non-Governmental Organisation

NIDS – National Income Dynamics Study

NIDS-CRAM – National Income Dynamics Study – Coronavirus Rapid Mobile Survey NDP

NDP– National Development Plan

NSNP – National School Nutrition Programme

PDIS – Provincial Dietary Intake Study

PID – Personal ID

PSychinfo – Database of abstracts in psychology field

PUBMED – Database of life sciences and biomedical topics

RCT – Randomized Controlled Trial

RTHC – Road to Health Card

SANHANES – South African National Health and Nutritional Examination Survey

Scopus – Elsevier abstract and citation database

SD – Standard Deviation

SDGs – Sustainable development goals

SDHS – South African Demographic and Health Survey

SDS – Self-rating Depression Scale

SES – Socioeconomic status

SGA – Small for gestational age

SMS – Short Message Service

SSA – Sub-Saharan Africa

STATS SA – Statistics South Africa

TNC – Transnational corporations

UK – United Kingdom

US – United States

USDA– United States Department of Agriculture

WFP – World Food Program

WHO – World Health Organization

WHZFA – Weight-for-length Z score

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Chapter 1 INTRODUCTION

1.1 Defining Food Security

The current broadly accepted definition of food security was adopted at the 1996 World Food Summit in Rome and states 'Food Security exists when all people, at all times, have physical, social and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life'.

Food insecurity exists on a spectrum, with food security as per the above definition at one end and severe hunger and famine as its most extreme manifestations at the opposite end. This definition of food insecurity can further be broken down into six separate measurable domains: availability (is the supply of food sufficient at a global and national scale?), access (can people purchase or produce the adequate food to meet their needs?), utilization (is nutrient intake sufficient?), and stability (is the food supply stable over time?). The increasing effects of climate change have caused the concept of food security to evolve further and recognize the importance of both agency and sustainability along with the previous four pillars (1).

These six dimensions of food security are reinforced in both our conceptual and legal understandings of the right to food. (1,2). Food insecurity also encompasses feelings of anxiety around food supply and various coping mechanisms to deal with insufficient food including foregoing meals, reducing portion sizes and purchasing cheaper and less desirable food. Although not all food insecure people will experience hunger, hungry people are classified as food insecure because hunger is the most severe manifestation of food insecurity.

However, it is important to bear in mind that the experience of food insecurity is a 'managed process'. This has been reflected by qualitative research by Radimer that explored food insecurity among women in low-income households. She found that people are not passive actors when circumstances suddenly change but are instead active participants who respond and manage their daily risks in a variety of ways (3). When access to food is limited, most households first feel anxiety and worry about how to procure food, followed by various strategies to augment their food supply, including the consumption of cheaper lower quality food. In cases of severe food insecurity, adults (and women in particular) will often forego

food to ensure that the children in the household are adequately fed and in the final and most severe instances of food insecurity, children's food supply is reduced. Although Radimer's research was based in the United States, the Voices of the Hungry study by the FAO noted similar coping patterns globally in both high and low-and middle income countries (4). Food security is also often seasonal or cyclical in nature, as food access may vary depending on household circumstances i.e. households may experience more food insecurity at the end of the month. In rural areas where people rely on subsistence agriculture to supplement food intake, certain seasons may be more food insecure than others. The shifting nature of food insecurity, as well as the variation in how people experience and report feelings of hunger or deprivation contribute to the difficulties in accurately measuring and describing it (5).

Accurate measurement is further complicated by the fact that nutrition insecurity is sometimes used interchangeably with food insecurity when the definition of nutrition security is broader than that of food security. Food security is necessary, but not sufficient for nutrition security (6). Nutrition security considers care, health, and hygiene practices in addition to food security. The FAO defines nutrition security as, 'A situation that exists when secure access to an appropriately nutritious diet is coupled with a sanitary environment, adequate health services and care, in order to ensure a healthy and active life for all household members' (7). In a recent correspondence in Nature Food, titled *Nutrition security is more than food security*, John Ingram makes a compelling argument that the term food insecurity be replaced with nutrition security considering rising obesity rates and the over-consumption of energy-dense foods and empty calories (8). Food is one factor (probably the most important) that contributes to nutrition security, as an enabling environment is also required for people to absorb and utilise nutrients appropriately. For example, a poor sanitation environment and intestinal parasites can reduce nutrient intake. Ingram goes on to note that while nutrition security pertains to individuals, there needs to be a recognition of the numerous factors that influence how this can be achieved at the national and global level and advocates for replacing the term 'food security' altogether with 'nutrition security' (8). However, for the purpose of this thesis, and in most of the chapters herein, I will still be using the term 'food security' as most of the literature that I cite has used this term and the measures are primarily focused on access to food and hunger and less on nutrition security. I have attempted to delineate between these two concepts where possible.

1.2 Towards estimating global prevalence and incidence of food insecurity

To describe the global prevalence estimates of food insecurity, I will refer here to the report from the United Nations data on food security as they have consistently collected data from over 140 countries using the same measurement instrument (the Food Insecurity Experience Scale) or the FIES since 2014, using nationally representative samples. The 2021 report by the Food and Agriculture Organization of the United Nations (FAO) on the state of food security and nutrition in the world highlighted the drastic increase in the incidence of global hunger resulting from the Covid-19 Pandemic. The report noted that between 720 million and 811 million people in the world faced hunger in 2020 – an estimated 161 million more than in 2019. A further 2.37 billion people did not have access to adequate food in 2020 – an estimated increase of 320 million people in just one year. In addition to the risk of food insecurity, adult obesity is increasing sharply across all regions (9). These global increases in food and nutrition insecurity have particularly severe consequences for infants and young children who are at critical stages in their development and risk being affected by stunting, wasting and other forms of malnutrition, including overweight and obesity. However, it is important to note that the UN data were cross-sectional data collected on an annual basis as part of the Gallup World Poll (GWP). Longitudinal data on food insecurity at the household and individual level are costly and time consuming to collect (5).

Despite increasingly sophisticated technology and a globalised world, food insecurity remains a global public health problem with adverse consequences for physical as well as mental health (10,11). While the majority of food insecure individuals reside in low- and middle-income (LMIC) countries, food insecurity persists among socioeconomically disadvantaged and marginalised groups (i.e. immigrants and refugees) in high income countries. Economic estimates of global prevalence are complicated by disparate measurement tools across different studies and regions as well as the episodic nature of food insecurity which may alter study findings depending upon the timing of data collection. Food insecurity is also profoundly impacted by economic downturns and is more common in countries with high levels of income and resource inequality (2). The Covid-19 pandemic, and subsequent poor economic growth around the world, has already had severe consequences for food insecurity in vulnerable regions, although the full effects of this remain to be seen and quantified. Thus far, increases in food insecurity have primarily occurred as a result of economic hardships and reduced purchasing capacity (the access dimension) as food supplies on global and national scales have remained relatively stable

(12). The FAO report also noted that the incidence of hunger is increasing in almost all African sub-regions, and that Africa has the highest prevalence of undernourishment in the world (almost 20%).

1.3 Food insecurity and the social determinants of health in South Africa

The Sheiham Fellowship that enabled this PhD study was focused on the social determinants of health inequity in South Africa. Ours is a country with substantial inequities that persist to this day across racial lines are deeply rooted in South Africa's segregationist apartheid policies. There is increased recognition that population health is largely determined by systemic social and environmental factors that are often beyond the control of individuals. Furthermore, the consequences of poor health are often intergenerational and improving health outcomes at the population level requires sustained commitment from government and civil society over long time periods (13–15) . The circumstances in which people live and work determine their health outcomes and are the root cause of much of the health-related inequalities around the world. These include lower life expectancy, a generally greater burden of disease and higher rates of maternal and child mortality among disadvantaged groups (16,17). In South African, stark inequalities persist between races in the social determinants of health, particularly in housing and sanitation for the poor (16). In 1997, the White Paper for the Transformation of the Health System in South Africa envisioned an equitable health system for all South Africans built on a primary health care approach (18). However, achieving and implementing the vision of the White Paper, and addressing the social determinants of health, have remained elusive. The growing burden of non-communicable diseases (NCDs) in South Africa is a leading cause of premature mortality. For example, diabetes mellitus and hypertensive heart disease comprise 2.8 and 3.3% respectively of all-age premature mortality in South Africa. Both conditions are associated with rising rates of obesity and are intrinsically linked to food insecurity and poor quality diets (18,19). However, simply addressing individual behaviour change and choices around food and diets is unlikely to be effective to reduce the obesity burden in South Africa. For poorer households, food price is the major determinant of household food purchase patterns, and processed foods high in salt, fat and sugar are often more affordable than fresh 'whole' foods. Furthermore, processed foods are less likely to spoil and do not require refrigeration. Thus, there are firm economic realities underlying the food choices of many South Africans. The rapid expansion of supermarkets into both urban and rural areas in South Africa has facilitated increased access to food but this has come at a cost. The transnational corporations

(TNCs) that now dominate the food industry in South Africa and elsewhere are largely unregulated and have replaced smaller, local markets in many areas (18). In addition to the deleterious impacts on physical health across the life course, food insecurity is an important social determinant of mental health and is consistently associated with an increased risk of depression across geographical regions (10,17). Multisectoral interventions that can improve the social determinants of employment opportunities, housing conditions and access to healthy food may also improve poor mental health outcomes in disadvantaged populations. However, improving the broader social determinants of health is a huge challenge as it requires a more equitable distribution of wealth in addition to social and economic changes (13). Below, I have included an initial conceptual framework below. (see Figure 1.1).

Figure 9.1 is a draft of the conceptual framework from my PhD proposal in 2018. I had listed the various factors associated with both maternal depression and food insecurity and how these might influence childhood health outcomes. During the course of my research, some of these factors were not found to be associated with the outcome of interest while others remained important across studies. The final version of the conceptual framework that visually represents the empirical findings of this thesis can be found in the Discussion on p 158.

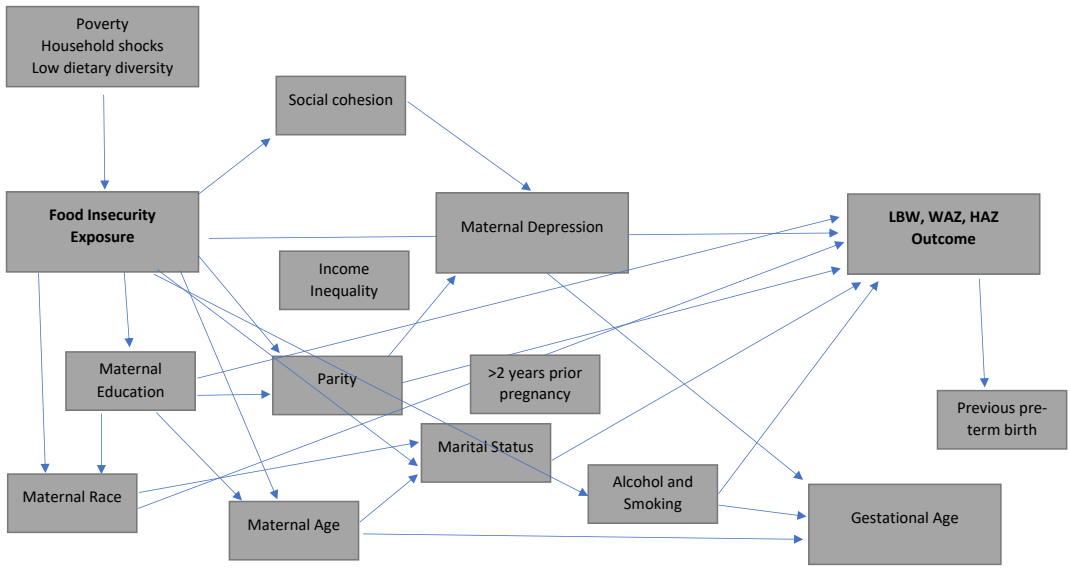

Figure 1.1: Draft Conceptual Framework from PhD Proposal (2018)

1.4 Correlates of food insecurity

In addition to prevalence estimates, several studies have also examined correlates of these estimates (20–23). While poverty and reduced income may appear to be the first and most obvious factor associated with food insecurity, the association between income and food insecurity varies across different contexts and has been well described in the literature (9,24,25). Although poverty may result in changes in the quantity of food consumed or the overall quality of diets, other factors such as intra-household food allocation or adults shielding children from hunger in the household could lead to children being protected from, or at increased risk of experiencing food insecurity (24). A UNICEF analysis of the prevalence and correlates of food insecurity around the globe noted that macro level factors including food supply chain disruptions and food price shocks can also affect the relationship between food insecurity and household income. In addition, the sensitivity of food insecurity to household income per capita was higher among households with children, and much more pronounced in LMIC following the global recession of 2008 (24). An analysis of food insecurity in Latin America and the Caribbean using 2014 data examined various determinants of food insecurity in the region found that low education levels, limited social capital and living in a country with low GDP per capita were associated with the largest increase in the likelihood of experiencing food insecurity (26). A seminal paper by Tomita and Burns published in 2013 defines social capital in relation to NIDS, with depression as the outcome. Social capital is defined as '*the features of social structure such as norms, trusts, and networks that can facilitate collective action for mutual benefit'* (27). Thus, factors like social capital and other broader social determinants of wellbeing that are not routinely collected in national surveys are also important determinants of household and individual food security.

Globally, conflicts, extremes in climate variability, and sustained economic slowdowns (increased by the COVID-19 pandemic) are among the primary drivers of food insecurity and malnutrition. These drivers are on the rise in both frequency and intensity and can also occur in combination. Rapid urbanisation has also led to more food insecure people in urban than rural areas. The vast amount of people moving to towns and cities have placed immense pressure on food supply chains to deliver foods in a sustainable and safe way to highly populated urban areas (9). Somewhat surprisingly, the majority of countries where food insecurity is on the rise are not low-income countries, but middle-income countries, particularly those who are dependent on the international trade of primary commodities (9).

1.5 Gender and Food Insecurity

There is mixed evidence on gender and food insecurity although at the global scale it appears that women are still more likely to be food insecure than men. Furthermore, the gender gap in the prevalence of food insecurity increased during the year of the COVID-19 pandemic, with women being 10% more likely than men to experience moderate or severe food insecurity. By comparison, in 2019, women were 6% more likely than men to experience food insecurity (9). An analysis that focused on female food insecurity using GWP data found that the gender gap in food security could be largely explained by gender differences in educational attainment, social networks and household income (28). Thus, policies that seek to improve employment and educational opportunities for women may also improve food security at the household and individual level. An analysis of women's empowerment in relation to nutritional outcomes found that women's empowerment score was positively associated with an increase in child height. However, women's empowerment accounted for a relatively small amount of the variance in nutritional outcomes. Ultimately country level factors and household wealth accounted for most of the variance in nutritional outcomes (29). Women produce up to 80% of the food in developing countries and their traditional roles generally mean that they purchase and prepare food for their families and manage feeding of infants and young children in most societies. Additionally, women struggle more to access resources for food production such as credit and agricultural land (29,30). These factors suggest that women warrant consideration as a separate group and studies that examine food security coping strategies as well as interventions should conduct separate analyses for men and women (30).

Some studies have also indicated that economic access to food is dependent not only on household income but also on the earner (31–33). These studies have observed that women tend to spend a great share of income on food for the family. A study in Nicaragua found that odds of household food insecurity were 60% lower when mothers managed household money and 34% lower when mothers contributed substantially to household income (31). Women's incomes are also a stronger predictor of the health and nutritional status of children than men's incomes. This may be due to a variety of reasons, including societal and cultural norms and a maternal sense of responsibility to ensure that children receive adequate food. Additionally, women tend to receive smaller and more frequent amounts of income than men which may also result in increased spending on subsistence needs (34).

Past literature has highlighted an increased risk for food insecurity in female headed households in South Africa, Mexico, the US and Brazil (22,35,36). However this is in contrast to research from some LMIC, including a study from Bangladesh that indicates that female-headed households are no more likely to be food insecure than male-headed households, and partly attributes this equality of outcome to a cultural willingness that enables women to seek employment outside the home and increase household income and food security (37).

Another critical aspect of household food insecurity is the intra household allocation and distribution of food resources between various household members. There is evidence from South Asia of a pro-male bias, particularly when men are engaged in manual labour and women, girl children and infants are more likely to experience nutritional deficits (34). Data regarding individual food consumption and intra household allocation are complicated and costly to collect, and as a result most household surveys will be completed by a single person in the household (generally, this is the mother or else another person in charge of purchasing and cooking food). Thus, purchase and consumption data are generalised to the entire household when this may not be the case. For this reason, child anthropometry measures are a robust indicator of whether children in a household are adequately nourished.

1.6 Prevalence of food insecurity in South Africa

The estimates of food insecurity in South Africa vary widely as sub-national surveys have utilised different measurement instruments that limit comparisons between surveys (38–41). Somewhat encouraging are the indications that the experience of household hunger and food insecurity appears to have decreased over the past 20 years (42,43). However, some of these gains may have been reversed by Covid-19, with a number of national surveys that indicated many households ran out of money to purchase food in April of 2020, and adults as well as children went hungry during the national lockdown period between March and April 2020 (12,44,45).

Data from the 1999 National Food Consumption Survey (NFCS) noted that among South African children, one in two households (52%) experienced hunger, one in four (23%) were at risk of hunger and only one in four households (25%) appeared food secure (46). Food security appears to have improved in South Africa since the NFCS was conducted, but it is important to note that the survey focused on households with children, while Stats SA data

were not limited to households with children, which are more likely to be food insecure than households that only include adults (35).

Statistics South Africa (StatsSA) uses the United States Department of Agriculture (USDA) Household Food Insecurity Access Scale (HFIAS) (35) and has measured food security at the national level between 2010 and 2017. The most recent Stats SA report on food security in South Africa recorded that 78.7% of the South African population was food secure in 2017 and that the population has become steadily more food secure since 2010 (35). However, the use of an experiential measurement instrument may be a limitation and underestimate the true prevalence of food insecurity in South Africa (47). By contrast, the most recent data from the FAO found a much higher prevalence of food insecurity in South Africa. Using data collected from the GWP that used the FIES tool, the FAO report noted that 19.3% of the population were severely food insecure in 2020 and 44.9% of the population were either moderately or severely food insecure (9). The stunting prevalence of almost 30% among South African children, as well as the findings from the FAO and smaller sub-national surveys, appear to contradict the Stats SA finding that only 5.5% of the population are severely food insecure and 15.8% moderately food insecure (48–50).

For example, a survey that explored urban food insecurity in Cape Town, South Africa using the Household Food Insecurity Access Prevalence (HFIAP) (40) indicator categorises 46% of households as food secure, while 36% are severely food insecure. The remaining 18% experience some degree of food insecurity (40). The SANHANES study used the Community Childhood Hunger Identification Project (CCHIP) measurement tool and noted far higher levels of food insecurity than the Stats SA data. SANHANES observed that only 45.6% of the population was food secure, 28.3% were at risk of hunger and 26.0% experienced hunger and were classified as food insecure (51). The Stats SA data, as well as the SANHANES data, suggest that the prevalence of food insecurity is greater in urban areas and this may partly explain the 36% prevalence of food insecurity observed in the Cape Town survey (35,40,51). In conclusion, although the data on food insecurity prevalence in South Africa varies and interpretation and comparisons are limited due to the use of different measurement instruments, food insecurity remains an intractable public health problem in South Africa, with national surveys estimating the prevalence of household food insecurity between 21% and 36%.

This thesis is particularly focused on dietary diversity for several reasons. Dietary diversity is consistently associated with child anthropometry and low dietary diversity has been found to be associated with stunting in the South African context (5,52,53). In addition, questions on childhood hunger in the household were answered by an adult, not by the children themselves. A list experiment study in Ethiopia found that subjective questions on hunger are not always answered honestly, this may be due to social desirability bias or a sense of shame about respondents inability to provide adequate food for their children (47).

My initial exploratory analyses also found that most stunted children lived in households who reported that a child 'never' went hungry during the past year, an indication that dietary quality and inadequate micronutrients may also be driving the stunting epidemic in South Africa. Thus, questions on the variety of food consumed by the household in the past month may be more applicable to everyone in the household and less subject to various forms of bias. In addition, the number of variables in the dietary diversity score offered additional nuance and enabled me to examine the score continuously and categorically in relation to anthropometry outcomes.

1.7 Global consequences of food insecurity

1.7.1 Rising obesity rates among both adults and children

The global prevalence of obesity has been rising steadily as countries experience a nutrition transition and shift from traditional diets to increasingly sedentary urban lifestyles in conjunction with poor quality processed foods. Thus, high rates of overweight and obesity are occurring concurrently with food insecurity (54,55). The 2021 FAO report noted that alongside the rise in global food insecurity prevalence, adult obesity and diet-related NCD continued to increase sharply across all regions (9,41). In contrast to the traditional view of food insecure or hungry people as being malnourished, a larger proportion of the world's population is now overweight or obese than severely underweight, and overweight and obesity are linked to more deaths worldwide than underweight (54). In addition, no country has successfully been able to reverse its obesity epidemic and LMIC are experiencing the most severe manifestations of this phenomenon (57,58). An analysis of cohort data from Mexico found that women with mild or moderate food insecurity were at increased risk of obesity, as well as those in the poorest income quintile, highlighting the complex links between food insecurity and obesity (59).

However, the obesity epidemic is also driven by increased income among people in middle-income countries as well as the affordability of nutrient-poor processed foods that are high in fat and sugar. A longitudinal analysis of obesity trends among NIDS participants found a strong positive trend in body mass index (BMI) and noted that obesity prevalence is likely to continue increasing. Risk factors for obesity in the South African context included female gender, younger age, larger waist circumference, white population group and higher household income per capita. The article also suggested an urgent need for interventions such as targeted campaigns that address the health problems caused by obesity (60). In the South African context, a preference for larger body shapes may also play an important role. The SANHANES study included a question on ideal body image and found that 87.9% of South Africans indicated that their ideal body image was fat, while only 12.0% indicated that they had a normal ideal body image (38). Obesity is a multi-faceted problem and the various drivers of obesity need to be carefully considered in the design and implementation of obesity interventions as well as public health messaging around obesity.

1.7.2 Urbanization and food insecurity

Closely linked to the obesity epidemic is the urbanisation that is occurring around the world. Every year, vast amounts of people move to urban areas and cities, primarily in search of employment and other opportunities (9). In LMIC, informal settlements and peri-urban communities have proliferated. These areas are generally characterised by poor service delivery and a lack of access to healthy and nutritious food. In many parts of Asia as well as Sub-Saharan Africa (SSA) these profound shifts in the food system have occurred as a result of the retail revolution and the monopoly of corporations over fresh markets and smaller retailers (57). For example, in Latin America and the Caribbean, the sales of packaged and processed foods comprised 10% of all food expenditures in 1990, but this figure had risen to 60% by 2000. This rate of change has been replicated in other parts of the world including SSA, although most of the growth in the African market has occurred in the 21st century (57).

1.8 Depression and psychosocial consequences of food insecurity

In addition to adverse physiological consequences, the experience of food insecurity has negative implication for mental health. Food is non-negotiable and essential to sustain human life. Thus, anxiety about food supply or the experience of hunger are intrinsically linked to the human need for security and survival.

Food insecurity is an important risk factor for depression and a cross-sectional global analysis of 149 countries using GWP data that explored food insecurity and mental health noted a dose response relationship with food insecurity and lower scores for mental health independent of socioeconomic status (10). One of the strengths of this analysis is that it only analysed studies which used the same tool (the FIES scale) to measure food insecurity. There is no gold standard for measuring either food insecurity or depression and different studies use different tools. In addition, concepts like depression and food insecurity may vary relative to the geographical location, the population being surveyed and the level of inequality within the population (6). As a result, the true magnitude of the impact of food insecurity on mental health is difficult to ascertain. However, the link between food insecurity and poor mental health was observed across global regions, which suggests that this is a universally distressing experience. The same analysis also noted that the effects of food insecurity on mental health appear to be similar for men and women, although women tend to score worse on mental health indices than their male counterparts regardless of food security status (10).

The increased risk of depression associated with food insecurity may be both psychological as well as physiological; distress and anxiety around inadequate food may increase depressive symptoms and a poor-quality diet and micronutrient deficiencies may also contribute to depressive symptoms. Distinguishing to what extent poor quality diets contribute to depression is an important avenue for future research. A recent analysis of cohort data from Spain found that study participants who consumed high quantities of ultra-processed foods were significantly more likely to develop depression even after adjusting for several confounders (60). This has important global mental health consequences given that processed foods are increasingly replacing 'whole' foods around the world.

Two studies from the US that examined household food insecurity among low income adults and college students respectively also observed a dose response relationship, and noted that those with low food security were between four and five times more likely to be depressed than those who were food secure (62,63). Additionally, other factors associated with the experience of poverty may exacerbate mental distress and contribute to depression but numerous studies have found that food insecurity and depression are positively associated and share a dose response relationship, even when study designs adjust for household income and SES (64). This is an important distinction because, while food insecurity often occurs in poor households, there are multiple other factors that contribute to food insecurity, including

gender, social support, intra-household food allocation and local and regional access to food. As such, food insecurity is a complex phenomenon and should not simply be used as a proxy for poverty.

The relationship between food insecurity and depression has important global consequences for health and productivity. In 2016, mental and addictive disorders affected more than one billion people globally and caused 7% of all global burden of disease as measured in DALY and 19% of all years lived with disability. Depression was associated with most DALY for both sexes, with higher rates in women (65). The review of food insecurity and mental health noted that there were more studies exploring mental health and food insecurity among women than men, but the focus on women is not necessarily unfounded (10). A systematic review and meta-analysis that explored food insecurity in relation to mental health across ten different countries found a positive relationship between food insecurity and risk of depression (OR= 1·40; 95 % CI: 1·30, 1·58) and stress (OR= 1·34; 95 % CI: 1·24, 1·44) but not anxiety. The same review also noted that men and people aged sixty five and over were at greater risk of depression than women (51). However, these finding have been contradicted by another systematic review which found that food insecurity was associated with anxiety across population groups (67) as well as smaller qualitative and quantitative studies (10,41,68).

1.9 COVID 19 and food insecurity in South Africa

Researchers conducted analysis of the National Income Dynamics Study – Coronavirus Rapid Mobile Survey (NIDS-CRAM) in response to the coronavirus and the subsequent social and economic crisis. Data were broadly nationally representative of adults from the 2017 wave of NIDS and were collected via computer assisted telephonic interviewing (CATI). The first wave of NIDS-CRAM data successfully interviewed 7041 adults over the age of 18 between 7 May and 27 June 2020.

Even at the height of the hard lockdown there was evidence that adults were shielding children in the household from hunger, as 22% of adults were likely to report going hungry versus only 15% of households reported children going hungry in the past week (69). Individuals who reported experiencing hunger (hunger ‘Every day’ or ‘Almost every day’) were significantly more likely to have depressive symptoms, highlighting the importance of food insecurity and hunger as a risk factor for depression and other CMD among adults (69).

Data from 2020 indicate that adult and child hunger both declined by almost 30% between Between Wave 1 and 2 of NIDS-CRAM. While it is encouraging to see reduction in hunger levels since the hard lockdown in March of 2020, these new rates remain above pre-COVID levels (70). While 20% fewer households ran out of money to buy food in June compared to April 2020, this indicator of food insecurity is twice as high as it was in 2016. In June of 2020, 37% of households still reported running out of money to purchase food. In addition, only a quarter of respondents indicated that their children had received a school meal in the past seven days, a steep decline from the pre-Covid survey where 80% of respondents reported their children receiving a school meal.

The most recent NIDS CRAM, released in May 2021, noted that the proportion of households who reported running out of money for food was between 47% and 39% between May and August of 2020. The figures for household hunger were similar, with hunger levels varying between 23% and 16% across study waves. The survey also found that these high levels of food insecurity remained similar to those of June of 2020. These findings indicate that the situation is very similar to 2020 and that child hunger has not decreased significantly (70). This has disturbing implications for subsequent stunting and wasting among vulnerable children who were exposed to chronic hunger and food insecurity during the Covid lockdown and the economic hardship that followed.

1.10 Conclusion

This chapter has summarized the background for the study and some of the gaps in the literature that this study aimed to address. The following chapter comprises the literature review and broadly describes the current evidence base on food security and maternal depression and their relationship with low birthweight and stunting. Gaps in the research as well as conceptual difficulties around food security measurement are also addressed. This is followed by Chapter 3 which is the methods chapter and five results chapters (Chapter 4 – Chapter 8), each of which is written in the format of a scientific article.

1.11 References

1. HLPE. Food Security and Nutrition: Building a Global Narrative towards 2030. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. [Internet]. High Level Panel of Experts. Rome; 2020. Available from: http://www.fao.org/3/ca9731en/ca9731en.pdf
2. FAO, IFAD, UNICEF, WFP, WHO. The State of Food Security and Nutrition in the World 2019. Rome; 2019.

3. Radimer KL, Olson CM, Greene JC, Campbell CC, Habicht J-P. Understanding hunger and developing indicators to assess it in women and children. J Nutr Educ [Internet]. 1992;24(1, Supplement 1):36S-44S. Available from: https://www.sciencedirect.com/science/article/pii/S0022318212801373

4. FAO. Voice of Hungry [Internet]. Vol. 2016. 2016. 60 p. Available from: http://www.fao.org/3/a-i4830e.pdf

5. Headey D, Ecker O. Improving the Measurement of Food Security. 2012.

6. Coates J, Frongillo EA, Rogers BL, Webb P, Wilde PE, Houser R, et al. What Are We Assessing When We Measure Food Security? A Compendium and Review of Current Metrics. Adv Nutr [Internet]. 2013;4(February):481–505. Available from: http://www.elgaronline.com/view/9780857939371.xml

7. FAO, IFAD, WFP. The State of Food Insecurity in the World 2015. 2015.

8. Ingram J. Nutrition security is more than food security [Internet]. Vol. 1, Nature Food. Springer US; 2020. p. 2. Available from: http://dx.doi.org/10.1038/s43016-019-0002-4

9. FAO. The State of Food Security and Nutrition in the World. Transforming food systems for food security, improved nutrition and affordable healthy diets for all [Internet]. Rome; 2021. Available from: https://doi.org/10.4060/ca9692en

10. Jones AD. Food Insecurity and Mental Health Status: A Global Analysis of 149 Countries. Am J Prev Med [Internet]. 2017;53(2):264–73. Available from: http://dx.doi.org/10.1016/j.amepre.2017.04.008

11. Weaver LJ, Hadley C. Moving beyond hunger and nutrition: A systematic review of the evidence linking food insecurity and mental health in developing countries. Ecol Food Nutr. 2009;48(4):263–84.

12. Laborde D, Martin W, Swinnen J, Vos R. COVID-19 risks to global food security. Science (80-). 2020;369(6503):500–2.

13. Marmot M, Allen J. Social determinants of health. Am J Public Health. 2014;104(4):517–9.

14. Marmot M, Friel S, Bell R, Houweling TA, Taylor S. Closing the gap in a generation: health equity through action on the social determinants of health. Lancet. 2008;372(9650):1661–9.

15. Frank J, Abel T, Campostrini S, Cook S, Lin VK, Mcqueen D V. The Social Determinants of Health : Time to Re-Think ?

16. Mayosi BM, Lawn JE, Van Niekerk A, Bradshaw D, Abdool Karim SS, Coovadia HM. Health in South Africa: Changes and challenges since 2009. Lancet [Internet]. 2012;380(9858):2029–43. Available from: http://dx.doi.org/10.1016/S0140-6736(12)61814-5

17. Alegría M, Nemoyer A, Bagué IF, Wang Y, Alvarez K. Social Determinants of Mental Health : Where We Are and Where We Need to Go. Curr Psychiatry Rep. 2018;20(95).

18. Scott V, Schaay N, Schneider H, Sanders D. Addressing social determinants of health in South Africa: the journey continues. In: SAHR 20th Edition. 2017. p. 77–88.

19. Robbiati C, Armando A, Conceição N, Putoto G, Cavallin F. Association between diabetes and food insecurity in an urban setting in Angola : a case – control study. Sci Rep [Internet]. 2022;(0123456789):1–6. Available from: https://doi.org/10.1038/s41598-022-04888-7

20. Power M, Uphoff E, Kelly B, Pickett KE. Food insecurity and mental health : an analysis of routine primary care data of pregnant women in the Born in Bradford cohort. J Epidemiol Community Health. 2017;(71):324–8.

21. Eaton L, Pitpitan E, Kalichman S, Sikkema K, Skinner D, Watt M, et al. Food Insecurity and Alcohol Use Among Pregnant Women at Alcohol Serving Establishments in South Africa. 2008;86(12):3279–88.

22. Felker-Kantor E, Wood CH. Female-headed households and food insecurity in Brazil. Food Secur. 2012;4(4):607–17.

23. Jung NM, de Bairros FS, Pattussi MP, Pauli S, Neutzling MB. Gender differences in the prevalence of household food insecurity: a systematic review and meta-analysis. Public Health Nutr [Internet]. 2017;20(5):902–16. Available from: http://www.ncbi.nlm.nih.gov/pubmed/27829486

24. Pereira AL, Handa S, Holmqvist G. Prevalence and Correlates of Food Insecurity among Children across the Globe. Innocenti Work Pap. 2017;(June):1–37.

25. Penne T, Goedemé T. Can low-income households afford a healthy diet? Insufficient income as a driver of food insecurity in Europe. Food Policy. 2021;99(October 2020).

26. Smith MD, Kassa W, Winters P. Assessing food insecurity in Latin America and the Caribbean using FAO's Food Insecurity Experience Scale. Food Policy [Internet]. 2017;71:48–61. Available from: http://dx.doi.org/10.1016/j.foodpol.2017.07.005

27. Tomita A, Burns JK. A multilevel analysis of association between neighborhood social capital and depression : Evidence from the first South African National Income Dynamics Study. J Affect Disord [Internet]. 2013;144(1–2):101–5. Available from: http://dx.doi.org/10.1016/j.jad.2012.05.066

28. Broussard NH. What explains gender differences in food insecurity? Food Policy [Internet]. 2019;83(January 2018):180–94. Available from: https://doi.org/10.1016/j.foodpol.2019.01.003

29. Quisumbing AR, Sproule K, Martinez EM, Malapit H. Do tradeoffs among dimensions of women's empowerment and nutrition outcomes exist? Evidence from six countries in Africa and Asia. Food Policy [Internet]. 2021;100. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85097753392&doi=10.1016%2Fj.foodpol.2020.102001&partnerID=40&md5=c4c0798ab28e016890abba7324037f92

30. Ivers LC, Cullen K a. Food insecurity : special considerations for women 1 – 4. Am J Clin Nutr. 2011;94:1740–4.

31. Schmeer KK, Piperata BA, Herrera Rodríguez A, Salazar Torres VM, Centeno Cárdenas FJ. Maternal resources and household food security: evidence from Nicaragua. Public Health Nutr [Internet]. 2015;18(16):2915–24. Available from: http://0-search.ebscohost.com.innopac.wits.ac.za/login.aspx?direct=true&db=lhh&AN=20153365881&site=ehost-live&scope=site

32. Smith LC, Ramakrishnan U, Ndiaye A, Haddad L, Martorell R, Mayufis RG, et al. The Importance of Women's Status for Child Nutrition in Developing Countries. Washington DC; 2003.

33. Sraboni E, Quisumbing A. Women's empowerment in agriculture and dietary quality across the life course: Evidence from Bangladesh. Food Policy [Internet]. 2018;81:21–36. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85055750948&doi=10.1016%2Fj.foodpol.2018.09.001&partnerID=40&md5=6e741f7db744327809970eda0f1e9199

34. Quisumbing AR, Brown LR, Feldstein HS, Haddad L, Peña C. Women: The Key to Food Security. Food Nutr Bull. 1996;17(1):1–2.

35. Stats SA. Towards measuring food security in South Africa: An examination of hunger and food inadequacy [Internet]. Pretoria: Statistics South Africa, Private Bag X44, Pretoria 0001; 2019. 26 p. Available from: www.statssa.gov.za

36. Magaña-Lemus D, Ishdorj A, Rosson CP, Lara-Álvarez J. Determinants of household food insecurity in Mexico. Agric Food Econ [Internet]. 2016;4(1). Available from: http://dx.doi.org/10.1186/s40100-016-0054-9

37. Mallick D, Rafi M. Are Female-Headed Households More Food Insecure? Evidence from Bangladesh. World Dev [Internet]. 2010;38(4):593–605. Available from: http://dx.doi.org/10.1016/j.worlddev.2009.11.004

38. Misselhorn A, Hendriks SL. A systematic review of sub-national food insecurity research in South Africa: Missed opportunities for policy insights. Vol. 12, PLoS ONE. 2017. 1–32 p.

39. Hendriks SL. The challenges facing empirical estimation of household food (in)security in South Africa. Dev South Afr. 2005;22(1):103–23.

40. Crush J, Caeser M, Haysom G. Hungry Cities Partnership: The State of Household Food Security in Cape Town, South Africa. Vol. 2. Cape Town; 2018.

41. Maharaj V, Tomita A, Thela L, Mhlongo M, Burns JK. Food Insecurity and Risk of Depression Among Refugees and Immigrants in South Africa. J Immigr Minor Heal. 2017;19(3):631–7.

42. Hall K, Sambu W, Berry L, Giese S, Almeleh C. South African Early Childhood Review 2017. Cape Town; 2017.

43. Labadarios D, McHiza ZJ-R, Steyn NP, Gericke G, Maunder EMW, Davids YD, et al. Food security in

South Africa: a review of national surveys. Bull World Health Organ [Internet]. 2011 Dec 1 [cited 2013 May 30];89(12):891–9. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3260897&tool=pmcentrez&rendertype=abstract

44. Wills G, Patel L, van der Berg S, Mpeta B. Household resource flows and food poverty during South Africa's lockdown: Short-term policy implications for three channels of social protection. 2020;(Wave 1):46. Available from: https://cramsurvey.org/wp-content/uploads/2020/07/Wills-household-resource-flows-and-food-poverty-during-South-Africa's-lockdown-2.pdf

45. van Bruwaene L, Goga A, Green RJ. What are we doing to the children of South Africa under the guise of COVID-19 lockdown ? South African Med J. 2020;15–6.

46. Labadarios D, Steyn N, Maunder E, MacIntryre U, Gericke G, Swart R, et al. The National Food Consumption Survey (NFCS): South Africa, 1999. Public Health Nutr. 2005;8(5):533–43.

47. Tadesse G, Abate GT, Zewdie T. Biases in self-reported food insecurity measurement: A list experiment approach. Food Policy [Internet]. 2020;92(May 2019):101862. Available from: https://doi.org/10.1016/j.foodpol.2020.101862

48. Said-Mohamed R, Micklesfield LK, Pettifor JM, Norris SA. Has the prevalence of stunting in South African children changed in 40 years? A systematic review. BMC Public Health. 2015;15(1):1–10.

49. Devereux S, Waidler J. Why does malnutrition persist in South Africa despite social grants? Food Security SA Working Paper Series No. 001. 2017.

50. Sung-King M, Lake L, Sanders D, Hendricks M. South African ChildGauge 2019: Child and adolescent health leave no one behind. South African Child Gauge. 2019. 30–62 p.

51. Shisana o, Labadarios D, Rehle T, Simbayi L, Zuma K, Dhansay A, Reddy P, Parker W, Hoosain E, Naidoo P, Hogoro C, Mchiza Z, Steyn NP, Dwane N, Makoae M, Maluleke T, Ramlagan S, zungu N, Evans MG, Jacobs L FM& S-1 T. The South African National health and Nutrition Examination Survey SANHANES-1. Cape Town; 2013.

52. Faber M, Laubscher R, Berti C. Poor dietary diversity and low nutrient density of the complementary diet for 6- to 24-month-old children in urban and rural KwaZulu-Natal, South Africa. Matern Child Nutr. 2016 Jul;12(3):528–45.

53. Faber M, Schwabe C, Drimie S. Dietary diversity in relation to other household food security indicators. Int J Food Safety, Nutr Public Heal. 2009;2(1):1.

54. Popkin BM, Gordon-Larsen P. The nutrition transition: worldwide obesity dynamics and their determinants. Int J Obes Relat Metab Disord [Internet]. 2004;28 Suppl 3(Suppl 3):S2-9. Available from: http://www.researchgate.net/publication/8184173_Popkin_BM_Gordon-Larsen_P._The_nutrition_transition_worldwide_obesity_dynamics_and_their_determinants._Int_J_Obes_Relat_Metab_Disord_28(Suppl)_S2-S9

55. Dowlatchahi M. Pakistan and FAO Partnering to eliminate hunger and malnutrition through agricultural development [Internet]. Vol. 1947. 2018. Available from: http://www.fao.org/3/ax985e/AX985E.pdf

56. Gregory CA, Coleman-Jensen A. Food insecurity, chronic disease, and health among working-age adults. 2017.

57. Popkin BM, Corvalan C, Grummer-Strawn LM. Dynamics of the double burden of malnutrition and the changing nutrition reality. Lancet [Internet]. 2020;395(10217):65–74. Available from: http://dx.doi.org/10.1016/S0140-6736(19)32497-3

58. Popkin BM. Relationship between shifts in food system dynamics and acceleration of the global nutrition transition. Nutr Rev. 2017;75(2):73–82.

59. Arredondo A, Torres C, Orozco E, Pacheco S, Huang F, Zambrano E, et al. Socio-economic indicators, dietary patterns, and physical activity as determinants of maternal obesity in middle-income countries: Evidences from a cohort study in Mexico. Int J Health Plann Manage. 2019;34(1):e713–25.

60. Cois A, Day C. Obesity trends and risk factors in the South African adult population. BMC Obes. 2015;2(1):1–10.

61. Shisana o, Labadarios D, Rehle T, Simbayi L, Zuma K, Dhansay A, Reddy P, Parker W, Hoosain E, Naidoo P, Hogoro C, Mchiza Z S. The South African National Health and Nutrition Examination

Survey, 2012 SANHANES-1. CAPiTiLPRESS; 2014. 423 p.

62. Leung CW, Epel ES, Willett WC, Rimm EB, Laraia BA. Household Food Insecurity Is Positively Associated with Depression among Low-Income Supplemental Nutrition Assistance Program Participants and Income-Eligible Nonparticipants. J Nutr. 2015;145(3):622–7.

63. Reeder N, Tapanee P, Persell A, Tolar-Peterson T. Food insecurity, depression, and race: Correlations observed among college students at a university in the Southeastern United States. Int J Environ Res Public Health. 2020;17(21):1–11.

64. Evensen M. Food insecurity and mental health: New answers and remaining questions. J Epidemiol Community Health. 2021;0(0):2021.

65. Rehm J, Shield KD. Global Burden of Disease and the Impact of Mental and Addictive Disorders. Curr Psychiatry Rep. 2019;21(2).

66. Pourmotabbed A, Moradi S, Babaei A, Ghavami A, Mohammadi H, Jalili C, et al. Food insecurity and mental health: A systematic review and meta-analysis. Public Health Nutr. 2020;23(10):1778–90.

67. Arenas DJ, Thomas A, Wang J, Delisser HM. A Systematic Review and Meta-analysis of Depression , Anxiety , and Sleep Disorders in US Adults with Food Insecurity. :2874–82.

68. Maynard M, Andrade L, Packull-McCormick S, Perlman CM, Leos-Toro C, Kirkpatrick SI. Food Insecurity and Mental Health among Females in High-Income Countries. Int J Environ Res Public Health. 2018 Jul;15(7).

69. van der Berg S, Zuze L, Bridgman G. The impact of hte Coronavirus and lockdown on children's welfare in South Africa; Evidence from NIDS-CRAM Wave 1. 2020.

70. Spaull N, Oyenubi A, Kerr A, Maghan-Brown B, Ardington C, Christian C, et al. Synthesis Report NIDS-CRAM Wave 2. 2020;(September):5–8.

Chapter 2 LITERATURE REVIEW

The previous chapter provided the background for the study and this chapter consists of the literature review. The following themes are presented:

2.1 Measurement of food insecurity

While the concept of food security is relatively recent, the measurement of food security began long before. In post-World War 1 and World War II, countries began to collect data on national food balance sheets to assist in food distribution and allocation to regions affected by conflict (1). Such balance sheet data are macro scale 'supply side' data that attempt to describe the total energy content available at a population level from food that imported and produced within a country. These types of measures emphasised the availability of food supplies at a national scale as the primary factor for measuring a country's food security status. In 1981, Amartya Sen published his seminal essay, *Poverty and Famines*, that demonstrated how people could still experience famines and starve to death in regions that were food secure at the national level (2). Sen's work highlighted that in many cases the availability of food in a macro sense was not the problem, but access to food at the individual and household level were the causes of food insecurity and famine. This work changed the course of food security measurement as the focus shifted from food supply at the regional and country level to access issues at the household and individual level.

Food insecurity can be envisioned as a continuum, with the completely food secure existing on one end and the most severe manifestation of famine or starvation on the other end (1). The lack of a gold standard to measure food insecurity has resulted in difficulty in estimating prevalence, incidence, or outcomes (3–5). Thus, data on food insecurity from the same regions and time periods may provide disparate prevalence estimates because of differing measurement instruments (1,6). These disparities are also reflected in LMIC contexts (7,8). For example, a systematic review and meta-analysis of studies of household food insecurity in Iran examined differing measures of food insecurity. This meta-analysis presented studies that used dietary recall, household income or expenditure and experiential or perception-based studies and noted substantial variance in prevalence estimates depending on the type of measure (8). An Ethiopian study demonstrated divergent findings using experiential measures in food security estimates when different measures were applied to the same data set (7).

2.1.1 Timing of food security measurement

The timing of food security indicators is important given the cyclical and seasonal nature of household food insecurity. It may intuitively seem that more recent recall period (24 hours or 7 days) may be more specific. However, a validation study that compared two food security measures in the United States with both a 12 month and a 30 day recall period found that for both tools, the 12-month recall version was more sensitive than and at least as specific as the 30-day recall version (9). A study that examined various food insecurity indicators across two seasons in South Africa found that only anthropometric indicators were sensitive enough to differentiate levels of food insecurity. The study authors further recommended that surveys use a combination of food consumption and experience of hunger measures backed up by anthropometric measures to obtain an accurate prevalence estimate of food insecurity (10).

2.2 A shift to experiential indicators

While there is some consensus about the definition, measurement has been inconsistent, partially due to a shift from indicators like anthropometry and dietary diversity to primarily experiential measures, i.e. individual perceptions regarding anxiety about food supply and the experience of hunger (11,12). Such measures primarily describe access to food and the stability of food security over time, but do not include indicators relating to food utilisation like dietary diversity or other nutrition indicators. In experiential measures, the least severe form of food insecurity is worrying about access to sufficient food while the most severe is characterised by skipping meals or losing weight due to lack of food. In commonly used measures including the FIES and the HFIAS (6,7), households are classified into three separate categories of severity (food secure, moderately food insecure or severely food insecure) for monitoring the food security status at a population level. One advantage of these categories is that they enable easier interpretation of household food security for policy makers and the public than an abstract number (13).

The severity levels of scales like HFIAS and FIES have been validated using Rasch modelling (14). This approach is based on item response theory and premised on the concept that hunger and food insecurity are universal experiences that exist along a spectrum of severity. Changes in severity are observed in the response patterns of surveyed households or individuals. While these typical response patterns are probabilistic, they generally hold true across populations and geographic regions (14). However, there is mixed evidence regarding

the associations between such scales and malnutrition indicators like stunting. Different indicators and measures capture different dimensions of food insecurity, resulting in difficulty estimating severity, incidence, or outcomes (1–5, 9). For example, food expenditure data may provide some indication of a household's food security status but cannot account for intra household food allocation or the micronutrient adequacy of the household's diet. National level prevalence estimates such as the FAO's prevalence of undernourishment (POU) are calculated through use of a series of indirect methods to estimate parameters in the absence of direct evidence, which may prove to be unreliable (11). Hunger based measures may not capture households that subsist on poor quality monotonous diets and experience hidden hunger as a result of micronutrient deficiencies as these households may not report experiencing hunger.

A study that examined self-reported food insecurity in Ethiopia using a list experiment approach found significant bias in self-reported food insecurity responses to direct interviews (15). The authors hypothesized that this is particularly prevalent in areas where households are chronically food insecure and receive government support as respondents are incentivized to misreport to questions which are directly related to food shortage (15). Another study that examined household food insecurity in the Eastern Cape province of South Africa across two seasons found that only anthropometric indicators were sufficiently sensitive to differentiate levels of food insecurity and recommended that surveys utilize a combination of food consumption and experiential measures as well as anthropometric measures (10).

Given the complexity of food security measurement and the various subjective and objective constructs that different indicators measure (ie. perceived hunger, dietary quality, nutrient adequacy, food preferences etc.) researchers must carefully consider their choice of measurement in light of their research question. Ideally, surveys can include more than one measure of food insecurity (both subjective and objective) and more than one recall period to ensure that food security is captured as accurately as possible. This thesis examined household hunger in the past 12 months (access and stability dimension), dietary diversity in the past 30 days (access and utilization dimension), food expenditure in the past 30 days (access dimension) as well as anthropometry (access and utilization dimension). The indicators and their various limitations are discussed in further detail in the Methods Chapter.

2.3 Maternal food insecurity

The experience of food insecurity is particularly harrowing for women with children, who often experience comorbid depression and anxiety (16–19). There is emerging evidence that maternal depression contributes to household food insecurity as depressed mothers may have less self-efficacy than those who are not depressed. A study that examined maternal food insecurity and depression among a group of low-income women in the US found that mothers with a high level of self-efficacy were less depressed by their food security status than those who had low self-efficacy (20). Thus, a mother's self-confidence, perceived competence in infant care, perception of motherhood role and overall self-esteem may also reduce the risk of developing depression despite experiencing food insecurity (20,21).

Many studies have noted that female headed households are at a greater risk for food insecurity. Qualitative studies from both low- and high-income countries have revealed the universal distress felt by women who are unable to care for their offspring (13). Women report feelings of frustration, anxiety and shame when they cannot feed their children, as well as a sense that they are failing to fulfil their primary role as caregivers and mothers (16,22,23). In many settings, hunger and food insecurity is stigmatising, and guilt and shame may prevent women from accessing their social network or other social safety nets, such as food banks that could mediate both food insecurity and alleviate the poor mental health outcomes arising from this. Thus, the cycle of food insecurity and maternal depression continues. The links between food insecurity and depression is a complex one that may be alleviated by protective factors such as a strong social support network, maternal self-efficacy, or access to resources like food banks in high-income countries (24).

One limitation of studies on maternal food insecurity in LMIC contexts is that the majority utilise cross-sectional study designs (19,25–27). There is a paucity of longitudinal research that examines food insecurity over time and how this impacts maternal depression, and whether depression or food insecurity precede one another. The limited evidence base of longitudinal research suggests a bidirectional relationship and highlights the importance of food security as a potentially modifiable risk factor for maternal depression in both the antenatal and postpartum stages. Two longitudinal studies of maternal depression in low-income families in the US observed a recursive and bidirectional relationship between food insecurity and maternal depression, whereby depression caused food insecurity to increase and vice versa (17,28). Another study from the US that examined how food insecurity

mediated maternal depressive symptoms over a five-year period found significant mediation pathways with household food insecurity mediating the link between family SES and maternal depression. A cross-lagged model showed that family SES was predictive of later household food insecurity, which was subsequently associated with maternal depression at a later date. These findings highlight the importance of household food insecurity as an important risk factor for maternal depression over time (29).

2.4 Antenatal food insecurity and adverse pregnancy and birth outcomes

There are several social and biological determinants of early childhood health, including that of maternal nutritional status and dietary intake during the pregnancy period. Global research of such deprivation, including studies of the Dutch and Chinese famine, suggests that critical environmental exposures during the antenatal period may influence the health of the child well into adulthood (30,31). The effects of famine on the unborn foetus depend on timing, but the period of early gestation is particularly important when organs and tissues are undergoing critical periods of development (30). While most food insecurity is not severe enough to be classified as famine, even moderate food insecurity may have adverse consequences for maternal and child health alike.

The evidence regarding pregnancy and birth outcomes is mixed, with some studies finding an association between food insecurity and adverse birth and pregnancy outcomes, while others do not. For example, a case control study from the US that controlled for various confounders has noted a link between food insecurity during the antenatal period and an increased risk for certain birth defects, such as cleft palate, d-transposition of the great arteries, tetralogy of Fallot, spina bifida, and anencephaly (32). Other studies that examined food insecurity during pregnancy (also in the US) found that it was associated with disordered eating, stress and an increased risk of gestational diabetes (33,34).

2.5 Maternal food insecurity and low birthweight

A study that used data from the Bangladesh Health and Demographic survey and examined birth size among 8753 babies noted that women from food insecure households were 38% more likely to give birth to a small infant. However, this study did have several limitations including the subjective nature of measuring babies' size (babies described as small, average, large) as accurate birthweight data were not available (35). A prospective cohort study that explored low birthweight (LBW) in Pakistan and assessed maternal food insecurity using the

US Household Food Security Survey found that food insecure women were more than five times as likely to deliver a LBW baby (36). A longitudinal cohort study from South Africa noted an increase in babies born small for gestational age (SGA) among food insecure women (37). A study in a rural province of Indonesia also found that food insecure women were more than five times as likely to deliver a LBW baby (38). A prospective facility-based cohort study in rural Haiti also observed an increased risk of preterm birth among food insecure women (39). We found that women who reported a child in the household going hungry in the past year were significantly more likely to give birth to a LBW infant during the reference period. These findings are presented in Chapter 7 which examines periconceptional and antenatal maternal food insecurity in relation to LBW and stunting.

Other studies, including the analysis for Chapter 6 of this thesis as well as work from cohorts in South Africa and the US, did not find an association with maternal food insecurity and LBW (40). Possible explanations for these observed differences may be that food insecurity in Southeast Asia is severe enough to cause maternal underweight BMI, which is a risk factor for LBW, while food insecurity in countries like the US and South Africa is not as severe. For example, in the study from Bangladesh, 27% of mothers were classified as underweight (BMI<18.5), while in the data for our article, less than 10% of mothers were underweight while almost 50% were either overweight or obese (35). However, this is not corroborated by the study from Pakistan which found a mean BMI of 29.4 among participants and still noted an association with LBW and food insecurity, as well as the study from Haiti which also had a high prevalence of obesity (36,39).

Hypertension also lies on the causal pathway between food insecurity and LBW. Hypertension is steadily increasing throughout the world and much of this can be attributed to poor quality diets, sedentary lifestyles, and a burgeoning obesity epidemic (41,42). While obesity and a poor-quality diet do not necessarily imply that a woman is food insecure, the high prevalence of both conditions in LMIC, as well as among women of lower SES in high-income countries, warrants consideration (43). This indirect link between food insecurity and birth outcomes is particularly important among women of childbearing age as both mother and baby can experience adverse pregnancy and birth outcomes, including preeclampsia, SGA, LBW and increased risk of c-section and neonatal unit admission (44).

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2.6 Global prevalence estimates of antenatal depression

Pregnancy is a time of major physiological as well as psychological change for women. As such, pregnant women are more vulnerable to developing CMD such as anxiety and depression. Antenatal depression is one of the most common psychiatric disorders and can have adverse health and developmental consequences for both mothers and their infants (45,46).

A systematic review and meta-analysis by Grote et al. observed a prevalence of antenatal depression from 7% to 15% in high-income countries and 19–25% in low-income and middle-income countries (37). A recent systematic review and meta-analyses by Yin and colleagues that examined antenatal depression in both high- and low-income countries observed a pooled prevalence of any antenatal depression across 173 studies of 20.7% (47). A systematic review and meta-analysis by Dadi et al., that examined the prevalence of antenatal depression in Africa across 28 studies and over 17 000 women, observed a pooled prevalence of antenatal depression of 26.3% (95%CI: 22.2, 30.4%) (48).

All three meta-analyses noted a higher prevalence of depression among women in LMIC. The Yin study observed that self-report tools to measure depression, as well as tools that were specifically designed for pregnant or postpartum women such as the Edinburgh Postnatal Depression Scale (EPDS), were associated with a higher prevalence of depression than women who were asked about their depression status by someone else or women who completed questionnaires that were intended for the general population and not specific to women in the perinatal period (47). The Grote study also observed that categorically defined depression was more strongly associated with adverse birth outcomes than studies that used continuous measures of depression (37).

2.7 Correlates of antenatal depression

Risk factors for antenatal depression in Africa included economic difficulties, marital problems, a lack of support from relatives as well as previous mental health problems (48). The systematic review by Yin et al. found that a previous CMD, single/separated/divorced status, unplanned pregnancy, unemployment, IPV, smoking before or during pregnancy and low social support were significantly associated with antenatal depression (47). Social and relational upheaval as well as the experience of violence, poverty and food insecurity associated with unemployment are all more common in LMIC and among low-income

women in developed countries. These social determinants of health and mental health significantly increase the risk for developing depression and other mental disorders.

The adverse implications for women, as well as their children, highlight the importance of screening and treatment for antenatal depression during this vulnerable period. Observational studies have observed that depressed women are at a greater risk for substance abuse and less likely to seek antenatal care and more likely to experience postpartum depression (25,26,49,50). With regards to poor birth outcomes, two systematic reviews and meta-analyses observed an association between maternal depression and preeclampsia, intrauterine growth restriction, preterm birth, and LBW (45,46). Although the magnitude of effect varies by depression measurement instrument and geographical location, two systematic reviews and meta-analyses have noted that women living in LMIC are at greater risk of depression in the antenatal period, and subsequently at greater risk for adverse birth outcomes (45,47).

2.8 Antenatal depression in South Africa

A study conducted in urban KwaZulu-Natal measured depression using the EPDS and observed a depression prevalence of 38.5% among pregnant women. Risk factors for depression included unplanned pregnancy, Human Immunodeficiency Virus (HIV) positive status as well as single marital status (51). Another study used the Mini International Neuropsychiatric Interview (MINI) measure to examine depression among 376 women attending their first antenatal visit at a primary-level, community-based clinic and observed a depression prevalence of major depressive episode (MDE) among 22% of women and that food insecure women were at greater risk of depression (25). Another study in urban Cape Town used the EPDS to measure depression in two groups of pregnant women and observed a prevalence between 42% and 46% (52).

A study that examined first trimester depression among urban women living in Soweto and used the EPDS measure observed a depression prevalence of 27% (53). A facility-based study that examined intimate partner violence (IPV) among pregnant women in South Africa and used the MINI tool to measure depression found a prevalence of 22%. The prevalence estimates described above vary between 20% and 46%, this may be partially due to measurement differences, but these figures are notably higher than those from high-income countries which vary between 9% and 15% (45). These studies shed light on the large proportion of South African women who suffer with depression during their pregnancies and

highlight the importance of maternal mental health as an urgent public health problem as well as an area for intervention.

2.9 Antenatal depression trajectories

Longitudinal research of depression trajectories in two cohorts of South African women presents a more nuanced picture of what proportion of women experience depression, how likely it is to resolve and how many women experience severe and chronic depression throughout their pregnancies and postnatally (54,55). Chronicity of depression is of particular importance as the children of mothers who experience severe depression during the first thousand days of life are more likely to have adverse consequences than the children of mothers with brief episodic depression.

A study by Garman et al. among 342 low-income South African women used the Hamilton Depression Rating Scale (HDRS) and the HFIAS to measure depression and food insecurity. Participants were less than 29 weeks pregnant at baseline and participants were followed up at 8 months gestation and 3 and 12 months postpartum. The study followed the observed two trajectories: antenatal only (91.4%), with moderate to severe symptoms which later subside; and antenatal and postnatal (8.6%), with severe depressive symptoms during pregnancy and postpartum, which subsided temporarily to moderate levels at three months postpartum (54). Notably, the predictors for the antenatal and postnatal trajectory included severe food insecurity, IPV and lower social support (54).

Another study by Pellowski among 831 low-income South African women used the EPDS to examine perinatal depressive trajectories with at least three depression measures from pregnancy through 18 months postpartum. The study observed five distinct trajectory patterns: moderate levels of depressive symptoms during pregnancy but minimal postpartum (3.5%), minimal levels during pregnancy and increasing postpartum (3.7%), unstable levels peaking at 12 months postpartum (6.6%), mild levels with slight decrease postpartum (82.9%), and severe levels during pregnancy and postpartum (3.1%). Membership in the chronic severe symptom group was associated with stressful life events, sexual IPV and tobacco use (55). These findings highlight the pernicious realities of living in poverty on the mental health of pregnant women in low-income countries.

Although the NIDS data did not measure experiences of IPV, the syndemic relationship between food insecurity and IPV is an emerging field of study and it has been suggested that

the two have a bidirectional relationship. In addition both are risk factors of depression during the perinatal period (19,56). The Garman study also observed that women who were only depressed during pregnancy experienced a natural remission without intervention and that this finding was consistent with other longitudinal studies (54). Both studies found that the prevalence of depression peaked during pregnancy in the second trimester and subsequently decreased postpartum (54,55). In the Pellowski study, 24.2% of the sample met criteria for probable depression in the second trimester, decreasing to 10.2% of the sample at 18 months postpartum (49). Although the natural remission of depressive symptoms for most women postpartum are somewhat encouraging, the small proportion of women who are chronically depressed may not be appropriately identified if healthcare workers do not screen them at several timepoints during their pregnancy and postpartum.

2.10 Food insecurity and depression during pregnancy

Pregnancy is a vulnerable period for women and a time of increased physiological as well as psychological need (57). Thus, women who are already food insecure may find themselves increasingly distressed when they become pregnant and subsequently develop depression or other mental disorders. Laraia and colleagues have suggested three reasons why food insecurity is particularly important during the pregnancy period: women have greater nutrient demands, preparing meals may be more challenging and pregnant women without stable employment may need to leave the workforce and experience financial stress and increased food insecurity as a result (58). The association between food insecurity and depression has been observed in both high- and low-income countries, and the distress caused by food insecurity for pregnant women as well as new mothers appears to be a universal experience (19,26,27,59)

A study by Abrahams and colleagues that examined factors associated with depression among a group of low-income South African women attending antenatal care observed that the odds of depression were greater in women who were food insecure (5.30; 1.63–17.30) and that 42% of households were classified as food insecure and 21% of pregnant women had depressive symptoms (26). These figures highlight the negative implications of food insecurity for mental health and wellbeing among vulnerable pregnant women in developing countries. Although women in LMIC are more likely to experience daily diversities like food insecurity, marginalised groups in high-income countries (i.e. recent immigrants) are also likely to suffer from food insecurity and adverse mental health (16,57,60,61). Food insecurity

is directly linked to lower SES and inequality; an important public health issue in a country like South Africa with wide disparities along racial lines and a Gini index of 0.65. In addition to measurement disparities regarding food insecurity in South Africa, there is also a paucity of longitudinal studies examining food insecurity in relation to depression; although depression and food insecurity are associated in several cross-sectional studies, evidence regarding the direction and causality of associations is unclear (24,26).

While the screening tools for antenatal depression have been well validated in LMIC, the appropriate treatment and referral for mental health services remain a challenge in low resource settings. Although the evidence regarding birthweight and linear growth in relation to maternal depression is mixed, there are well documented detrimental psychosocial consequences for children who grow up with chronically depressed mothers (62). In addition, systematic reviews have suggested that children growing up in LMIC are more adversely affected by a depressed mother than those in high-income countries. Numerous large observational studies suggest a relationship between maternal depression and various child health outcomes, although more research is needed to elucidate the causal pathways between maternal mental health and child outcomes (37,58,59).

2.11 Global prevalence estimates of stunting

The World Health Organization (WHO) growth standards are the most widely used standards across studies and geographical regions (60). In a healthy population, ~2.5% of all children have a height-for-age Z score (HAZ) HAZ <–2SD and a higher proportion of stunted children in a population is indicative of a deficient growth environment (58). LBW, a lack of stimulation, low dietary diversity, poor breastfeeding practices as well as infectious diseases in early childhood are all associated with an increased risk of stunting.

The most recent FAO report on the state of food and nutrition security in the world estimated that in 2020, one in five children (22%) under five years of age were affected by stunting. A further 6.7 % (45.4 million) were suffering from wasting and 5.7 % (38.9 million) were overweight. The true numbers, particularly for stunting and wasting, may be higher as a result of the Covid-19 pandemic and its adverse health and economic consequences (61). Furthermore, the majority of malnourished children live in Africa and Asia, which account for over 90% of all children with stunting and wasting, and over 70% of overweight children worldwide. In the past several decades there has been some progress in stunting reduction,

with a decrease from 33.1% in 2000 to 26.2 % in 2012 and further to 22.0 % in 2020 (61). Stunting, defined as having a height-for-age z score (HAZ) <–2SD. HAZ is calculated by subtracting an age- and sex-appropriate median value from a standard population and dividing by the SD of the standard population.

When discussing stunting, it is important to note that linear growth restriction is associated with (but does not actually cause) delayed child development, chronic diseases in adulthood, and reduced earning potential as children age (62). While LBW may be more amenable to preventative interventions, many longitudinal and cross-sectional studies have found that stunting is genetically-mediated, whereby short maternal stature and adverse foetal conditions predispose children to restricted growth in later life and continue the cycle of poor growth outcomes (62–64).

Differentiating the primary drivers of stunting is a complex endeavour given the numerous factors that are associated with restricted growth among children. A path analysis of four different cohorts in SSA, using 42 different indicators, found that the factors with the strongest associations with 18-month length-for-age Z score (LAZ) were length for gestational age z-score (LGAZ) at birth, maternal height and gestational age at birth (63). This is corroborated by an analysis of SGA births in LMIC which found that short maternal stature is associated with an estimated 6 million SGA births annually (64). The path analyses found other factors that showed significant associations with 18-month LAZ were child dietary diversity, improved household water source, child dietary diversity, the incidence of diarrhoea infection and 6-month or 9-month haemoglobin concentration (63). The study further noted much of the variance in linear growth status remained unaccounted for by individual level factors and a more holistic approach that improves living standards at the household and community level may be required to achieve meaningful progress (63).

Recent intervention studies in India that were able to successfully reduce stunting found improvements in healthcare, household wealth and parental education were important predictors of success (65). These social determinants of health and nutrition may be more effective for stunting reduction than purely nutrition focused programmes. Nutrition and agriculture focused interventions aimed at improving linear growth have had limited success and in many cases an improvement in linear growth will not necessarily translate into improved outcomes for children if their other needs (i.e. education and stimulation) are not met (62,65). Thus, it is important to view stunting holistically and focus on interventions that

can improve the broader social determinants of health in addition to improving nutrition and complementary feeding practices in early childhood.

2.12 Stunting prevalence in South Africa

The most recent South African child gauge (2020) found that an estimated 27% of children under five years are stunted as a result of chronic malnutrition and a generally deficient growth environment (66). The high proportion of stunting among South African children has persisted for the past twenty years, despite one of the largest social grant systems in the world, with monthly disbursements to caregivers of over 12 million children as well as a decrease in hunger (66,67). Although the child grant system may have improved access to food and reduced hunger this doesn't necessarily mean that children are consuming better quality diets or experiencing subsequent improvements in their nutritional status (68). It may appear contradictory that children living in households that have sufficient access to food are stunted or severely stunted, but hunger and access-based measures are not focused on the dietary quality or nutrition content of foods that a household consumes, an important risk factor for stunting in early childhood and overweight and obesity in later life (66). Table 2-1 includes stunting prevalence from several South African surveys beginning with the National Food Consumption Survey (NFCS) in 1999 (74) as well as the Health and Demographic Surveys (DHS) (75–77) and the South African National Health and Nutrition Examination Survey (SANHANES) (78). All surveys find a stubbornly high prevalence of stunting that has remained virtually unchanged since the 90's.

Table 2-1: Prevalence of Stunting Across South African National Surveys

Study	NFCS	DHS	DHS	DHS	SANHANES
Year	1999	2003	2008	2016	2012
Stunting %	21.6% of children aged 1-9 were stunted and 6.9% were severely stunted	27% of children aged 5 and under were stunted	18% of children aged 5 and were stunted and 10% were severely stunted	18% of children aged 5 and under were stunted and 9.4% were severely stunted	26.5% of children aged 1-9 were stunted

Numerous studies in LMIC have found that increased maternal education is associated with a reduction in stunting and improved nutritional outcomes among children. An analysis of South African children who received the child support grant (CSG) found no overall improvements in stunting but did observe a significant improvement among children with educated mothers. For children with mothers who had more than eight years of schooling,

early receipt of the CSG had a positive impact, and increased children's HAZ by 0.19 standard deviations (SDs) (69). Thus, grants may be more effective at improving stunting rates when combined with maternal education as improving children's dietary diversity requires both money as well as knowledge about nutrition These findings indicate that interventions like the CSG or other improvements in household income alone are insufficient to improve household nutritional outcomes. When combined with factors like maternal education and improved dietary diversity, such interventions may be more effective.

2.13 Global prevalence of low birthweight

LBW is defined as birthweight less than 2500 grams. Globally, one in seven babies, or 20.5 million (14.6 %) babies were born at LBW in 2015. It is estimated that 91% of babies born with LBW in 2015 were from LMIC (80). Newborns with LBW have a higher risk of dying in the first 28 days after birth; and those who do survive are at risk of stunting, cognitive deficits and are more likely to become overweight or obese and experience adult-onset conditions, including cardiovascular diseases and diabetes (71–73). An analysis of the risk of childhood undernutrition related to babies born SGA as well as preterm birth (the leading causes of LBW) noted that LBW was associated with 2.5–3.5-fold higher odds of wasting, stunting and underweight, and the population attributable risk for overall SGA for outcomes of childhood stunting and wasting was 20% and 30%, respectively (82).

However, birthweight data were not available for almost a third of children globally, and the true number of babies born at LBW in these regions may be higher than these estimates (80). The risks of LBW for early childhood mortality and morbidity as well as subsequent health problems into adulthood highlight a reduction in LBW rates as an important area for public health interventions. Unfortunately, the most recent data indicate that little progress has been made to reduce LBW since 2012. New data will become available in early 2022 and will also provide researchers and practitioners with insight into potential impacts of the pandemic on global birthweight figures..

2.14 Prevalence of low birthweight in South Africa

LMIC have the highest burden of LBW. For example, in more developed countries like Sweden and the US, the prevalence of LBW is between 2% and 8% of all live births. By contrast, the prevalence of LBW in South Africa is 15% (66). These huge disparities are primarily related to social and economic inequalities, inadequate nutrition and infections

during pregnancy as well as poor quality antenatal care. These figures are corroborated by three recent studies that examined LBW in South Africa and observed prevalence estimates of 15%, 13.5% and 14.8% respectively (84–86). In addition to an increased risk of mortality and morbidity in the first year of life, LBW is also associated with stunted linear growth among older children. The links between stunting and LBW are particularly important as stunting is an iterative process and women who are themselves stunted are more likely to give birth to LBW children. Thus, LBW and stunting continue the intergenerational transfer of poor birth and health outcomes across the life course (71).

2.15 Problem Statement

Food insecurity is a global public health problem, but pregnant women and mothers are a particularly vulnerable group for a variety of reasons. Pregnancy and childbirth place additional physiological strain on the body and increase nutritional needs (57). In addition, many women in LMIC have precarious informal work arrangements and may lose work and income as a result of pregnancy and childbirth (59). Maternal food insecurity has adverse consequences for both mothers and their children. Among mothers, food insecurity is associated with disordered eating behaviour in pregnancy, anaemia, depression and anxiety (60–63). Qualitative studies have suggested that mothers will first go hungry themselves to shield their children from food insecurity, and child hunger is generally the final manifestation of severe food insecurity in a household. As food insecurity is a managed process, mothers will also implement other coping strategies such as feeding children monotonous diets primarily consisting of starchy staples to ward off hunger (89). Nutrient poor diets are associated with stunting among children as well as overweight and obesity among children and adults, the double burden of malnutrition (DBM).

While the links between depression and food insecurity are well established in cross-sectional studies, more longitudinal research is needed to elucidate to what extent depression is caused by distress around food supply and actual hunger and to what extent a poor-quality diet causes depression. The broader social and structural determinants of depression are of increasing interest to researchers. This includes an emerging field of research that is focused on nutrition and depression outcomes. To this end, I conducted a scoping review on the existing evidence base around dietary diversity and maternal depression. I further examined food insecurity indicators and depression among periconceptional and pregnant women and aimed to better elucidate these relationships. Most of the evidence on food insecurity and

birth and early childhood outcomes is cross-sectional. In addition, few studies in LMIC contexts have examined if periconceptional maternal food insecurity has an impact on birthweight or linear growth outcomes.

2.16 Justification

South Africa has a high rate of early childhood stunting as well as a concurrent high prevalence of overweight and obesity among adults, indicating that the quality of food consumed is a problem (DBM) (45,64). However, the general household survey (GHS) conducted annually by StatsSA records most households as being food secure. This is primarily due to the use of hunger and access-based measures for food insecurity. More accurate measurement of food insecurity (that includes indicators of dietary quality) are needed to monitor and evaluate the nutritional status of South Africans, particularly vulnerable children.

The purpose of this study is to utilise longitudinal data to examine if food insecurity in the periconceptional and antenatal period is associated with birthweight and linear growth in the first five years of children's lives.

2.17 Conclusion

While this chapter has summarized the recent empirical evidence on food insecurity, maternal depression, and child health outcomes the following chapter will outline the methods used for this PhD study. This includes in depth descriptions of the two primary data sources, the measures used and the outcomes of interest. The analytical approaches for each chapter are described as well as the limitations of these approaches.

2.18 References

1. Coates J, Frongillo EA, Rogers BL, Webb P, Wilde PE, Houser R, et al. What Are We Assessing When We Measure Food Security? A Compendium and Review of Current Metrics. Adv Nutr [Internet]. 2013;4(February):481–505. Available from: http://www.elgaronline.com/view/9780857939371.xml
2. Sen A. Poverty and Famines An Essay on Entitlement and Deprivation. Poverty and Famines An Essay on Entitlement and Deprivation. Oxford University Press; 1981. 21–23 p.
3. Wang H, Naghavi M, Allen C, Barber RM, Bhutta ZA, Carter A, et al. Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet [Internet]. 2016;388(10053):1459–544. Available from: https://www.sciencedirect.com/science/article/pii/S0140673616310121
4. Webb P, Coates J, Frongillo EA, Loreg Rogers B, Swindale A, Bilinsky P. Advances in Developing Country Food Insecurity Measurement Measuring Household Food Insecurity : Why It ' s So Important and Yet So. Adv Dev Ctry Food Insecurity Meas. 2006;136(2):1404S-1408S.
5. Hendriks SL. The challenges facing empirical estimation of household food (in)security in South Africa. Dev South Afr. 2005;22(1):103–23.
6. Webb P, Coates J, Frongillo EA, Loreg Rogers B, Swindale A, Bilinsky P. Advances in Developing Country Food Insecurity Measurement Measuring Household Food Insecurity : Why It ' s So Important and Yet So. Adv Dev Ctry Food Insecurity Meas. 2006;136(2):1404S-1408S.
7. Maxwell D, Coates J, Vaitla B. How Do Different Indicators of Household Food Security Compare ? Empirical Evidence from Tigray. Somerville, MA; 2013.
8. Mohammadi-Nasrabadi F, Omidvar N, Khoshfetrat MR, Kolahdooz F. Household food insecurity in the Islamic Republic of Iran: A systematic review and meta-analysis. East Mediterr Heal J. 2014;20(11):698–706.
9. Makelarski JA, Abramsohn E, Benjamin JH, Du S, Lindau ST. Diagnostic Accuracy of Two Food Insecurity Screeners Recommended for Use in Health Care Settings. 2017;107(11):1812–7.
10. Hendriks SL, van der Merwe C, Ngidi MS, Manyamba C, Mbele M, McIntyre AM, et al. What are we measuring? Comparison of household food security indicators in the Eastern Cape Province, South Africa. Ecol Food Nutr [Internet]. 2016;55(2):141–62. Available from: http://dx.doi.org/10.1080/03670244.2015.1094063
11. Cafiero C, Melgar-Quiñonez HR, Ballard TJ, Kepple AW. Validity and reliability of food security measures. Ann N Y Acad Sci. 2014;1331(1):230–48.
12. Maxwell S. Food Security: A Post-modern Perspective. Brighton, England; 1994. Report No.: ISSN 1353-6141.
13. Measuring Food Insecurity and Hunger. National Research Council, Phase 1 Report. Washington DC: The National Academies Press; 2005.
14. Nord M. Introduction to Item Response Theory applied to Food Security Measurement: Basic Concepts , Parameters and Statistics. 2014.
15. Tadesse G, Abate GT, Zewdie T. Biases in self-reported food insecurity measurement: A list experiment approach. Food Policy [Internet]. 2020;92(May 2019):101862. Available from: https://doi.org/10.1016/j.foodpol.2020.101862
16. Kruger LM, Lourens M. Motherhood and the "Madness of Hunger": "…Want Almal Vra vir My vir 'n Stukkie Brood" ("…Because Everyone Asks Me for a Little Piece of Bread"). Cult Med Psychiatry. 2016;40(1):124–43.
17. Reesor-Oyer L, Cepni AB, Lee CY, Zhao X, Hernandez DC. Disentangling food insecurity and maternal depression: Which comes first? Public Health Nutr. 2021;24(16):5506–13.
18. Huddleston-Casas C, Charnigo R, Simmons LA. Food insecurity and maternal depression in rural, low-income families: a longitudinal investigation. Public Health Nutr. 2009 Aug;12(8):1133–40.
19. Barnett W, Pellowski J, Kuo C, Koen N, Donald KA, Zar HJ, et al. Food-insecure pregnant women in South Africa: A cross-sectional exploration of maternal depression as a mediator of violence and trauma risk factors. BMJ Open. 2019;9(3):1–11.
20. Koury AJ, Dynia J, Dore R, Logan JAR, Purtell KM, Joy E, et al. Food Insecurity and Depression among Economically Disadvantaged Mothers: Does Maternal Efficacy Matter? Appl Psychol Heal Well-Being. 2020;12(2):432–48.
21. Noonan K, Corman H, Reichman NE. Effects of maternal depression on family food insecurity. Econ Hum Biol. 2016 Sep;22:201–15.
22. Hadley C, Patil CL. Food insecurity in rural Tanzania is associated with maternal anxiety and depression. Am J Hum Biol Off J Hum Biol Counc. 2006;18(3):359–68.
23. Weaver LJ, Hadley C. Moving beyond hunger and nutrition: A systematic review of the evidence

linking food insecurity and mental health in developing countries. Ecol Food Nutr. 2009;48(4):263–84.
24. Tsai AC, Tomlinson M, Comulada WS, Rotheram-Borus MJ. Food insufficiency, depression, and the modifying role of social support: Evidence from a population-based, prospective cohort of pregnant women in peri-urban South Africa. Soc Sci Med [Internet]. 2016;151:69–77. Available from: http://dx.doi.org/10.1016/j.socscimed.2015.12.042
25. van Heyningen T, Myer L, Onah M, Tomlinson M, Field S, Honikman S, et al. Antenatal depression and adversity in urban South Africa. J Affect Disord [Internet]. 2016;203:121–9. Available from: http://dx.doi.org/10.1016/j.jad.2016.05.052
26. Abrahams Z, Lund C, Field S, Honikman S. Factors associated with household food insecurity and depression in pregnant South African women from a low socio-economic setting: a cross-sectional study. Soc Psychiatry Psychiatr Epidemiol [Internet]. 2018;0(0):0. Available from: http://www.ncbi.nlm.nih.gov/pubmed/29445850%0Ahttp://link.springer.com/10.1007/s00127-018-1497-y
27. Hromi-Fiedler A, Bermúdez-Millán A, Segura-Pérez S, Pérez-Escamilla R. Household food insecurity is associated with depressive symptoms among low-income pregnant Latinas. Matern Child Nutr. 2011 Oct;7(4):421–30.
28. Huddleston-Casas C, Charnigo R, Simmons LA. Food insecurity and maternal depression in rural, low-income families: A longitudinal investigation. Public Health Nutr. 2009 Aug;12(8):1133–40.
29. Wu Q, Harwood RL, Feng X. Family socioeconomic status and maternal depressive symptoms: Mediation through household food insecurity across five years. Soc Sci Med. 2018 Oct;215:1–6.
30. Roseboom TJ, Painter RC, Van Abeelen AFM, Veenendaal MVE, De Rooij SR. Hungry in the womb: What are the consequences? Lessons from the Dutch famine. Maturitas [Internet]. 2011;70(2):141–5. Available from: http://dx.doi.org/10.1016/j.maturitas.2011.06.017
31. Fan W, Qian Y. Long-term health and socioeconomic consequences of early-life exposure to the 1959-1961 Chinese Famine. Soc Sci Res [Internet]. 2015;49:53–69. Available from: http://dx.doi.org/10.1016/j.ssresearch.2014.07.007
32. Carmichael SL, Yang W, Herring A, Abrams B, Shaw GM. Maternal food insecurity is associated with increased risk of certain birth defects. J Nutr [Internet]. 2007;137(9):2087–92. Available from: http://www.ncbi.nlm.nih.gov/pubmed/17709447%5Cnhttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC2063452
33. Laraia BA, Siega-Riz AM, Gundersen C. Household Food Insecurity Is Associated with Self-Reported Pregravid Weight Status, Gestational Weight Gain, and Pregnancy Complications. J Am Diet Assoc [Internet]. 2010;110(5):692–701. Available from: http://dx.doi.org/10.1016/j.jada.2010.02.014
34. Laraia B, Vinikoor-Imler LC, Siega-Riz AM. Food insecurity during pregnancy leads to stress, disordered eating, and greater postpartum weight among overweight women. Obesity. 2015;23(6):1303–11.
35. Chowdhury M, Dibley MJ, Alam A, Huda TM, Raynes-Greenow C. Household Food Security and Birth Size of Infants: Analysis of the Bangladesh Demographic and Health Survey 2011. Curr Dev Nutr [Internet]. 2018;2(3):1–8. Available from: https://academic.oup.com/cdn/article/doi/10.1093/cdn/nzy003/4851100
36. Saeed A, Naqvi M, Javed A. Effects of Maternal food Insecurity on Birth Weight of Neonates: A Prospective Cohort. Ann King Edward Med Univ. 2018;23(4).
37. Zar HJ, Pellowski JA, Cohen S, Barnett W, Vanker A, Koen N, et al. Maternal health and birth outcomes in a South African birth cohort study. PLoS One. 2019;14(11):1–16.
38. Jonatan G, Hasanah N, Kusuma S, Pramesthi L, Ananada A, Ermayani E. Association Between Food Insecurity Status Towards Low Birth Weight Among 0-11 Month-Old Infants in Sambas District, West Kalimantan. Adv Sci Lett. 2018;24:6393–7.
39. Richterman A, Raymonville M, Hossain A, Millien C, Joseph JP, Jerome G, et al. Food insecurity as a risk factor for preterm birth: a prospective facility-based cohort study in rural Haiti. BMJ Glob Heal. 2020 Jul;5(7).
40. Madlala S. The dietary diversity, household food security status and presence of depression in relation to pregnancy pattern of weight gain and infant birth weight. University of KwaZulu-Natal; 2017.
41. Cois A, Day C. Obesity trends and risk factors in the South African adult population. BMC Obes. 2015;2(1):1–10.
42. Gregory CA, Coleman-Jensen A. Food insecurity, chronic disease, and health among working-age adults. 2017.
43. Irving SM, Njai RS, Siegel PZ. Food insecurity and self-reported hypertension among hispanic, black, and white adults in 12 states, behavioral risk factor surveillance system, 2009. Prev Chronic Dis. 2014;11(9):1–6.
44. Bramham K, Parnell B, Nelson-Piercy C, Seed PT, Poston L, Chappell LC. Chronic hypertension and

pregnancy outcomes: Systematic review and meta-analysis. BMJ [Internet]. 2014;348(April):1–20. Available from: http://dx.doi.org/doi:10.1136/bmj.g2301
45. Grote, N.K. Bridge, J.A. Gavin, A.R. Melville, J.L. Iyengar, S. Katon WJ. A meta-analysis of depression during pregnancy and the risk of preterm birth, low birth weight, and intrauterine growth restriction. Arch Womens Ment Health [Internet]. 2011;14(10):S26. Available from: http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L70557360%5Cnhttp://dx.doi.org/10.1007/s00737-010-0203-1
46. Ghimire U, Papabathini SS, Kawuki J, Obore N, Musa TH. Depression during pregnancy and the risk of low birth weight, preterm birth and intrauterine growth restriction- an updated meta-analysis. Early Hum Dev [Internet]. 2021;152(October 2020):105243. Available from: https://doi.org/10.1016/j.earlhumdev.2020.105243
47. Yin X, Sun N, Jiang N, Xu X, Gan Y, Zhang J, et al. Prevalence and associated factors of antenatal depression: Systematic reviews and meta-analyses. Clin Psychol Rev [Internet]. 2021;83(September 2020):101932. Available from: https://doi.org/10.1016/j.cpr.2020.101932
48. Dadi AF, Wolde HF, Baraki AG, Akalu TY. Epidemiology of antenatal depression in Africa: A systematic review and meta-analysis. BMC Pregnancy Childbirth. 2020;20(1):1–13.
49. Dewing S, Tomlinson M, Le Roux IM, Chopra M, Tsai AC. Food insecurity and its association with co-occurring postnatal depression, hazardous drinking, and suicidality among women in peri-urban South Africa. J Affect Disord [Internet]. 2013;150(2):460–5. Available from: http://dx.doi.org/10.1016/j.jad.2013.04.040
50. Lund C, Schneider M, Garman EC, Davies T, Munodawafa M, Honikman S, et al. Task-sharing of psychological treatment for antenatal depression in Khayelitsha, South Africa: Effects on antenatal and postnatal outcomes in an individual randomised controlled trial. Behav Res Ther [Internet]. 2020;130(September 2019):103466. Available from: https://doi.org/10.1016/j.brat.2019.103466
51. Manikkam L, Burns JK. Antenatal depression and its risk factors: An urban prevalence study in KwaZulu-Natal. South African Med J. 2012;102(12):940–4.
52. Tsai AC, Tomlinson M, Dewing S, Ingrid M, Harwood JM, Chopra M, et al. Antenatal depression case-finding by community health workers in South Africa : feasibility of a mobile phone application. Arch Womens Ment Health. 2015;17(5):423–31.
53. Redinger S, Norris SA, Pearson RM, Richter L, Rochat T. First trimester antenatal depression and anxiety: Prevalence and associated factors in an urban population in Soweto, South Africa. J Dev Orig Health Dis. 2018;9(1):30–40.
54. Garman EC, Schneider M, Lund C. Perinatal depressive symptoms among low-income South African women at risk of depression: Trajectories and predictors. BMC Pregnancy Childbirth. 2019;19(1):1–11.
55. Pellowski JA, Bengtson AM, Barnett W, DiClemente K, Koen N, Zar HJ, et al. Perinatal depression among mothers in a South African birth cohort study: Trajectories from pregnancy to 18 months postpartum. J Affect Disord [Internet]. 2019;259(January):279–87. Available from: https://doi.org/10.1016/j.jad.2019.08.052
56. Laurenzi C, Field S, Honikman S. Food Insecurity, Maternal Mental Health, and Domestic Violence: A Call for a Syndemic Approach to Research and Interventions. Matern Child Health J. 2020 Apr;24(4):401–4.
57. Ivers LC, Cullen K a. Food insecurity : special considerations for women 1 – 4. Am J Clin Nutr. 2011;94:1740–4.
58. Laraia BA, Siega-Riz AM, Gundersen C, Dole N. Psychosocial factors and socioeconomic indicators are associated with household food insecurity among pregnant women. J Nutr [Internet]. 2006;136(1):177–82. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16365079
59. Barker ED, Kirkham N, Ng J, Jensen SKG. Prenatal maternal depression symptoms and nutrition, and child cognitive function. Br J Psychiatry. 2013;203(6):417–21.
60. Kersey M, Geppert J, Cutts DB. Hunger in young children of Mexican immigrant families. Public Health Nutr. 2007 Apr;10(4):390–5.
61. Tang MN, Ettinger de Cuba S, Coleman SM, Heeren T, Sandel M, Chilton M, et al. Maternal Place of Birth, Socioeconomic Characteristics, and Child Health in US-Born Latinx Children in Boston. Acad Pediatr. 2020 Mar;20(2):225–33.
62. Herba CM, Glover V, Ramchandani PG, Rondon MB. Maternal depression and mental health in early childhood: an examination of underlying mechanisms in low-income and middle-income countries. The Lancet Psychiatry [Internet]. 2016;3(10):983–92. Available from: http://dx.doi.org/10.1016/S2215-0366(16)30148-1
63. Herba CM, Glover V, Ramchandani PG, Rondon MB. Maternal depression and mental health in early childhood: an examination of underlying mechanisms in low-income and middle-income countries. The lancet Psychiatry. 2016 Oct;3(10):983–92.

64. Buffa G, Dahan S, Sinclair I, St-Pierre M, Roofigari N, Mutran D, et al. Prenatal stress and child development: A scoping review of research in low- and middle-income countries. PLoS One. 2018;13(12):1–24.
65. WHO. WHO Child Growth Standards. Vol. 7, World Health Organization. Geneva; 2008.
66. FAO. The State of Food Security and Nutrition in the World. Transforming food systems for food security, improved nutrition and affordable healthy diets for all [Internet]. Rome; 2021. Available from: https://doi.org/10.4060/ca9692en
67. Leroy JL, Frongillo EA. Perspective: What Does Stunting Really Mean? A Critical Review of the Evidence. Adv Nutr. 2019;10(2):196–204.
68. Prado EL, Yakes Jimenez E, Vosti S, Stewart R, Stewart CP, Somé J, et al. Path analyses of risk factors for linear growth faltering in four prospective cohorts of young children in Ghana, Malawi and Burkina Faso. BMJ Glob Heal [Internet]. 2019;4(1). Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85061779800&doi=10.1136%2Fbmjgh-2018-001155&partnerID=40&md5=0b3665ef638cfabb8ec5b442e84d7f29
69. Kozuki N, Katz J, Lee ACC, Vogel JP, Silveira MF, Sania A, et al. Short Maternal Stature Increases Risk of Small- for-Gestational-Age and Preterm Births in Low- and Middle-Income Countries : Individual Participant Data Meta-Analysis and Population Attributable Fraction. J Nutr. 2015;145:2452–2450.
70. Heidkamp RA, Piwoz E, Gillespie S, Keats EC, Alimonte MRD, Menon P, et al. Series Maternal and Child Undernutrition Progress 2 Mobilising evidence , data , and resources to achieve global maternal and child undernutrition targets and the Sustainable Development Goals : an agenda for action. Lancet [Internet]. 2021;6736(21):1–19. Available from: http://dx.doi.org/10.1016/S0140-6736(21)00568-7
71. May J, Witten C, Lake L. South African Child Gauge 2020: Food and nutrition security. Cape Town; 2020.
72. Hunter W, Patel L, Sugiyama NB. How family and child cash transfers can empower women: Comparative lessons from Brazil and South Africa. Glob Soc Policy. 2021;21(2):258–77.
73. Devereux S, Waidler J. Why does malnutrition persist in South Africa despite social grants? Food Security SA Working Paper Series No. 001. 2017.
74. Labadarios D, Steyn N, Maunder E, MacIntryre U, Gericke G, Swart R, et al. The National Food Consumption Survey (NFCS): South Africa, 1999. Public Health Nutr. 2005;8(5):533–43.
75. National Department of Health Republic of South Africa. South Africa Demographic and Health Survey. 1998.
76. National Department of Health Republic of South Africa. South Africa Demographic and Health Survey 2003. 2003.
77. National Department of Health Republic of South Africa. South Africa Demographic and Health Survey 2016. 2016.
78. Shisana o, Labadarios D, Rehle T, Simbayi L, Zuma K, Dhansay A, Reddy P, Parker W, Hoosain E, Naidoo P, Hogoro C, Mchiza Z, Steyn NP, Dwane N, Makoae M, Maluleke T, Ramlagan S, zungu N, Evans MG, Jacobs L FM& S-1 T. The South African National health and Nutrition Examination Survey SANHANES-1. Cape Town; 2013.
79. DSD, SASSA, UNICEF. The South African Child Support Grant Impact Assessment: Evidence form a survey of children [Internet]. 2012. Available from: https://www.unicef.org/evaldatabase/files/The_South_African_Child_Support_Grant_Impact_Assessment.pdf
80. Blencowe H, Krasevec J, de Onis M, Black RE, An X, Stevens GA, et al. National, regional, and worldwide estimates of low birthweight in 2015, with trends from 2000: a systematic analysis. Lancet Glob Heal [Internet]. 2019;7(7):e849–60. Available from: http://dx.doi.org/10.1016/S2214-109X(18)30565-5
81. UNICEF. Low birthweight prevalence, by country and region, 2015 [Internet]. 2019. Available from: https://data.unicef.org/topic/nutrition/low-birthweight/
82. Christian P, Lee SE, Angel MD, Adair LS, Arifeen SE, Ashorn P, et al. Risk of childhood undernutrition related to small-for-gestational age and preterm birth in low- and middle-income countries. Int J Epidemiol. 2013;42(5):1340–55.
83. Madzorera I, Ghosh S, Wang M, Fawzi W, Isanaka S, Hertzmark E, et al. Prenatal dietary diversity may influence underweight in infants in a Ugandan birth-cohort. Matern Child Nutr. 2021 Jul;17(3):e13127.
84. Budree S, Stein DJ, Brittain K, Goddard E, Koen N, Barnett W, et al. Maternal and infant factors had a significant impact on birthweight and longitudinal growth in a South African birth cohort. Acta Paediatr Int J Paediatr. 2017;106(11):1793–801.
85. Jeena PM, Asharam K, Mitku AA, Naidoo P, Naidoo RN. Maternal demographic and antenatal factors, low birth weight and preterm birth: findings from the mother and child in the environment (MACE)

birth cohort, Durban, South Africa. BMC Pregnancy Childbirth. 2020;20(1):1–11.
86. Tomita A, Labys CA, Burns JK. Depressive Symptoms Prior to Pregnancy and Infant Low Birth Weight in South Africa. Matern Child Health J. 2015;19(10):2179–86.
87. Laraia B, Vinikoor-Imler LC, Siega-Riz AM. Food insecurity during pregnancy leads to stress, disordered eating, and greater postpartum weight among overweight women. Obesity [Internet]. 2015 Jun;23(6):1303–11. Available from: http://0-search.ebscohost.com.innopac.wits.ac.za/login.aspx?direct=true&db=psyh&AN=2015-24029-024&site=ehost-live&scope=site
88. Sparling TM, Waid JL, Wendt AS, Gabrysch S. Depression among women of reproductive age in rural Bangladesh is linked to food security, diets and nutrition. Public Health Nutr. 2020 Mar;23(4):660–73.
89. Radimer KL, Olson CM, Greene JC, Campbell CC, Habicht J-P. Understanding hunger and developing indicators to assess it in women and children. J Nutr Educ [Internet]. 1992;24(1, Supplement 1):36S-44S. Available from: https://www.sciencedirect.com/science/article/pii/S0022318212801373

Chapter 3 RESEARCH APPROACH

3.1 Methods

To pursue the specific objectives for this doctoral research, secondary analysis was conducted on data from the NIDS) Wave 1 conducted in 2008 and Wave 3 conducted in 2012. NIDS data were used for Chapter 2–4 while data from MomsConnect was used for the Chapter 5. Chapter 1 consists of a scoping review of existing literature on maternal depression and dietary diversity. This chapter illustrates the methods used for the study objectives and their subsequent research outputs and provides details of methodological and analytical approaches. The analyses employed in each of the study papers will be described in detail in this chapter as well as within the five articles that have been the result of this work, two of which have been accepted for publication. This chapter describes the primary data, the measures and indicators used in the various results chapters and then goes on to discuss the analytical approach of each chapter. The limitations of measures and indicators, as well as the limitations of analytical approaches for each results chapter are also discussed.

This study generated three articles arising from NIDS data wave 1 (2008) and Wave 3 (2012). The measure article (Chapter 5) utilised cross-sectional data from Wave 1 (2008) to examine various food insecurity indicators and two different measures in relation to adult and child anthropometry. The two articles on maternal depression and food insecurity in relation to early childhood outcomes, as well as the article that examined periconceptional and antenatal food insecurity in relation to stunting and LBW used data from both wave 1 and wave 3. Data on household hunger (both child and adult hunger in the past year) were only collected in wave 1 of NIDS (2008). In addition, although dietary diversity appeared in subsequent waves of NIDS, only Wave 1 of NIDS had sufficient data on dietary diversity to enable analysis of dietary diversity in relation to adult and child anthropometry. These data limitations only became apparent during the course of the PhD analysis. I had initially intended to work with Wave 1 and Wave 2 of the NIDS study and use the child data collected in Wave 2. However, I ended up working with Wave 1 and Wave 3 for several reasons; the data quality in Wave 2 was quite poor and many of the children born to mothers between Wave 1 and Wave 2 were missing data on birthweight and height-for-age. In addition, many of the children who did not have data missing in Wave 2 were very young at the time of data collection (infants of less than a year). Given that stunting was one of the primary outcomes

of the study, and this usually peaks at around 24 months, I decided to work with maternal data from Wave 1 (2008) and child data from Wave 3, which was collected in 2012.

3.2 The Primary Study

The NIDS is the first national panel study to document a sample of representative households and household members in South Africa. The aims of the study are to document changes in income, expenditures, assets, access to services, education, health and other factors. NIDS is unique in its ability to continue to follow study participants as they move out of their original households. This enables study investigators to track the movement of household members as they leave and/or return to the household or begin their own households. This information is recorded in subsequent waves of the study. The first 'baseline' wave of NIDS was conducted by the Southern Africa Labour and Development Research Unit (SALDRU) based at the University of Cape Town's School of Economics in 2008 (1). The most recent wave of data collection (wave 5) took place in 2017. In 2020, a sub-sample of wave 5 households were interviewed telephonically to explore the impact of the Coronavirus pandemic on livelihoods, household food security and unemployment and these data form the basis of the NIDS-CRAM reports.

Sampling Frame

Households included in the first wave (2008) were selected using a stratified, two-stage cluster sample design. In the first stage, 400 Primary Sampling Units (PSUs)2 were selected from Stats SA's 2003 Master Sample of 3000 PSUs. This was the same sample that Stats SA employed for its Labour Force Surveys and GHSs between 2004 and 2007. However, to ensure that households did not have to take part in two surveys, NIDS drew a non-overlapping sample from each PSU. The target population for NIDS was private households across the nine provinces of South Africa and residents in workers' hostels, convents and monasteries. Those residing in other collective living quarters, such as students' hostels, old age homes, hospitals, prisons and military barracks were excluded from participation (1).

Representativeness and Generalisability

The original NIDS survey aimed to be as representative as possible of the South African population. However, the fieldworkers in Wave 1 struggled to recruit White and Asian households in formal urban areas. Non response rates were particularly low among white households (64% non-response rates for for Whites versus 24% non-response rates for Black Africans). As such, the NIDS team initiated a second phase of fieldwork (Phase 2) with the explicit aim of recruiting additional White, Asian and Coloured households. This was in line with representativeness. This phase managed to recruit an additional 807 households (43% response rate) for the survey. Given that the focus of this PhD study was food insecurity and the majority of South African Indian and Whites tend to be more affluent and less likely to experience food insecurity (compared to Black African or Coloured Households) this may have underestimated the true prevalence of food insecurity and related health outcomes among the sample, particularly when comparing rates of stunting across racial categories.

3.3 Secondary analysis

3.3.1 Generating the cross-sectional dataset for measure article (Chapter 5)

Anonymised response data for individual questionnaires (both adult and child) as well as anonymised household data were downloaded from the NIDS website. All files were in Stata format and were merged by household ID (HID) or, when combining responses to questionnaires, by personal ID (PID). The responses to household questionnaires were merged by HID with the household derived file and the household roster to generate a dataset that contained all of the household information as well as information and participating ID numbers (PIDs) for all the individuals who resided in the household. The anonymised responses of adults aged 18 and over were then merged by PID with the individual derived file (which included anthropometry information). The questionnaires for children aged 17 and under were answered on behalf of the child by their mother or another head of household who was able to answer on their behalf. These questionnaires were then merged with the individual derived file to obtain anthropometry information. Adult and child files were subsequently merged to the completed household questionnaire file by merging 1:1 on HID to capture individual as well as household information in a single dataset.

3.3.2 Generating the longitudinal dataset for articles focused on maternal exposures and child outcomes (Chapter 6 & Chapter 7)

The household questionnaire and household derived file from Wave 1 were merged with the household roster to generate a cross-sectional dataset of household characteristics. The questionnaires of women who became pregnant between Wave 1 and wave 2 (infants born between 2008 and 2011) were merged 1:1 to their household by HID. Infants who were already born during data collection in wave 1 (2008) were excluded from the analysis as we were interested in periconceptional and antenatal exposures. Child questionnaires from wave 3 (2012) were merged with child derived files to obtain anthropometry and birthweight information. These files were merged 1:1 by maternal ID number (PID). Mother infant pairs that were missing both birthweight and HAZ information were excluded from the analysis but mother infant pairs that included one of the outcomes of interest (either birthweight or HAZ) remained in the analyses. Analyses of children's outcomes (HAZ scores and birthweight) were clustered at the level of maternal ID number (PID) to account for multiple births and mothers who gave birth more than once during the reference period (2008–2011).

3.4 Outcomes

Stunting

Height-for-age information was included in the child derived file of the NIDS metadata and this data was merged to the child questionnaire. Children were classified as stunted (height-for-age ≤2SD) and severely stunted (height-for-age ≤3SD) using the WHO child growth standards (16). Chapter 5 (measure article), Chapter 6 (depression and growth article) and Chapter 7 (food insecurity and growth article) all examined stunting as an outcome, but there were differences in how the outcome was classified. Chapter 5 combined stunted and severely stunted children into a single category, with children of normal height as the reference category, Chapter 7 kept stunted and severely stunted children separate, with children of normal height as the reference category. Chapter 6 was focused on depression and child growth and examined the mean differences in children's height across different maternal categories, and thus examined this outcome as a continuous variable.

Child weight-for height-scores

Chapter 4 also included children's weight-for-height information. Children's weight-for-length (WHZFA) information was included in the child derived file of the NIDS metadata and these data were merged to the child questionnaire. Children were classified as normal

weight (weight-for-length >-1 & weight-for length<2) and overweight or obese (weight-for-length >2) or wasted (weight-for-length ≤ -2SD) using the WHO child growth standards (2).

Adult BMI

Adult BMI information for both males and females was used in Chapter 2 while maternal BMI information was included in Chapter 3 and Chapter 4. Adult BMI information was included in the adult derived file of the NIDS metadata and these data were merged to the adult questionnaire. Adult BMI measurements were also classified according to the WHO growth standards and categorised as underweight (BMI<18.5), normal weight (BMI>18.5 & BMI<24.9), overweight (BMI>25) and obese (BMI>29.9), with normal weight used as the reference standard (2).

Low Birthweight

Birthweight information was obtained from the child's Road to Health Card (RTHC), this is a free booklet provided to all women who give birth at a health facility in South Africa. The RTHC records birthweight, children's length at birth and also keeps track of children's linear growth and vaccination status. LBW was the primary outcome of Article 4 and we used a binary measure of LBW (≤2500g). It is common practice for birth attendants to record birthweight at 2500 grams and thus avoid extra interventions required if the baby is classified as LBW. We therefore included babies that were classified as 2500 grams on the RTHC. Chapter 3 also examined birthweight but we examined the mean differences in birthweight across different maternal categories and thus examined this outcome as a continuous variable.

3.5 Measures

Household dietary diversity

The head of the household or the woman in charge of purchasing and preparing food was questioned about household dietary diversity in the past 30 days. Food was divided into 12 separate groups using the FAO tables. Foods were grouped into the following 12 categories: 1. Cereals and Grain Products; 2. Starchy Roots, Tubers, and Fruits; 3. Grain Legumes and Legume products; 4. Vegetables and Vegetable Products; 5. Fruits and Nuts; 6. Sugars and Syrups; 7. Meats, Poultry, and Insects; 8. Eggs; 9. Fish and Shellfish; 10. Milk and Milk Products; 11. Oils and Fats; 12. Miscellaneous (including beverages).

Although there is no pre-defined cut-off to define low dietary diversity, one method that has been used in food security literature is to define the mean score as food secure and households who consume fewer food groups than the mean as food insecure (3). For wave 1, the mean household dietary diversity in the past 30 days was nine out of 12 food groups. Thus, households that consumed eight or less food groups out of the 12 possible food groups were classified as having low dietary diversity. We analysed household dietary diversity as both a binary and continuous measure depending on the outcome in question.

In Chapter 4 we divided household dietary diversity into three categories (low, medium and high) per the comments of a reviewer on the first draft of the paper. The following scores were used for the various categories: Dietary diversity scores (DDS) was summed up by counting each of the 12 food groups, and classified as low (≤4), medium (5–8) and high (9–12) with high dietary diversity being the reference standard.

Household food expenditure

Household food expenditure was generated as a proportion of total household expenditure using the food expenditure and total household expenditure variable, which were pre-imputed by the NIDS team. We used the FAO recommended cut-off for food security of household food expenditure, >60% of total monthly expenditure, to classify households as food insecure (2). Households were asked generally what they spent each month on various items including food. The cut-off of 60% is per the FAO recommendation. Every section of the questionnaire was piloted by the end of July 2007. Subject area experts participated in some of these pilots (3).

Household hunger

Adult and child hunger in the past 12 month were reported by the respondent with the question, 'In the past twelve months did an adult in the household go hungry? (never, seldom, sometimes, often or always). These questions were adapted from the Household Food Insecurity Access Scale (HFIAS) (1). To create a binary indicator for both adult and child hunger we classified respondents who reported 'never or seldom' as having a score of 0, while households who reported hunger sometimes, often or always received a score of 1. We examined hunger as a binary indicator in Chapter 4 and Chapter 6. However, in Chapter 7 we kept both adult and child hunger as a categorical variable to examine if a higher frequency of hunger was associated with LBW or stunting.

Household food sufficiency

Household food sufficiency in the past 12 months was reported by the respondents with the question, 'In the past twelve months was the food in your household sufficient to meet your needs? (more than enough or just enough versus not sufficient for household needs). To create a binary indicator for food sufficiency we classified respondents who reported 'more than enough or just enough' as having a score of 0, while households who reported that the food was not sufficient received a score of 1. We examined food sufficiency as a binary indicator in Chapter 4 and Chapter 6. Food sufficiency was also kept as a categorical variable in Chapter 7.

Statistics South Africa food poverty line

Chapter 7 also examined household food poverty line in relation to birthweight and stunting among children. This variable was generated by dividing total monthly household food expenditure by the number of household members. The monthly per capita food poverty line at the time of data collection in 2008 was equivalent to R274 (USD 36.24).

Maternal Depression

The NIDS study collected depression data on adult respondents using the Center for Epidemiologic Studies Depression Scale Revised (CESD-10) (4). Study participants were asked how often they had experienced symptoms associated with depression over the past week: '0' being 'rarely or none of the time (\1 day)' and '3' being 'almost or all of the time (5–7 days)'. Previous studies that examined depression in South Africa used a total of 10 as a cut-off for a positive screen for significant depressive symptoms. However, the CESD-10 had not been previously validated in South Africa and a validation study by Baron et al. recommended cut-offs between 11 and 13 depending on the first language of study respondents (5). We used a cut-off of 12 in the articles that examined depression as most of our respondents were Xhosa speaking women. This reduced the prevalence of depression by about 10% in our respondents than a cut-off of 10 and explains why our studies had a lower depression prevalence than a previous article by Tomita and colleagues (6).

The multidimensional food security measure

Chapter 6 used this measure to examine food insecurity and maternal depression. A composite food security measure with a score between 0 and 6 was constructed to describe the severity of food insecurity utilising a methodology of multidimensional poverty measurement. This adapted composite measure of food security includes three separate domains (anxiety about food supply, food quality and food utilisation). Individual indicators included binary variables for adult and child hunger, household food sufficiency, dietary diversity, proportion of household expenditure on food and maternal underweight BMI (7). Each indicator was assigned a value of 0 or 1, with the final score being a minimum of 0 (food secure) and a maximum of 6 (severely food insecure). The final score was examined as a continuous and binary (domain insecure) variable.

3.6 Limitations of the measures and indicators

Household dietary diversity had a recall period of 30 days and this may have caused household to appear to have more diverse diets as the dietary diversity tool does not ask about the frequency of food consumption but simply whether a food was consumed at all by the household in the past 30 days. Thus, a household that had eaten red meat once in the past month would have scored the same as a household that had eaten red meat daily.

Household food expenditure can be difficult to collect and may be subject to recall bias. In addition, the expenditure data did not include data on the amount spent on specific food groups which would have enabled more detailed analyses of food group consumption in relation to stunting and other outcomes.

The Centre for Epidemiological Studies Depression Scale – Revised (CESD-R) is intended for use in the general population among both men and women and is not specifically aimed at mothers or pregnant women. Tools like the EPDS that are specifically focused on the mental states of pregnant or postpartum women tend to report a higher prevalence of depression than more general use scales (8). Chapter 3 and 4 include both pregnant and postnatal women but the causes and consequences of maternal depression may differ across stages. In addition, depression trajectories can vary considerably across the antenatal period, and research of depression trajectories among pregnant and postnatal women in South Africa has found that maternal depression during pregnancy often resolves naturally by the third trimester without intervention, but Chapter 3 and 4 only included a single measure of depression as this data is only collected once at each study wave (9).

BMI and stunting categories are somewhat arbitrary as nothing changes immediately above or below the cut-off thresholds. In addition, countries like South Africa, with a high rate of stunting among children, are likely to underestimate the true magnitude of stunting given that the entire distribution is shifted to the left. However, these categories are useful in that they are more easily understood in the context of policy and public health messaging.

I had initially intended to use the weighted data throughout my chapters and I did use the panel weights in initial chapters but as the study progressed I did not use weights in later chapters. The purpose of the weighting was to make the NIDS sample more representative of the South African population (ie. there were very few White or Indian respondents). Given that these groups are more affluent in South Africa and less likely to experience food insecurity I opted not to use the panel weights in later chapters as these underestimated both the prevalence of food insecurity and low birthweight.

Table 3-1 Synthesis table of analytical approach for Chapters 4-8

Chapter Title	Sample & Primary Data	Analytical Approach	Limitations
Chapter 4: Maternal Depression and Dietary Diversity: A Scoping Review	We screened a total of 813 records for studies that met our inclusion criteria. A total of 11 articles from 13 different studies met our inclusion criteria:	This was a scoping review using the Johanna Briggs Institute (JBI) Methodology. A search of the following databases was conducted: Pubmed, Psychinfo, Scopus and a database on nutrition and mental health produced by the Agriculture, Nutrition and Health (ANH) Academy, a global community of interdisciplinary researchers, practitioners, and policymakers working on agriculture and food systems. Our keywords were 'maternal' 'dietary diversity' and 'depression' and 'depressive symptoms'. The first and second author (AH and SM) reviewed abstracts together to ensure that they met the inclusion criteria.	The heterogeneity of studies did not enable a more systematic review or a meta-analysis of the outcome of interest. Given the diverse studies and findings, I was unable to draw any firm conclusions about the relationship between dietary diversity and maternal depression, but the relationship between dietary diversity and child growth and developmental outcomes was more consistent across studies.
Chapter 5: Dietary diversity, food insecurity and the double burden of malnutrition among children, adolescents and adults in South Africa: Findings from a national survey	This study used cross-section data from Wave 1 of NIDS (2008) to examine anthropometry outcomes in relation to various food security indicators. Height for age scores were available for 8 777 children across 3 831 household clusters. BMI scores were available for 7 385	Logistic regression models were used to examine child anthropometry in relation to food security measures and indicators. Multinomial regression models were used to examine adult BMI in relation to food security measures and indicators. Analyses were clustered at the household level on the assumption that children in the same household had similar access to food. The study also examined the prevalence of	While the analysis approach was appropriate for the objectives described here, more nuanced analyses are required of the food security dynamics in double burden households. This is because, while low dietary diversity is associated with stunting among children, higher dietary diversity is associated with

Chapter Title	Sample & Primary Data	Analytical Approach	Limitations
	children across 3 559 household clusters. Anthropometry measurements were available for 12 199 adults aged 18 and above across 6 483 household clusters.	double burden households whereby stunted children live in the same household as overweight or obese adults.	overweight and obesity among adults. Thus, these two different associations can exist within the same household and this limits analyses approaches for double burden households.
Chapter 6: Examining maternal depression, birthweight and linear growth: Findings from the South African National Income Dynamics Study	The study examined 1 431 children in relation to maternal exposures of food insecurity and depression among 1 208 women who gave birth between Wave 1 and Wave 2 of NIDS (2008-2011). During data collection in Wave 1, most women (78%) were pre-conception and 22% were pregnant.	A retrospective cohort methodology was used. Generalized Linear Mixed (GLM) effects models were used to account for clustering due to multiple births or mothers who gave birth more than once during the reference period. GLM effects model with a logit link function was used to explore food security indicators, household stressors and maternal characteristics associated with depression. In the second part of the analyses that focused on child health outcomes, Generalized Linear Mixed Effects Model with a Gaussian link function was used to compare differences in mean birthweight and height-for-age scores (HAZ) among children.	There was a very low number of women who were both depressed and food insecure (N=69) and this low sample size may have limited inferences about the extent to which depression and food insecurity impact birth outcomes. The analysis approach was suitable for the outcomes in questions (birthweight and height-for-age scores) and the examination of means instead of categorical variables may have presented a more nuanced picture of the outcomes in relation to the exposure.
Chapter 7: Household Food Insecurity and Demographic Factors, Low Birth Weight and Stunting in Early Childhood: Findings from a Longitudinal Study in South Africa	The study examined birthweight data for 1173 children and height for age data for 1216 children among 1 232 women who gave birth between Wave 1 and Wave 2 of NIDS (2008-2011).	A retrospective cohort methodology was used. Logistic regression modelling was used to examine the relationship between LBW or stunting and maternal risk factors. The standard errors in the logistic regression models were estimated using the clustered robust method to account for the clustering due to multiple births. Initial bivariate analyses were conducted to explore covariates associated with LBW, stunting and severe stunting. Exposures with a strength of association of $p<=0.05$ were then selected. These variables were added to the model one at a time, with those showing the strongest association added first. We used multiple logistic regression for the final LBW model as the outcome was binary, and multivariable regression for the final stunting model in children aged 0–60 months as there were three outcomes (normal height, stunted and	The primary limitation is the time that elapsed between the exposures recorded in Wave 1 and the child health outcomes from Wave 3. Another limitation of multivariable regression models for child health outcomes, such as LBW or stunting is potential collinearity and distinguishing the associations between maternal characteristics and outcomes. For example, overweight and obese women are more likely to give birth to a baby with very high birthweight (macrosomia) over 4500 g, but overweight and obese women are also more likely to have hypertension, a risk factor for LBW in this study. Data on gestational age were also not available in the dataset and this would have been an

Chapter Title	Sample & Primary Data	Analytical Approach	Limitations
		severely stunted). Post-stratification weights adjusted for age, sex and race were used for cross-sectional data. All analyses were conducted using Stata (version 15). BMI data were missing for 14% of women. Multiple imputation was used to impute these scores based on the available BMI data.	important risk factor for LBW in the case of preterm birth
Chapter 8*: "Giving My Baby The Life She Deserves":* Hunger and Maternal Depressive Symptoms Amongst South African Women	The primary data came from a mobile survey conducted among MomConnect participants. This SMS survey recruited pregnant women and mothers with babies younger than 12 months using the MomConnect platform, a South African National Department of Health. The final sample included 3140 women for the first batch of questions. The same sample of 3140 women received an invitation to a follow-up survey two weeks later. The second survey had 2287 respondents. The attrition rate between the two surveys was thus 27%.	We used univariate and bivariate analysis (logistic regressions), employing a 5% significance level as a cut-off for statistical significance. We applied a mixed effects logistic regression model to examine factors associated with child hunger clustered at maternal ID level.	The SMS format of the study limited the depth of questions and responses for the survey. There were significantly fewer women from the Eastern Cape who participated in the study as well as fewer women with babies in the 0–3 month category. The low number of women from the Eastern Cape who participated in the study may have meant that the poorest women (and those from rural and underserved areas) were not sufficiently represented in the study findings. There is also the possibility of selection bias, whereby the most depressed women may have been too distressed or apathetic to participate in the survey, or that survey respondents were biased by characteristics that were not observable in the data available.

3.7 Conclusion

This chapter has summarized the primary study data and presented an overview of the various analytical approaches employed for each results chapter. The results chapters provide additional detail regarding the methods for each study. The following chapter is a scoping review that broadly examines the evidence base around dietary diversity and maternal depression.

3.8 References

1. Leibbrandt M, Woolard I, De Villiers L. Methodology: Report on NIDS Wave 1 [Internet]; 2009 [cited 2022 Aug 24]. Available from: http://www.nids.uct.ac.za/publications/technical-papers/108-nids-technical-paper-no1/file
2. World Health Organization & United Nations Children's Fund. WHO Child Growth Standards [Internet]. World Health Organization & United Nations Children's Fund. Geneva; 2009 [cited 2022

Aug 24]. Available from: https://apps.who.int/iris/bitstream/handle/10665/44129/9789241598163_eng.pdfWHO Child Growth Standards. Vol. 7, World Health Organization. Geneva; 2008.

3. Webb P, Coates J, Frongillo EA, Loreg Rogers B, Swindale A, Bilinsky P. Measuring household food insecurity: Why it's so important and yet so difficult to do. J Nutr [Internet]. 2006 [cited 2022 Aug 24];136(5):1404S-8S. DOI:10.1093/jn/136.5.1404S

4. Center for Epidemiologic Studies Depression Scale Revised (CESD-R- 10) [Internet]; 2008 [cited 2022 Aug 24]. p. 0–2. Available from: https://www.brandeis.edu/roybal/docs/CESD-10_website_PDF.pdf

5. Baron EC, Davies T, Lund C. Validation of the 10-item Centre for Epidemiological Studies Depression Scale (CES-D-10) in Zulu, Xhosa and Afrikaans populations in South Africa. BMC Psychiatry [Internet]. 2017 [cited 2022 Aug 24];17(6). Available from: https://doi.org/10.1186/s12888-016-1178-x

6. Tomita A, Labys CA, Burns JK. Depressive symptoms prior to pregnancy and infant low birth weight in South Africa. Matern Child Health J [Internet]. 2015 [cited 2022 Aug 24];19(10):2179-86. DOI: 10.1007/s10995-015-1732-z

7. Ryan J, Leibbrandt M. Multidimensional food insecurity measurement. Southern Africa Labour and Development Research Unit (SALDRU) Working Paper No. 160 [Internet]; 2015 [cited 2022 Aug 25]. Available from: http://hdl.handle.net/11090/793

8. Ali GC, Ryan G, De Silva MJ. Validated screening tools for common mental disorders in low and middle income countries: A systematic review. PLoS One [Internet]. 2016 [cited 2022 Aug 25];11(6):e0156939. Available from: https://doi.org/10.1371/journal.pone.0156939

9. Garman EC, Schneider M, Lund C. Perinatal depressive symptoms among low-income South African women at risk of depression: Trajectories and predictors. BMC Pregnancy Childbirth [Internet]. 2019 [cited 2022 Aug 25];19(202). Available from: https://doi.org/10.1186/s12884-019-2355-y

10. Miller LC, Neupane S, Sparling TM, Shrestha M, Joshi N, Lohani M, et al. Maternal depression is associated with less dietary diversity among rural Nepali children. Matern Child Nutr [Internet]. 2021 Oct [cited 2022 Aug 25];17(4):e13221. DOI:10.1111/mcn.13221

11. Sparling TM, Waid JL, Wendt AS, Gabrysch S. Depression among women of reproductive age in rural Bangladesh is linked to food security, diets and nutrition. Public Health Nutr [Internet]. 2020 Mar [cited 2022 Aug 25];23(4):660-73. DOI:10.1017/S1368980019003495

12. Emerson JA, Caulfield LE, Musafiri Kishimata E, Nzanzu J-P, Doocy S. Maternal mental health symptoms are positively associated with child dietary diversity and meal frequency but not nutritional status in Eastern Democratic Republic of Congo. Public Health Nutr [Internet]. 2020 Jul [cited 2022 Aug 25];23(10):1810-9. DOI:10.1017/s1368980019004087

13. Emerson JA, Caulfield LE, Kishimata EM, Nzanzu J-P, Doocy S. Mental health symptoms and their relations with dietary diversity and nutritional status among mothers of young children in eastern Democratic Republic of the Congo. BMC Public Health [Internet]. 2020 Feb [cited 2022 Aug 25];20(225). Available from: https://doi.org/10.1186/s12889-019-8092-3

14. Jiang W, Mo M, Li M, Wang S, Muyiduli X, Shao B, et al. The relationship of dietary diversity score with depression and anxiety among prenatal and post-partum women. J Obstet Gynaecol Res [Internet]. 2018 Oct;44(10):1929-36. DOI: 10.1111/jog.13728

15. Adhikari RP, Williamson R, Sparling TM, Ferguson E, Cunningham K. Parental depression and nutrition: findings from a cross-sectional household survey in Nepal. Public Health Nutr [Internet]. 2020 Nov;23(16):2983-93. DOI: 10.1017/S1368980020000968

16. Wemakor A, Iddrisu H. Maternal depression does not affect complementary feeding indicators or stunting status of young children (6–23 months) in Northern Ghana. BMC Res Notes[Internet]. 2018 Jun [cited 2022 Aug 25];11(408). Available from: https://doi.org/10.1186/s13104-018-3528-x

17. Anato A, Baye K, Tafese Z, Stoecker BJ. Maternal depression is associated with child undernutrition: A cross-sectional study in Ethiopia. Matern Child Nutr [Internet]. 2020 Jul [cited 2022 Aug 25];16(3):e12934. DOI:10.1111/mcn.12934

18. Prado EL, Yakes Jimenez E, Vosti S, Stewart R, Stewart CP, Somé J, et al. Path analyses of risk factors for linear growth faltering in four prospective cohorts of young children in Ghana, Malawi and Burkina

Faso. BMJ Glob Heal [Internet]. 2019 [cited 2022 Aug 25];4(1):e001155. DOI:10.1136/bmjgh-2018-001155

19. Prado EL, Abbeddou S, Adu-Afarwuah S, Arimond M, Ashorn P, Ashorn U, et al. Predictors and pathways of language and motor development in four prospective cohorts of young children in Ghana, Malawi, and Burkina Faso. J Child Psychol Psychiatry [Internet]. 2017 Nov [cited 2022 Aug 25];58(11):1264-75. DOI:10.1111/jcpp.12751

20. Ahun MN, Aboud FE, Aryeetey R, Colecraft E, Marquis GS. Child development in rural Ghana: Associations between cognitive/language milestones and indicators of nutrition and stimulation of children under two years of age. Can J Public Health [Internet]. 2017 [cited 2022 Aug 25];108(5-6):e578-85. DOI:10.17269/CJPH.108.5875

21. LeFevre AE, Dane P, Copley CJ, Pienaar C, Parsons AN, Engelhard M, et al. Unpacking the performance of a mobile health information messaging program for mothers (MomConnect) in South Africa: Evidence on program reach and messaging exposure. BMJ Glob Health [Internet]. 2018 [cited 2022 Aug 25];3(Suppl 2):e000583. DOI:10.1136/bmjgh-2017-000583

Chapter 4 MATERNAL DEPRESSION AND DIETARY DIVERSITY; A SCOPING REVIEW

4.1 Abstract

Background

There is an emerging interest in the relationship between nutrition and maternal mental health, including during the antenatal period. Several studies have examined dietary patterns in relation to depression, but the majority are restricted to high-income regions. Dietary diversity is a nutrition indicator that has been examined in relation to maternal depression yielding inconsistent results. The objective of this scoping review was to synthesize the evidence on maternal depression and dietary diversity.

Methods

We searched Pubmed, Psychinfo, Scopus and the ANH database in July 2021 – December 2021. Our keywords were 'maternal', 'dietary diversity' and 'depression' and 'depressive symptoms' for studies of mothers or pregnant women using observational epidemiological methods, cross-sectional, baseline studies or quasi experimental studies. Maternal depression as well as dietary diversity needed to be measured using a validated tool. Dietary diversity could be an outcome or an exposure and could be measured among mothers or children or both. We limited our search to studies conducted in 2010 or later.

Results

We screened a total of 813 records. A total of 11 articles from 13 different studies met our inclusion criteria. Included articles used six different measures for depression and five different measures for dietary diversity. Four studies examined maternal dietary diversity in relation to depressive symptoms among mothers, four studies examined maternal depression as an exposure and child dietary diversity as an outcome, three studies examined maternal depression and dietary diversity as predictor variables for child outcomes but did not explore the direct relationship between dietary diversity and depression. All articles originated in LMIC except for one study from China. The findings on maternal depression and maternal dietary diversity were mixed, with two studies finding an association and the remaining studies finding no association or an inverse association. The findings on maternal depression

and children's dietary diversity were also mixed with two studies finding an association and the remaining studies finding no association or an inverse association. In the studies that examined maternal depression and dietary diversity as predictor variables for child outcomes, the findings on depression were mixed but dietary diversity was consistently associated with both cognitive and linear growth outcomes among children.

Conclusion

Comparisons of findings was limited by the number of tools used to measure both depression and dietary diversity across articles as well as a relatively low number of articles on this topic. Dietary diversity emerged as an important predictor of children's health and developmental outcomes. The evidence on dietary diversity and maternal depression was inconclusive, as well as the evidence on maternal depression and children's dietary diversity. The relationship between nutritional indicators and depression has important implications for maternal and child health, particularly in LMIC. More rigorous longitudinal research is required to elucidate these relationships. Dietary diversity tools could be refined to also include a category for processed foods given the nutrition transition occurring in many LMICS.

4.2 Background

Pregnancy and the postpartum period can be a physically and emotionally vulnerable time for women. Research suggests an increased risk of physical health conditions and CMD (including depression) during this period with a heightened risk in LMIC (1,2). There are several potential reasons for this, including the fact that women in LMIC are more likely to live in poverty, to be food insecure and to be exposed to IPV and other daily stressors that increase the risk of depression (3,4). Among other adverse consequences, antenatal and postpartum depression has been found to be associated with preterm birth and LBW as well as reduced caregiving behaviour, poor complementary feeding practices and compromised linear growth in older children (5–7). While the links between food insecurity and maternal depression are well established, there is an emerging interest in the association between maternal depression and nutrition in both mothers and children (8,9). The causal pathway between nutrition and depression may be twofold; anxiety and distress regarding insufficient food supply may cause depressive symptoms, and a diet with insufficient nutrient and energy content may contribute to depressive symptoms.

There have been several systematic reviews and meta-analyses that examined the Mediterranean diet and other dietary patterns in relation to depression among adults (10–13). While these have yielded useful findings about the potential benefits of certain diets and depression risk, the studies were primarily conducted in high-income countries and results are not applicable to SSA and many other LMIC where some of the foods that form the basis of the Mediterranean diet (i.e. olive oil and seafood) are unavailable or unaffordable to many. In examining the relationship between nutrition and depression, one indicator which may allow for some comparison across regions is dietary diversity. These data, defined as the number of different foods or food groups consumed over a given reference period, are relatively simple to collect and measurement instruments tend to be quite similar (14). Dietary diversity is consistently associated with child anthropometry, captures the consumption of both micro- and macro-nutrients and are relatively valid across households and between different countries (15). Given the variety of different dietary patterns in SSA and other LMIC, a scoping review on the relationship between dietary diversity and maternal depression is warranted.

Both mental health as well as diet quality are intrinsically linked to the social determinants of health, the broader structural determinants and conditions of daily life that are a primary cause of health inequity globally (16,17). Nutrition may be of particular importance during the peripartum period when pregnancy and lactation place additional demands on women's bodies and may cause them to become nutrient deficient. A systematic review that examined diets and nutritional supplementation in relation to perinatal depression reported mixed findings and found that the evidence for a causal link between nutritional biomarkers and perinatal depression remains inconclusive (18). These findings highlight the importance of evidence synthesis and further examination of how depression and nutrition are related, particularly in LMIC contexts. Thus, the objective of this scoping review was to review existing research on maternal depression and dietary diversity, to summarise the measures used for both, the general relationships between depression and dietary diversity, to examine what other social determinants of health were included in analyses and to make recommendations for future research.

4.3 Methods

A scoping review was conducted to present an overview of the literature examining dietary diversity and maternal depression.

Inclusion criteria: Study participants must be mothers or pregnant women and study designs can be observational epidemiological studies or cross-sectional baseline studies or quasi experimental studies nested within randomised controlled trials (RCTs). Maternal depression as well as dietary diversity need to be measured using a validated tool. Dietary diversity can be an outcome or an exposure and can be measured among mothers or children or both (19–21). We limited our search to studies conducted in 2010 or later.

Exclusion criteria: Studies that did not include pregnant women or mothers as participants. RCTs or intervention studies that were focused on improving dietary diversity. Studies conducted prior to 2010.

We searched Pubmed, Psychinfo, Scopus and a database on nutrition and mental health produced by the Agriculture, Nutrition and Health (ANH) Academy, a global community of interdisciplinary researchers, practitioners, and policymakers working on agriculture and food systems. Our keywords were 'maternal', 'dietary diversity' and 'depression' and 'depressive symptoms'. The first and second author (AH and SM) reviewed abstracts together to ensure that they met the inclusion criteria.

4.4 Results

We screened a total of 813 records for studies that met our inclusion criteria. Of the full text records that we screened, two were excluded as they examined distress and did not measure depression. A total of 11 articles from 13 different studies met our inclusion criteria: four studies examined maternal dietary diversity in relation to depressive symptoms among mothers (20,22–24), four studies examined maternal depression as an exposure and child dietary diversity as an outcome (7,19,21,25). Three studies examined maternal depression and dietary diversity as predictor variables for child outcomes (linear growth, cognitive development and birthweight) but did not explore the direct relationship between dietary diversity and depression (26–28). Apart from the Chinese study, all studies originated in LMIC including Ghana, the Democratic Republic of Congo (DRC), Ethiopia, Nepal, Malawi, Burkina Faso and Bangladesh. Two of the included studies were sub-studies of a quasi-

experimental food assistance programme in the DRC, with one focused on depression in relation to maternal nutrition indicators and the other focused on maternal depression in relation to child nutrition indicators and outcomes. Three of the studies, one from China and two that conducted path analysis using data from SSA utilised longitudinal data while the remaining studies had cross-sectional designs. Maternal education was the social determinant of health that was most included across studies.

4.4.1 Maternal Depression and Maternal Dietary Diversity

A total of four studies examined maternal depression in relation to maternal dietary diversity using three different measures for dietary diversity and four different measures for depression (20,22–24). The studies had conflicting results, with two studies observing that increased dietary diversity decreased depression risk, one study finding no relationship and one study observing a positive relationship between increased dietary diversity and depression risk.

A longitudinal study by Jiang and colleagues examined data from pregnant and postpartum Chinese women across four time periods beginning in the first trimester of pregnancy (23). This study used the self-rating depression scale (SDS) (32) and the FAO DD (33) measure and found higher dietary diversity to be negatively associated with depression (>6) in both cross-sectional and longitudinal analysis in which high dietary diversity status (>6) was related to decreased risk of depression [OR (95% CI) = 0.52 (0.44, 0.63)]. The study also examined individual food groups in relation to depression scores but found no obvious consistency of the association between food group and SDS scores.

A cross-sectional study of 2599 mothers in Bangladesh measuring depression using the EPDS (34) and DD using the FAO measure (33) also observed low dietary diversity (<5 food groups) was associated with approximately double the odds of depression in mothers with older children (OR= 1·80) and peripartum women (OR= 1·99). Of the individual food groups consumed in the previous day, eggs, fish, vitamin A-rich foods and vitamin C-rich foods, were associated with reduced odds of depression in mothers with older children. Among peripartum women, eating dairy, eggs (borderline), fish and vitamin C-rich foods on the previous day was associated with lower odds of depression (20,23). The Bangladesh study had conducted a rigorous analysis and noted that the relationship between dietary diversity and depression remained significant after adjusting for other measures of food and nutrition security and a variety of potential confounders (20). Although both the Chinese study and the Bangladesh study used a variation of the FAO measure for dietary diversity,

they had different cut-offs, with the Chinese study using a cut-off of 6 and the Bangladesh study using a cut-off of 5 (20,23). Both these studies also measured dietary diversity as a binary variable and not a continuous score.

The study that found increased dietary diversity increased the risk of depression was conducted by Emerson et al. focused on 828 mothers of young children in the DRC and measured depression using the Hopkins Symptom Checklist (HSCL-25) (35) and dietary diversity using the MDD-W (36) tool from the FAO. Study authors found that depression was positively and statistically significantly associated with higher DDSs in adjusted analyses (HSCL-25: ß= 0.18, p = 0.002). This result is difficult to explain but may be highly contextual and not necessarily generalisable to other regions. Notably, regardless of their depression status, the women in this sample all had low dietary diversity, consuming on average less than three food groups the previous day. In addition, many of the participants also had symptoms of post-traumatic stress disorder and anxiety, highlighting generally poor mental health in this sample. The authors suggest that the extremely resource-limited context as well as other underlying or modifying factors, such as social support and work burden might have contributed to the contrary findings (22).

A cross-sectional study from Nepal that measured maternal depression among 3158 mothers using the PHQ-9 (37) and dietary diversity using the WHO DD (38) measure found no association between maternal depression and dietary diversity or other indicators of anthropometric status but also noted a very low prevalence of depression with only 5% of mothers classified as depressed (24).

The prevalence of maternal depression varied considerably (between 5% and 60% across studies) which limits comparisons across groups. The extent to which disparities in depression prevalence are related to measurement instruments, geography or social and cultural norms is an important avenue for future research. The prevalence of depression was somewhat comparable in China and Bangladesh, with between 18–35% of participants reporting depressive symptoms across the four study periods in the Chinese study and a prevalence of 20% among the mothers in Bangladesh (20,23). In the study from the DRC however, 60% of surveyed women were classified as depressed (22). This is not surprising as the region has been characterised by decades of armed conflict, population displacement and extreme poverty (22). This review includes two studies that used the same dataset from the DRC and they are notably the only studies in the review that found that increased dietary

diversity among both women and children was associated with increased depression among mothers (21,22). This limits inferences and comparisons of the findings from the DRC to other developing countries included in this review. In the study from Nepal, only 5% of women screened positive for depression which is surprisingly low given that other studies among postpartum women in Nepal have observed a prevalence of over 30%, and another study included in this review observed a prevalence of 20% among Nepali mothers in rural areas (19,29,30). Although the prevalence of depression was similar in the Bangladesh and Chinese studies, China is not classified as a LMIC and daily living conditions, as well as economic adversities of the pregnant women, in the Chinese study would differ considerably from those of mothers in Bangladesh, Nepal and the DRC.

The studies from Bangladesh and China that found increased dietary diversity to be associated with a decrease in depressive symptoms among mothers conducted rigorous analyses that controlled for multiple sociodemographic factors and potential confounding variables (20,23). In addition, the Chinese study conducted both cross-sectional and longitudinal analyses on the relationship between dietary diversity and depression and found the association to be consistent (23). These findings are somewhat intuitive as women with access to a wider variety of foods tend to be wealthier, may experience fewer socioeconomic stressors and may also have greater social support, an important protective factor for depression in the perinatal period.

4.4.2 Maternal Depression and Children's Dietary Diversity

There were a total of four cross-sectional studies that examined maternal depression in relation to children's dietary diversity, and these included data from Ghana, Nepal, Ethiopia and the DRC (7,19,21,25). The ages of children in the included studies varied between 0 and 5.6 years, with only one study from Ethiopia that focused strictly on infants between 5 and 10 months of age (7). The DRC study examined mother-child pairs with children aged between 2.6 to 5.6 years of age, while the study from Northern Ghana focused on children from 6 months to 2 years of age (21,25). The study from Nepal was focused on children aged two to 5.5 years (19). The ages of children may be an important factor in children's dietary diversity outcomes in relation to maternal depression as younger infants are more dependent on their mothers for nourishment and may still be breastfed. Slightly older children may be more able to procure food for themselves through other means. However, the findings of the four

studies included here were mixed with regards to maternal depression and children's dietary diversity, as well as children's ages.

Two studies from Nepal and Ethiopia observed that maternal depression was associated with decreased dietary diversity among children. The Ethiopian study focused on infants aged 5–10 months, while the Nepal study focused on older children between 23 and 66 months (7,19). Another study from Northern Ghana found no association between maternal depression and complementary feeding factors (25). The study with contrarian findings was also conducted by Emerson et al. and used the same data from the DRC as the study previously cited on maternal depression and nutrition indicators. This study found that increased severity of maternal depression was associated with an increase in child dietary diversity (21). The reasons for this are likely to be similar to the factors discussed earlier, such as social support or other factors that might influence nutrition but were not measured in the study.

The study of Nepali children by Miller et al. measured depression using the EPDS (34 with a cut-off of ≥ 13 and children's dietary diversity using the FAO/FANTA 12 item measure. This study observed that maternal depression was associated with 11% lower likelihood that the child consumed one additional food group p = 0.024] and 13% lower likelihood that the child consumed one additional animal source food (ASF) p = 0.061] compared with children of non-depressed mothers (19). However, maternal depression was not associated with either child anthropometry or development (19). This study conducted robust multivariate analyses that included several social determinants of health and adjusted for mother's age and education, child age and gender, and household characteristics, wealth, livestock and land ownership, and home child-rearing quality. After adjusting for confounding factors, the relationship between maternal depression and child stunting was attenuated, but the association between maternal depression and children's diet remained significant (19).

In the Ethiopian study by Anato et al., depression was measured using the EPDS (34with a cut-off of ≥ 13. Complementary feeding practices were assessed using the WHO IYCF (38) indicators, including breastfeeding, minimum meal frequency (MMF) and minimum dietary diversity (MDD) (WHO, 2008). The infant who did not meet the WHO composed indicators (timely introduction of semi-solid or solid complementary feeding, MDD and MMF) was considered inappropriately fed. Although this study did not individually examine the relationship between dietary diversity and depression, it did observe, in adjusted multivariate

logistic regression, maternal depression symptoms and lack of maternal education were the only factors significantly associated with complementary feeding practices (7). The AOR for inappropriate complementary feeding among mothers with depression was 3.67 (95% CI: 1.09–12.32) which suggests that maternal depression may influence complementary feeding practices in some settings. The children in the Ethiopian study also had very low dietary diversity with only 9.1% of children meeting MDD requirements. The study from Northern Ghana measured maternal depression using the CES-D (44) tool with a cut-off of ≥ 20 and noted a prevalence of depression at 33.5%. The proportion of children meeting MDD requirements was 56.5% but there was no association between maternal depression and children's dietary diversity (25).

The DRC study by Emerson measured maternal depression using the HSCL-25 (35) and children's dietary diversity was measured using the WHO IYCF (38) with possible scores between 1 and 7. In the adjusted analysis higher mean HSCL-25 (35) score was associated with an increase of 0·18 in DDS (P< 0·05). While this finding was statistically significant the magnitude of effect is also relatively low (less than a single food group) and insufficient to impact growth or developmental outcomes among young children. Indeed, the same study found that while maternal depression was significantly associated with child feeding indicators, small negative but non-statistically significant associations were found between maternal mental health variables and HAZ, WAZ and WHZ (21). Thus, the effect of maternal depression on feeding indicators was not sufficiently large to impact growth outcomes. This finding highlights the difficulty of interpreting results when analysing dietary diversity data as a continuous variable and is why many studies use pre-defined cut-offs for ease of interpretation.

Both studies that measured maternal depression using the EPDS (34) observed that the children of depressed mothers consumed less diverse diets (7,19). Across studies, the prevalence of maternal depression was comparable between Ethiopia (22.8%), Nepal (20%) and Ghana (33.5%), but not comparable to that of the mothers in the DRC study, which was 60%.

4.4.3 Studies that included both depression and dietary diversity as predictor variables

There were three studies that examined both maternal depression and children's dietary diversity in relation to child health outcomes, including linear growth, cognitive and motor skills as well as language milestones. A study by Ahun and colleagues conducted secondary

analysis of data from two separate studies among mother-child pairs in Ghana to examine cognitive and language milestones in relation to nutritional and psychosocial indicators, and measured depression and DD using SRQ-20 (46) with a cut-off of 11 and DD using the WHO 7 item measure (30). This study found that children's dietary diversity was negatively associated with maternal depressive symptoms ($r = -0.19$ to -0.12, $p < 0.0001$), in keeping with the findings of the studies from Nepal and Ethiopia that found the children of depressed mothers were at greater risk for low dietary diversity (7,19). In this study, maternal education was significantly correlated with several child variables, including WAZ scores, dietary diversity, and preventive health practices and less educated mothers had more depressive symptoms. The study also pointed out that independent of the child's age, the best predictor of children's length-for-age or stimulation remained the child's diet (28).

Two studies by Prado and colleagues used structural equation modelling and path analysis to examine various maternal and environmental characteristics associated with linear growth and language and motor development respectively, using data from longitudinal cohorts in Ghana, Malawi and Burkina Faso (26,27). The first study used path analyses to examine the association of 42 indicators of environmental, maternal, caregiving and child factors with 18-month LAZ. The study examined how the impact of maternal adult height on child linear growth may be mediated by socioeconomic conditions, maternal adult factors (nutritional status, stress, depression, cognition), caregiving practices and child characteristics, or may directly affect linear growth. Of the various indicators, dietary diversity was associated with 18 month LAZ in two of the four included cohorts (26). However, the authors found no associations with maternal stress and depression and children's linear growth (26).

The second study by Prado, using the same dataset, examined predictors and pathways of language and motor development among children and noted that dietary diversity was associated with language and motor development at 18 months, but maternal depression was not (27). In both of these studies using data from three different African countries and adjusted for multiple household and maternal characteristics, dietary diversity emerged as an important predictor of children's growth and development while maternal depression was not associated with any of these outcomes (26,27).

4.5 Discussion

We found a total of 11 studies that met our inclusion criteria. Four of these studies examined dietary diversity in relation to maternal depression, while the remaining seven studies examined maternal depression in relation to children's dietary diversity or examined maternal depression and dietary diversity separately in relation to stunting, cognition and other child health and developmental outcomes. Across studies, six different measures were used for depression and five different measures were used for dietary diversity. The most commonly used measure for depression was the EPDS (34) which was used in four studies, while measures for dietary diversity varied depending upon the population of interest (children versus adults). Three of the included studies utilised longitudinal study designs (23,26,27), while the remaining studies used cross-sectional data (7,20–22,24,25,31). All included studies were published between 2017 and 2020, with the majority published in 2020, highlighting the importance of nutrition and mental health as an emerging field of study.

The study from China by Jiang et al. was the only study included in this review that examined the direct association between DD and maternal depression across four time periods, this study finding a consistent association between low DD and increased risk of depression (23). The lack of longitudinal data that examines maternal depression in relation to dietary diversity limits inferences about causation between the two factors, but several potential causal pathways exist. Depressed women may lack social support and other forms of agency that could allow them to procure a more diverse diet for themselves and their children. However, women who experience long periods characterised by poor quality diets are at greater risk of becoming malnourished and nutrient deficient, which may in turn contribute to the development of depressive disorders (32). A recent systematic literature review on maternal depression and nutritional deficiencies in LMIC observed that 95% of included studies reported positive associations between nutrition deficiencies, poor diet, and maternal depression and suggested that nutritional interventions may reduce the risk of maternal depression (33). Lastly, longitudinal research on food insecurity and depression among low-income women in the US has suggested that depression and food insecurity share a simultaneous bidirectional (causal) relationship, and dietary diversity, often used as a proxy for food insecurity, may operate in a similar way (34,35).

Of the studies in this review that found a positive association between maternal depression and low dietary diversity, the longitudinal study from China and the study from Bangladesh

individually examined the various food groups in relation to depression outcomes. The cross-sectional study from Bangladesh did find that some food groups were associated with a reduced risk of depression, while the Chinese study did not find any consistent associations between individual food groups and depression (20,23). It may simply be that a generally more diverse diet is sufficient to reduce depression risk, but this may also be highly contextual and examining different food groups in relation to depression outcomes is still a useful endeavour. This is an important distinction from an intervention perspective as programmes need to ascertain how to improve dietary quality in the antenatal period and what to improve regarding nutritional status at household and individual level (14). Two studies that used the same data from the DRC found that increased dietary diversity was associated with increased depression among mothers and that maternal depression was associated with increased dietary diversity among children. These findings are highly contextual and may be related to confounding factors that were not measured in the study (21,22).

While the studies of maternal depression, dietary diversity, and child outcomes have mixed findings, dietary diversity consistently emerges as an important factor for both linear and cognitive growth among children, regardless of whether maternal depression is present or not (26,27,28). However, it is also plausible that dietary diversity is an effective proxy for SES and that children with higher dietary diversity also tend to come from wealthier households, and their better growth and developmental outcomes are also due to improved healthcare, maternal education and other factors that enable them to thrive (14). Given the relationship between wealth and increased dietary diversity and quality, it is important that studies adjust appropriately for socioeconomic factors when examining DD in relation to other outcomes (14). Of the 11 studies included in this review, eight of them adjusted for household wealth, either using monthly household income, quintiles, or constructing asset indexes as a proxy for household wealth. Of the included studies, only one study from Ghana that examined maternal depression in relation to complementary feeding indicators failed to adjust for any socioeconomic factors in the analysis (25). The two studies from the DRC did record mean household income but did not include this variable in the final analysis as a potential confounding factor (21,22).

In recent years, there has been a growing interest in the relationship between maternal depression and child growth (44). Again, there are several causal pathways that may elucidate

this relationship. Depressed mothers may be more apathetic, less likely to engage in caregiving behaviour and their children may receive less stimulation (36,37). This is particularly important in LMIC, where the children of depressed mothers may be more likely to experience poor health as a result of recurrent infections, a finding that was observed in one of our included studies from Ghana (28,38). In addition, the pathway between maternal depression and stunted linear and cognitive growth among children may be moderated by the association with dietary diversity and other nutritional indicators, whereby the children of depressed mothers consume a poorer quality diet and become malnourished as a result (7,19,37).

A longitudinal study in the United Kingdom (UK) observed that higher prenatal depressive symptoms were associated with lower levels of healthy nutrition and higher levels of unhealthy nutrition, each of which was prospectively associated with reduced cognitive function among infants. Thus, maternal depression symptoms were indirectly associated with infant outcomes via an unhealthy nutritional environment (37). The interactions between maternal depression and nutritional environment are likely to be more severe in LMIC where more women are food insecure and there is less access to social protection and other government funded interventions to alleviate food insecurity and malnutrition. As noted in the path analysis by Prado, mothers who provide a more diverse diet (associated with improved linear growth) also appear to offer a broader variety of play materials (associated with improved cognitive development) (37). However, five of the studies included in this review from Nepal, the DRC, Ghana and the path analysis studies by Prado found no association between maternal depression and children's nutritional and developmental outcomes (21,24–27). Distinguishing the effects of maternal characteristics like depression status and nutrition indicators like dietary diversity on child growth are further complicated by the fact that the same risk factor might act as a moderator of depression risk, as a potential confounder, and may also be on the causal pathway between depression and child outcomes (38).

Qualitative research among low-income mothers in South Africa observed that mothers felt both sadness, hopelessness and guilt about their failure to fulfil their maternal role and provide appropriately for their children in the context of hunger and food insecurity. This reinforced a vicious cycle of hunger, sadness, aggression and withdrawal among some mothers (39). Maternal depression is thus of particular concern in settings of poverty, where

the physical and emotional distress of hunger is amplified among the mothers of young children. In combination with a lack of access to healthcare, poor hygiene and sanitation and other poverty associated risks, maternal depression is emerging as another risk for adverse outcomes among children, particularly in the crucial first 1000 days of life (38)

Previous studies that have found associations with child health outcomes and maternal depression noted that the magnitude of the effect can vary as a function of depression measurement and geographical location, although children growing up in LMIC were at greater risk of adverse outcomes related to maternal depression (36,40,41). Notably, a systematic review and meta-analysis on child growth and depression observed that less than half of the studies on underweight and stunting found a statistically significant relationship between maternal depression and these outcomes (36). The use of multiple different measures for depression across the studies included in this review limit inferences about the meaning of findings and may partially explain why some studies observe associations and others do not, as well as the substantial differences in prevalence estimates of maternal depression across and within different regions. It is also important to note that of the studies that examined maternal dietary diversity and maternal depression, as well as the studies that examined maternal depression and children's dietary diversity, conclusions were limited by the contrarian findings of both articles from the DRC which found that increased dietary diversity among mothers and children increased maternal depression.

4.5.1 Implications for future research

One of the primary limitations of dietary diversity is the lack of standardised measurement as well as its failure to capture the amount of food groups consumed (42). There is now a valid measure of DD in women, (the WHO MDD-W). However, there is not a universal one for children. It is therefore recommended that countries consider validating their own based on the main foods of nutritional importance and availability in their countries. Among the studies included in this review, five different measures were used to capture DD, and in some cases different cut-offs were used for the same measure. With both depression and DDSs, some studies also examined these as a continuous variable while others converted the scores to binary variables using various cut-offs. This may partially explain the divergent results, and while continuous data may be more sensitive, they are also more difficult to interpret when it comes to outcomes such as food groups. A recent study of DHS data from Bangalore, by Purushotham et al., using quantile regression to examine six different measures of dietary

diversity in relation to anthropometry outcomes between women, young children and school aged children, found that certain measures of DD were associated with anthropometry outcomes while others were not, highlighting different measures as a potential reason for null findings between and within studies (62). In this study, the DD measures varied considerably and measured between seven and 16 food groups across studies.

The nutrition transition is of particular importance when examining dietary diversity, as numerous studies have observed that increased dietary diversity simultaneously reduces malnutrition and stunting but increases obesity and overweight (62,63). Globally, increased urbanisation and greater access to processed foods have adverse implications for dietary quality, but current dietary diversity measures fail to capture this complexity and are better suited to regions without access to processed food (62). In LMIC, like the majority of those included in this review, there is a need to devise and validate new DD measures that can account for the negative effects of excess sugar, fats and cholesterol consumption (62). Given that the global burden of overweight and obesity has overtaken that of undernutrition among both mothers and children in much of the world, a DD measure designed to reflect this can improve the monitoring and evaluation of dietary quality and food consumption in relation to anthropometry and other health outcomes (64,65).

Although the measures used for depression in our included studies had all been validated in LMIC settings, and validation research of different depression tools has found good cross-cultural applicability of depression symptoms, the use of six different depression tools to measure depression across the 11 studies included in this review does limit comparisons between regions and findings in relation to DD. The most commonly used measures across studies was the EPDS , which was used across four studies and has been well validated in LMIC countries (66).

4.5.2 Social Determinants of Health

Of the 11 studies included in this review, 10 adjusted for several social determinants of health at both the individual and the household level, including maternal education, family size, women's empowerment indicators, household income, access to healthcare, marital status and land and livestock ownership in rural areas. Only one study from Ghana (that found no association between maternal depressive symptoms and complementary feeding indicators) did not appear to adjust for any of the social determinants of health or other sociodemographic variables but simply compared complementary feeding indicators between

depressed and non-depressed women (25). However, most of the studies conducted robust analyses with multiple covariates, including social determinants of health, and several of these still found dietary diversity to be significantly associated with both maternal and child health outcomes. The most commonly included social determinant of health across studies was maternal education, which was adjusted for in the ten remaining studies described here. Globally, gender is an important determinant of both food security and nutritional outcomes and women are 10% more likely to be food insecure than men (67). Although some of the associations between maternal education and improved nutrition among children are attributable to maternal employment and improved SES, there is also evidence that maternal education is associated with improved care behaviours and child outcomes, regardless of maternal income. This provision of 'care' describes '*the time and attention devoted to meeting the physical, mental, and social needs of growing children and has an important nutritional component via complementary feeding and hygiene and sanitation practices*' (68,69).

4.6 Conclusion

This scoping review found 11 studies that examined dietary diversity and maternal depression, either in relation to maternal dietary diversity, child dietary diversity or growth and developmental outcomes, or examined the two factors separately as predictor variables of child health and developmental outcomes. The majority of the studies were published in the last two years and highlight the emerging interest in mental health and nutrition, particularly in LMIC. Although the findings of maternal depression and nutritional status were mixed, dietary diversity was consistently associated with children's linear and cognitive growth and remains an important nutritional indicator in these settings. Only three studies used longitudinal data and this limits causal inferences about the relationship between depression and dietary diversity. Generalisability of the findings is further complicated by a lack of consistent measurement of both depression and dietary diversity across geographical regions and studies. Most studies adjusted for SES as well as multiple social determinants of health, with maternal education being the most commonly included covariate. More observational longitudinal studies with robust analysis of maternal and socioeconomic factors can further elucidate the relationship between maternal mental health and dietary diversity. In addition, modifications of existing dietary diversity tools to include processed foods and an effort to quantify excess consumption of unhealthy foods may improve the use of these measures in the context of the global nutrition transition.

Table 4-1: Characteristics of Included Studies

Title and Year of publication	Study Type	Population	Result and social determinants of health included in analysis	Measurement tool for dietary diversity and depression
1.Mental health symptoms and their relations with dietary diversity and nutritional status among mothers of young children in eastern Democratic Republic of the Congo Published in 2020	Cross-sectional sub-study of a larger, quasi-experimental evaluation of a United States Agency for International Development (USAID) food assistance pro- gram called Jenga Jamaa II	828 mothers of young children	Maternal mental health measures were positively and statistically significantly associated with higher dietary diversity scores in adjusted analyses (HSCL-25: ß= 0.18, p = 0.002, HTQ: ß= 0.12, p = 0.029, High Distress: ß= 0.47, p < 0.001). background and demographic characteristics: age, years of education obtained, ethnic group, living in territory of origin, currently pregnant, number of children, and marital status. Education was recoded as a categorical variable with three categories: no education, completing at least some primary school, and completing at least some secondary school or higher education. Participants were also asked if they had a child that died, and to rate their physical health status, using a scale that ranged from excellent to poor. Household-level data, including household size, in- come in the past month, and food insecurity, were collected as part of the parent study survey questionnaire. Food insecurity was measured using the Household Food Insecurity Access Scale (HFIAS)	Minimum Dietary Diversity for Women (MDD-W) tool [45]. Hopkins Symptom Checklist-25 (HSCL- 25) and post-traumatic stress disorder (PTSD) with the Harvard Trauma Questionnaire (HTQ), using a four-point Likert scale. Mean scale scores were calculated ranging from one to four. A variable was created for high distress (participants scoring in the upper quartile of both measures). Independent variables for maternal mental health were mean item HSCL-25 score (measuring depression and anxiety symptoms), mean item HTQ score (measuring PTSD symptoms), and a binary variable for high psychological distress (upper quartile of both mea- sures). Separate analyses were conducted for each of the three independent variables due to multicollinearity.
2.The relationship of dietary diversity score with depression and anxiety among prenatal and post-partum women. Published in 2018	Longitudinal cohort of Chinese women	T1 was 3698, 2343 at T2, 2162 at T3 and 924 at T4	In the cross-sectional analysis, high dietary status (>6) was negatively associated with depression status [T1: OR (95% CI) = 0.56 (0.46, 0.69); and anxiety status [T1: OR (95% CI) = 0.70 (0.56, 0.88); In the longitudinal analysis, it was demonstrated that the DDS level was negatively associated with SDS [β(se) = −0.99 (0.09), P = <0.0001] and SAS scores [β(se) = −0.37 (0.08), P = <0.0001] throughout pregnancy. Social determinants of health included The frequency of physical exercise, sleep quality, level of family care, morning sickness and medical problems in pregnancy were collected at baseline and each follow-up through our self-designed questionnaire. Maternal age (years), education level (years of schooling), marital status (married including first marriage and remarriage; single including spinster- hood, the separated, the divorced and widow.), per capita income (<10 000, 10 000–30 000, >30 000 rmb) and	FAO DDS Self-Rating Anxiety Scale (SAS), Self-Rating Depression Scale (SDS) and

Title and Year of publication	Study Type	Population	Result and social determinants of health included in analysis	Measurement tool for dietary diversity and depression
			occupation (manual workers, mental workers and others) and smoking or drinking of the past 3 months before pregnancy	
3.Depression among women of reproductive age in rural Bangladesh is linked to food security, diets and nutrition. 10.1017/S136898 0019003495 Published in 2020	Cross-sectional baseline sample of FAARM trial.	2599 women 40 % were pregnant or up to 1 year postpartum, while 60 % were not peripartum. Overall,	Low dietary diversity (<5 food groups) was associated with approximately double the odds of depression in NPW (OR= 1·80) and PW (OR= 1·99). Consumption Age in years, age at first marriage, years of completed education and a detailed birth history as self-reported by the index woman. Literacy was determined by asking the index woman to read a simple sentence. Religion of the household head, the size of the household, and if anyone in the household owned a set list of assets in order to construct a wealth index(31).	Dichotomous cut-off used in the thirteen-group Women's Dietary Diversity Score (WDDS), including the 15 g restriction. Depression The Edinburgh Postpartum Depression Scale (EPDS) is a ten-item psychometric screening tool used to identify prob- able minor and major depression. The cutoff was 12 or greater.
4.Maternal depression does not affect complementary feeding indicators or stunting status of young children (6-23 months) in Northern Ghana. Published in 2018	Population based cross-sectional survey	200 mother child pairs	Outcome was child dietary diversity and exposure was maternal depression. The prevalence of MDD, MMF, and MAD were 56.5, 65.0, and 44.0% respectively and 41.0% of the children sampled were stunted. A third of the mothers (33.5%) screened positive for depression. Maternal depression did not influence significantly MDD (p = 0.245), MMF (p = 0.442), and MAD (p = 0.885) or children's risk of stunting (p = 0.872). In conclusion maternal depression and child stunting are prevalent in Northern Ghana but there is a lack of evidence of an association between maternal depression and child feeding practices or nutritional status in this study population. Study did not appear to explore other social determinants of health or to adjust for these in the analysis.	WHO indicators for assessing young child feeding Maternal depression status was determined using Centre for Epidemiologic Studies-Depression (CES-D) scale [20]. CES-D scale comprised of 20 items and asks caregivers to rate how often over the past week they experienced depression-associated symptoms
5. Child development in rural Ghana: Associations between cognitive/languag e milestones and indicators of nutrition and stimulation of children under two years of age	Two studies: A secondary analyses on health and nutrition data from 1081 mother–child pairs (the children aged 0–12 months) Ghana's Eastern Region. Second Study: the Ghana Milestones Measure, consisting of items assessing cognitive and language development, was used to assess child development in a subsample (N = 330)	1081 mother-child pairs (first study) 330 children (sub-sample of study 1)	Outcome is child development and study examines dietary diversity and maternal depression in relation to child development. Family assets and maternal education were identified as key factors of the family context. Both variables were positively associated with preventive health practices (r = 0.08 to 0.13, p < 0.0001 to 0.01), and dietary diversity (r = 0.15, p = 0.0001 to 0.0006), and negatively associated with maternal depressive	DD measured out of 7 food groups consumed in the past 24 hours and converted to a dietary diversity score defined as the number (0–7) of food groups (grains/ tubers, legumes, meat/fish, eggs, vitamin A rich fruits and vegetables, non-vitamin A rich fruits and vegetables, and dairy) eaten by the child and the number (0–3) of animal-source food groups (meat, eggs and dairy) eaten.1

Title and Year of publication	Study Type	Population	Result and social determinants of health included in analysis	Measurement tool for dietary diversity and depression
doi: 10.17269/CJPH.108.5875 M Published in 2017	of Study 1 participants one year later (children 10–24 months of age).		symptoms (r = −0.19 to −0.12, p < 0.0001). Recent child illness did not correlate with preventive health practices but was related to mother's depressive symptoms, more stimulation and lower hemoglobin. Mother's education was significantly correlated with several child variables, including weight-for-age (WAZ) scores, dietary diversity, and preventive health practices. Less educated mothers had more depressive symptoms. Although family assets and maternal education were correlated with child's diet and health and maternal depression, they were not the main predictors of children's length-for-age or stimulation. Independent of the child's age, the best predictor was the child's diet.	The Self-Reporting Questionnaire (SRQ-20),18 a measure of maternal depressive symptoms, was used to assess the mother's emotional availability to provide support for the child. Mothers responded yes or no to each of the 20 symptoms based on their experiences over the last 30 days. The total score was the number of symptoms to which the mother responded affirmatively. A cut-off score of 11 or more was used to identify high levels of depressive symptoms.
6. Maternal depression is associated with child undernutrition: A cross-sectional study in Ethiopia. 10.1111/mcn.12934 Published in 2020	The study was nested in a larger quasi-experimental study evaluating Jenga Jamaa II, a food and nutrition assistance project in Uvira and Fizi territories	812 mother child pairs	HSCL-25 (ß: 0·18, P < 0·05) and HTQ (ß: 0·19, P < 0·05) were statistically significantly associated with higher dietary diversity scores, and all maternal mental health measures were associated with higher meal frequency (HSCL-25: ß: 0·13, P = 0·001; HTQ: ß: 0·12, P = 0·001; high distress: ß: 0·15, P < 0·05) and consumption of at least three meals/snacks per day (HSCL-25: OR: 2·06, HTQ: OR: 1·93, high distress: OR: 2·68, P < 0·001 for all). No significant associations were found with HAZ, WAZ, WHZ, stunting or underweight indicators. Social determinants included in the model: Data on maternal background characteristics included maternal age, years of education, ethnic group, marital status, currently living in territory of origin, currently pregnant, maternal self-reported health status (poor, average, good, very good/ excellent), number of children, and having had a child who died. Maternal education was recoded as a categorical variable with three categories: no education, completed at least some primary school and completed at least some sec- ondary school. Multivariate analyses adjusted for maternal age, education, intervention group, livelihoods zone and number of children	Childrens DD measured using the WHO ICYF indicators. A dietary diversity score (range 0–7) was calculated from the sum of food groups consumed. The seven food groups were starchy staples (grains, roots and tubers), legumes and nuts, dairy products, flesh foods, eggs, Vitamin A-rich fruits and vegetables, and other fruits and vegetables. Maternal depression and anxiety symptoms were measured by the Hopkins Symptom Checklist-25 (HSCL-25), and post-traumatic stress was measured by the Harvard Trauma Questionnaire (HTQ). Participants were classified as having high psychological distress if their mean item score was in the upper quartile of both measures
7. Maternal mental health symptoms are	The study was nested in a larger quasi-experimental study evaluating Jenga	812 mother child pairs	HSCL-25 (ß: 0·18, P < 0·05) and HTQ (ß: 0·19, P < 0·05) were statistically significantly associated	Childrens DD measured using the WHO ICYF indicators. A dietary diversity score (range

Title and Year of publication	Study Type	Population	Result and social determinants of health included in analysis	Measurement tool for dietary diversity and depression
positively associated with child dietary diversity and meal frequency but not nutritional status in Eastern Democratic Republic of Congo. 10.1017/S136898 0019004087 Published in 2020	Jamaa II, a food and nutrition assistance project in Uvira and Fizi territories		with higher dietary diversity scores, and all maternal mental health measures were associated with higher meal frequency (HSCL-25: ß: 0·13, P = 0·001; HTQ: ß: 0·12, P = 0·001; high distress: ß: 0·15, P < 0·05) and consumption of at least three meals/snacks per day (HSCL-25: OR: 2·06, HTQ: OR: 1·93, high distress: OR: 2·68, P < 0·001 for all). No significant associations were found with HAZ, WAZ, WHZ, stunting or underweight indicators. Social determinants included in the model: Data on maternal background characteristics included maternal age, years of education, ethnic group, marital status, currently living in territory of origin, currently pregnant, maternal self-reported health status (poor, average, good, very good/ excellent), number of children, and having had a child who died. Maternal education was recoded as a categorical variable with three categories: no education, completed at least some primary school and completed at least some sec- ondary school. Multivariate analyses adjusted for maternal age, education, intervention group, livelihoods zone and num- ber of children	0–7) was calculated from the sum of food groups consumed. The seven food groups were starchy staples (grains, roots and tubers), legumes and nuts, dairy products, flesh foods, eggs, Vitamin A-rich fruits and vegetables, and other fruits and vegetables. Maternal depression and anxiety symptoms were measured by the Hopkins Symptom Checklist-25 (HSCL-25). Participants were classified as having high psychological distress if their mean item score was in the upper quartile of both measures
8. Maternal depression is associated with less dietary diversity among rural Nepali children. Published in 2020	a cross-sectional study embedded at endline of a longitudinal community development intervention	mothers of 629 children (age 23–66 months) in rural Nepal	Maternal depression was associated with 11% lower likelihood that the child consumed one additional food group [Poisson regression, adjusted relative risk (aRR) 0.89, 95% confidence intervals (95% CI 0.81, 0.99), p = 0.024] and 13% lower likelihood that the child consumed one additional animal source food (ASF) [aRR 0.87, (95% CI 0.76, 1.01), p = 0.061] compared with children of nondepressed mothers. However, maternal depression was not associated with either child anthropometry or development. Social determinants: . In an attempt to control for confounding of the relationship between maternal depression, children's diet and development, we performed adjustment using a set of covariates that were chosen a priori, including child gender and age, maternal age and education, and household wealth quintile, intervention group assignment, land and livestock ownership, and home child-rearing	Child's consumption in the past 24 h of 12 specific foods/food groups (Kennedy et al., 2013). The 24-h diet recall information was aggregated into eight categories based on the (FAO/FANTA) dietary diversity scores. The Edinburgh Post-Partum Depression Scale (EPDS) was administered by field enumerators to the mothers of the 629 enrolled children. This 10-item measure has been validated in LMICs (Shrestha et al., 2016) including Nepal (Bhusal et al., 2016; Gibson et al., 2009;

Title and Year of publication	Study Type	Population	Result and social determinants of health included in analysis	Measurement tool for dietary diversity and depression
			quality. These were included in the adjusted model if they were associated ($p \leq 0.10$) with the anthropometric, developmental and dietary outcomes.	
9. Path analyses of risk factors for linear growth faltering in four prospective cohorts of young children in Ghana, Malawi and Burkina Faso Published in 2019	Longitudinal cohort - four prospective cohorts of children who participated in trials conducted as part of the International Lipid-Based Nutrient Supplements Project four African countries. In two cohorts, women were enrolled during pregnancy. In two other cohorts, infants were enrolled at 6 or 9 months.	Mother infant pairs in Ghana (n=1039), Malawi (n=684 and 1504) and Burkina Faso (n=2619).	Study did not examine correlates between DD and depression but examined both DD and maternal depression in relation to child health outcomes using SEM. Out of 42 indicators, 2 were associated with 18-month LAZ in three or four cohorts: maternal height and body mass index (BMI). Six factors were associated with 18-month LAZ in two cohorts: length for gestational age z-score (LGAZ) at birth, pregnancy duration, improved household water, child dietary diversity, diarrhoea incidence and 6-month or 9-month haemoglobin concentration. Factors that were not associated with LAZ were maternal iron status, illness and inflammation during pregnancy, maternal stress and depression, exclusive breast feeding during 6 months post partum, feeding frequency and child fever, malaria and acute respiratory infections. These	A dietary diversity score (DDS) was created using data from 24-hour recall of food types/groups available in Ghana DHS data set. The DDS is a count of the number of food groups consumed by the child over the past 24 hours preceding the DHS interview of the mother, who reported the child's food consumption. The DDS has a range from 0 to 16, summed using these food groups: 1) tinned/powder or fresh milk; 2) baby formula; 3) baby cereal; 4) bread, rice, noodles, other made from grains; 5) potatoes, cassava, or other tubers; 6) eggs; 7) meat (beef, pork, lamb, goat, chicken etc.); 8) dark green leafy vegetables; 9) mangoes, papayas, other vitamin A fruits; 10) other fruits; 11) pumpkin, carrots, squash (yellow or orange inside); 12) liver, kidney, heart, other organs; 13) fish or shellfish(fresh or dried); 14) food made from beans, peas, lentils, nuts; 15) oils, fats, butter, products made from them; 16) cheese, yogurt, other milk products. A value of 1 was assigned for each of the nutritionally important types of food the child might have eaten. Mothers were interviewed regarding depressive symptoms at 6 months post partum in DYAD-M using a locally validated adaptation of the Self-Re- porting Questionnaire and in DYAD-G with the Edin- burgh Post-natal Depression Scale.

Title and Year of publication	Study Type	Population	Result and social determinants of health included in analysis	Measurement tool for dietary diversity and depression
10. Predictors and pathways of language and motor development in four prospective cohorts of young children in Ghana, Malawi, and Burkina Faso. 10.1111/jcpp.12751 Published in 2017	Longitudinal cohort : path analyses of factors associated with 18-month language and motor development in four prospective cohorts of children who participated in trials conducted as part of the International Lipid-Based Nutrient Supplements (iLiNS) Project in four African countries	Mother infant pairs Ghana (*n* = 1,023), Malawi (*n* = 675 and 1,385), and Burkina Faso (*n* = 1,122).	Out of 42 indicators of the 34 factors examined, 6 were associated with 18-month language and/or motor development in 3 or 4 cohorts: child linear and ponderal growth, variety of play materials, activities with caregivers, dietary diversity, and child hemoglobin/iron status. Factors that were not associated with child development were indicators of maternal Hb/iron status, maternal illness and inflammation during pregnancy, maternal perceived stress and depression, exclusive breastfeeding during 6 months postpartum, and child diarrhea, fever, malaria, and acute respiratory infections. Study adjusted for both maternal and paternal education and found that paternal education was associated with language and motor development while maternal education was not.	A dietary diversity score (DDS) was created using data from 24-hour recall of food types/groups available in Ghana DHS data set. Individual food groups are described in the column above. Mothers were interviewed regarding depressive symptoms at 6 months post partum in DYAD-M using a locally validated adaptation of the Self-Re- porting Questionnaire and in DYAD-G with the Edin- burgh Post-natal Depression Scale.
11. Parental depression and nutrition: findings from a cross-sectional household survey in Nepal Published in 2020	Cross-sectional community based survey nested within a nutrition intervention district spanning mountains, hills and plains in Nepal.	Study examined parents with child age 6-59 moths and included fathers as well as 3158 mothers		WHO DD indicators for adults and children with 24 hour recall. The possible scores, thus, ranged from 0 to 10 for adults and 0 to 7 for children. Depression measured using (Patient Health Questionnaire-9 score ≥ 10).

The following chapter uses cross-sectional data from Wave 1 of NIDS to examine various food insecurity indicators in relation to adult and child anthropometry measures.

4.7 References

1. Grote, N.K. Bridge, J.A. Gavin, A.R. Melville, J.L. Iyengar, S. Katon WJ. A meta-analysis of depression during pregnancy and the risk of preterm birth, low birth weight, and intrauterine growth restriction. Arch Womens Ment Health [Internet]. 2011;14(10):S26. Available from: http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L70557360%5Cnhttp://dx.doi.org/10.1007/s00737-010-0203-1

2. Fisher J, de Mello MC, Patel V, Rahman A, Tran T, Holton S, et al. Prevalence and determinants of common perinatal mental disorders in women in low-and lower-middle-income countries: A systematic review. Bull World Health Organ. 2012;90(2):139–49.

3. Fisher J, Tran T, Duc Tran T, Dwyer T, Nguyen T, Casey GJ, et al. Prevalence and risk factors for symptoms of common mental disorders in early and late pregnancy in Vietnamese women: A prospective population-based study. J Affect Disord [Internet]. 2013;146(2):213–9. Available from: https://www.sciencedirect.com/science/article/pii/S0165032712006350

4. Abrahams Z, Lund C, Field S, Honikman S. Factors associated with household food insecurity and depression in pregnant South African women from a low socio-economic setting: a cross-sectional study. Soc Psychiatry Psychiatr Epidemiol [Internet]. 2018;0(0):0. Available from: http://www.ncbi.nlm.nih.gov/pubmed/29445850%0Ahttp://link.springer.com/10.1007/s00127-018-1497-y

5. Woody CA, Ferrari AJ, Siskind DJ, Whiteford HA, Harris MG. A systematic review and meta-regression of the prevalence and incidence of perinatal depression. J Affect Disord [Internet]. 2017;219(April 2017):86–92. Available from: http://dx.doi.org/10.1016/j.jad.2017.05.003

6. Dadi AF, Miller ER, Mwanri L. Antenatal depression and its association with adverse birth outcomes in low and middleincome countries: A systematic review and meta-analysis. PLoS One [Internet]. 2020;15(1):1–23. Available from: http://dx.doi.org/10.1371/journal.pone.0227323

7. Anato A, Baye K, Tafese Z, Stoecker BJ. Maternal depression is associated with child undernutrition: A cross-sectional study in Ethiopia. Matern Child Nutr. 2020 Jul;16(3):e12934.

8. Richards M, Weigel M, Li M, Rosenberg M, Ludema C. Household food insecurity and antepartum depression in the National Children's Study. Ann Epidemiol [Internet]. 2020;44:38-44.e1. Available from: https://www.sciencedirect.com/science/article/pii/S1047279719305599

9. Pourmotabbed A, Moradi S, Babaei A, Ghavami A, Mohammadi H, Jalili C, et al. Food insecurity and mental health: A systematic review and meta-analysis. Public Health Nutr. 2020;23(10):1778–90.

10. Almudena S-V, Miguel R-C, Alfredo G, Francisca L, A M-GM. The association between the Mediterranean lifestyle and depression [Internet]. Vol. 4, Clinical Psychological Science. 2016. p. 1085–93. Available from: http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=psyc13&NEWS=N&AN=2016-55681-013

11. Quirk SE, Williams LJ, O'Neil A, Pasco JA, Jacka FN, Housden S, et al. The association between diet quality, dietary patterns and depression in adults: A systematic review. BMC Psychiatry [Internet]. 2013 Jun 27;13. Available from: http://0-search.ebscohost.com.innopac.wits.ac.za/login.aspx?direct=true&db=psyh&AN=2013-26178-001&site=ehost-live&scope=site

12. Molendijk M, Molero P, Sanchez-Pedreno O, F, Does V der, W, et al. Diet quality and depression risk: A systematic review and dose-response meta-analysis of prospective studies. Vol. 226, Journal of Affective Disorders. 2018. p. 346–54.

13. Shafiei F, Salari-Moghaddam A, Larijani B, Esmaillzadeh A. Adherence to the Mediterranean diet and risk of depression: a systematic review and updated meta-analysis of observational studies. Vol. 77,

Nutrition Reviews. 2019. p. 230–9.

14. Ruel MT. Operationalizing Dietary Diversity: A Review of Measurement Issues and Research Priorities. Am Soc Nutr Sci. 2003;133:3927S–3931S.

15. Headey D, Ecker O. Rethinking the measurement of food security: From first principles to best practice. Food Secur. 2013;5(3):327–43.

16. Marmot M, Friel S, Bell R, Houweling TA, Taylor S. Closing the gap in a generation: health equity through action on the social determinants of health. Lancet. 2008;372(9650):1661–9.

17. Marmot M, Allen J. Social determinants of health. Am J Public Health. 2014;104(4):517–9.

18. Sparling TM, Henschke N, Nesbitt RC, Gabrysch S. The role of diet and nutritional supplementation in perinatal depression: a systematic review. Vol. 13, Maternal & Child Nutrition. 2017. p. 1.

19. Miller LC, Neupane S, Sparling TM, Shrestha M, Joshi N, Lohani M, et al. Maternal depression is associated with less dietary diversity among rural Nepali children. Matern Child Nutr. 2021 Oct;17(4):e13221.

20. Sparling TM, Waid JL, Wendt AS, Gabrysch S. Depression among women of reproductive age in rural Bangladesh is linked to food security, diets and nutrition. Public Health Nutr. 2020 Mar;23(4):660–73.

21. Emerson JA, Caulfield LE, Musafiri Kishimata E, Nzanzu J-P, Doocy S. Maternal mental health symptoms are positively associated with child dietary diversity and meal frequency but not nutritional status in Eastern Democratic Republic of Congo. Public Health Nutr. 2020 Jul;23(10):1810–9.

22. Emerson JA, Caulfield LE, Kishimata EM, Nzanzu J-P, Doocy S. Mental health symptoms and their relations with dietary diversity and nutritional status among mothers of young children in eastern Democratic Republic of the Congo. BMC public Heal. 2020 Feb;20(1):225.

23. Jiang W, Mo M, Li M, Wang S, Muyiduli X, Shao B, et al. The relationship of dietary diversity score with depression and anxiety among prenatal and post-partum women. J Obstet Gynaecol Res. 2018 Oct;44(10):1929–36.

24. Adhikari RP, Williamson R, Sparling TM, Ferguson E, Cunningham K. Parental depression and nutrition: findings from a cross-sectional household survey in Nepal. Public Health Nutr. 2020 Nov;23(16):2983–93.

25. Wemakor A, Iddrisu H. Maternal depression does not affect complementary feeding indicators or stunting status of young children (6-23 months) in Northern Ghana. BMC Res Notes. 2018 Jun;11(1):408.

26. Emerson JA, Caulfield LE, Musafiri Kishimata E, Nzanzu J-P, Doocy S. Maternal mental health symptoms are positively associated with child dietary diversity and meal frequency but not nutritional status in Eastern Democratic Republic of Congo. Public Health Nutr [Internet]. 2020;23(10):1810–9. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85083382565&doi=10.1017%2FS1368980019004087&partnerID=40&md5=fead6a8428f028949607ce012b7d9a03

27. Miller LC, Neupane S, Sparling TM, Shrestha M, Joshi N, Lohani M, et al. Maternal depression is associated with less dietary diversity among rural Nepali children. Matern Child Nutr [Internet]. 2021;17(4). Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85107831785&doi=10.1111%2Fmcn.13221&partnerID=40&md5=d55c50b01bb09c89975413ac555b947c

28. Prado EL, Yakes Jimenez E, Vosti S, Stewart R, Stewart CP, Somé J, et al. Path analyses of risk factors for linear growth faltering in four prospective cohorts of young children in Ghana, Malawi and Burkina Faso. BMJ Glob Heal [Internet]. 2019;4(1). Available from:

https://www.scopus.com/inward/record.uri?eid=2-s2.0-85061779800&doi=10.1136%2Fbmjgh-2018-001155&partnerID=40&md5=0b3665ef638cfabb8ec5b442e84d7f29

29. Prado EL, Abbeddou S, Adu-Afarwuah S, Arimond M, Ashorn P, Ashorn U, et al. Predictors and pathways of language and motor development in four prospective cohorts of young children in Ghana, Malawi, and Burkina Faso. J Child Psychol Psychiatry. 2017 Nov;58(11):1264–75.

30. Ahun MN, Aboud FE, Aryeetey R, Colecraft E, Marquis GS. Child development in rural Ghana: Associations between cognitive/language milestones and indicators of nutrition and stimulation of children under two years of age. Can J Public Heal [Internet]. 2017;108(5–6):e578–85. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85040927379&doi=10.17269%2Fcjph.108.5875&partnerID=40&md5=85fb6ed087d868069fe8ae458c3a6a3a

31. Sparling TM, Waid JL, Wendt AS, Gabrysch S. Depression among women of reproductive age in rural Bangladesh is linked to food security, diets and nutrition. Public Health Nutr. 2020 Mar;23(4):660–73.

32. ZUNG WWK. A Self-Rating Depression Scale. Arch Gen Psychiatry [Internet]. 1965;12(1):63–70. Available from: https://doi.org/10.1001/archpsyc.1965.01720310065008

33. Gina Kennedy, Terri Ballard MD. Guidelines for measuring household and individual dietary diversity. FAO. 2010. 1–60 p.

34. Cox JL, Holden JM, Sagovsky R. Detection of Postnatal Depression: Development of the 10-item Edinburgh Postnatal Depression Scale. Br J Psychiatry. 1987;150(6):782–786.

35. Derogatis LR, Lipman RS, Rickels K, Uhlenhuth EH, Covi L. The Hopkins Symptom Checklist (HSCL): a self-report symptom inventory. Behav Sci. 1974 Jan;19(1):1–15.

36. Minimum Dietary Diversity for Women. Rome; 2021.

37. Kroenke K, Spitzer RL, Williams JBW. The PHQ-9. J Gen Intern Med [Internet]. 2001;16. Available from: http://dx.doi.org/10.1046/j.1525-1497.2001.016009606.x

38. World Health Organization (WHO). Infant and young child feeding [Internet]. Available from: https://www.who.int/data/nutrition/nlis/info/infant-and-young-child-feeding

39. Giri RK, Khatri RB, Mishra SR, Khanal V, Sharma VD, Gartoula RP. Prevalence and factors associated with depressive symptoms among post-partum mothers in Nepal. BMC Res Notes. 2015;8(1):1–7.

40. Singh DR, Sunuwar DR, Adhikari S, Singh S, Karki K. Determining factors for the prevalence of depressive symptoms among postpartum mothers in lowland region in southern Nepal. PLoS One [Internet]. 2021;16(1 January):1–16. Available from: http://dx.doi.org/10.1371/journal.pone.0245199

41. Miller LC, Neupane S, Sparling TM, Shrestha M, Joshi N, Lohani M, et al. Maternal depression is associated with less dietary diversity among rural Nepali children. Matern Child Nutr [Internet]. 2021; Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85107831785&doi=10.1111%2Fmcn.13221&partnerID=40&md5=d55c50b01bb09c89975413ac555b947c

42. Wemakor A, Iddrisu H. Maternal depression does not affect complementary feeding indicators or stunting status of young children (6-23 months) in Northern Ghana. BMC Res Notes [Internet]. 2018;11(1). Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85049095363&doi=10.1186%2Fs13104-018-3528-x&partnerID=40&md5=86e43b7b1cbdf7c65b30519652df7cc4

43. Anato A, Baye K, Tafese Z, Stoecker BJ. Maternal depression is associated with child undernutrition: A cross-sectional study in Ethiopia. Matern Child Nutr [Internet]. 2020;16(3). Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-

85076362450&doi=10.1111%2Fmcn.12934&partnerID=40&md5=1444f446b5ec60673e78a28e0792d157

44. Deitchler, M. Ballard, T. Swindale, A. & Coates J. Introducing a Simple Measure of Household Hunger for Cross-Cultural Use. Washington, DC Food Nutr … [Internet]. 2011;(2010):16. Available from: http://www.fantaproject.org/research/validation-hhs

45. Radloff L. The CES-D Scale: A Self-Report Depression. Appl Psychol Meas. 1977;1:385–400.

46. Beusenberg M, Orley J. A user's guide to the self reporting questionnaire (SRQ). Geneva; 1994.

47. Ahun MN, Aboud FE, Aryeetey R, Colecraft E, Marquis GS. Child development in rural Ghana: Associations between cognitive/language milestones and indicators of nutrition and stimulation of children under two years of age. Can J Public Heal [Internet]. 2017 Jan;108(5–6):e578–85. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85040927379&doi=10.17269%2Fcjph.108.5875&partnerID=40&md5=85fb6ed087d868069fe8ae458c3a6a3a

48. Miller LC, Neupane S, Joshi N, Shrestha M, Neupane S, Lohani M, et al. Diet quality over time is associated with better development in rural Nepali children. Matern Child Nutr. 2020 Jul;16(3):e12964.

49. Sparling TM, Nesbitt RC, Henschke N, Gabrysch S. Nutrients and perinatal depression: a systematic review. J Nutr Sci. 2017;

50. Madeghe BA, Kogi-Makau W, Ngala S, Kumar M. Nutritional Deficiencies and Maternal Depression: Associations and Interventions in Lower and Middle-Income Countries: a Systematic Review of Literature. Glob Soc Welf. 2021;

51. Huddleston-Casas C, Charnigo R, Simmons LA. Food insecurity and maternal depression in rural, low-income families: a longitudinal investigation. Public Health Nutr. 2009 Aug;12(8):1133–40.

52. Reesor-Oyer L, Cepni AB, Lee CY, Zhao X, Hernandez DC. Disentangling food insecurity and maternal depression: Which comes first? Public Health Nutr. 2021;24(16):5506–13.

53. Emerson JA, Caulfield LE, Kishimata EM, Nzanzu J-P, Doocy S. Mental health symptoms and their relations with dietary diversity and nutritional status among mothers of young children in eastern Democratic Republic of the Congo. BMC Public Health. 2020 Feb;20(1):225.

54. Surkan PJ, Kennedy CE, Hurley KM, Black MM. Maternal depression and early childhood growth in developing countries: systematic review and meta-analysis. Bull World Health Organ. 2011;89(8):607–15.

55. Barker ED, Kirkham N, Ng J, Jensen SKG. Prenatal maternal depression symptoms and nutrition, and child cognitive function. Br J Psychiatry. 2013;203(6):417–21.

56. Herba CM, Glover V, Ramchandani PG, Rondon MB. Maternal depression and mental health in early childhood: an examination of underlying mechanisms in low-income and middle-income countries. The lancet Psychiatry. 2016 Oct;3(10):983–92.

57. Herba CM, Glover V, Ramchandani PG, Rondon MB. Maternal depression and mental health in early childhood: an examination of underlying mechanisms in low-income and middle-income countries. The Lancet Psychiatry [Internet]. 2016;3(10):983–92. Available from: http://dx.doi.org/10.1016/S2215-0366(16)30148-1

58. Kruger LM, Lourens M. Motherhood and the "Madness of Hunger": "…Want Almal Vra vir My vir 'n Stukkie Brood" ("…Because Everyone Asks Me for a Little Piece of Bread"). Cult Med Psychiatry. 2016;40(1):124–43.

59. Ghimire U, Papabathini SS, Kawuki J, Obore N, Musa TH. Depression during pregnancy and the risk of

low birth weight, preterm birth and intrauterine growth restriction- an updated meta-analysis. Early Hum Dev [Internet]. 2021;152(October 2020):105243. Available from: https://doi.org/10.1016/j.earlhumdev.2020.105243

60. Accortt EE, Cheadle ACD, Dunkel Schetter C. Prenatal Depression and Adverse Birth Outcomes: An Updated Systematic Review. Vol. 19, Maternal and Child Health Journal. 2015. 1306–1337 p.

61. Andrew D. Jones,3,4* Francis M. Ngure,4 Gretel Pelto 4 and Sera L. Young4. What Are We Assessing When We Measure Food Security? A Compendium and Review of Current Metrics. Am Soc Nutr. 2013;4:481–505.

62. Purushotham A, Mittal N, Ashwini BC, Umesh KB, Taubadel S von C-, Vollmer S. A quantile regression analysis of dietary diversity and health outcomes among children and women in the rural-urban interface of India Anjali. Food Policy [Internet]. 2003;107(1):6–8. Available from: https://doi.org/10.1016/j.foodpol.2021.102216

63. Cois A, Day C. Obesity trends and risk factors in the South African adult population. BMC Obes. 2015;2(1):1–10.

64. Popkin BM, Corvalan C, Grummer-Strawn LM. Dynamics of the double burden of malnutrition and the changing nutrition reality. Lancet [Internet]. 2020;395(10217):65–74. Available from: http://dx.doi.org/10.1016/S0140-6736(19)32497-3

65. Popkin BM. Relationship between shifts in food system dynamics and acceleration of the global nutrition transition. Nutr Rev. 2017;75(2):73–82.

66. Ali GC, Ryan G, De Silva MJ. Validated screening tools for common mental disorders in low and middle income countries: A systematic review. PLoS One. 2016;11(6):1–14.

67. FAO, IFAD, UNICEF, WFP, WHO. The State of Food Security and Nutrition in the World 2019. Rome; 2019.

68. Quisumbing AR, Brown LR, Feldstein HS, Haddad L, Peña C. Women: The Key to Food Security. Food Nutr Bull. 1996;17(1):1–2.

69. Azeze AA, Bank W, Huang W-C. Maternal Education, Linkages and Child Nutrition in the Long and Short-run: Evidence from the Ethiopia Demographic and Health Surveys. Int J African Dev v1 n2 Spring [Internet]. 2014;(1):5. Available from: http://scholarworks.wmich.edu/ijad

Chapter 5 DIETARY DIVERSITY AND THE DOUBLE BURDEN OF MALNUTRITION

5.1 Abstract

Childhood stunting remains a global public health problem. Many stunted children live in the same household as overweight or obese adults (the so-called double burden of malnutrition), evidence that quality as well as quantity of food is important. In recent years, food security measurement has shifted away from anthropometry (e.g., stunting) to experiential measures (e.g., self-reported hunger). However, given the continued problem of stunting, it is important that national surveys identify malnutrition.

Objectives

To examine the associations between a variety of food security indicators, including dietary diversity, with adult, child (0-4 years) (5-9 years) and adolescent (10-17 years) anthropometry. To estimate the prevalence of double burden households.

Methods

The study utilized cross-sectional data from the South African National Income Dynamics Survey NIDS (2008). We examined the associations between five food security indicators and anthropometry outcomes. The indicators were adult and child hunger in the household, self-reported household food sufficiency, food expenditure>60% of monthly expenditure and household dietary diversity. Multinomial and logistic regression models were employed to examine the associations with adult BMI categories and children's stunting and BMI.

Results

The prevalence of stunting was 18.4% and the prevalence of wasting and overweight was 6.8% and 10.4% respectively. Children <5 and adolescents with medium dietary diversity were significantly more likely to be stunted than children with high dietary diversity. Among children <5, child hunger and medium dietary diversity were significantly associated with wasting. None of the food security indicators were associated with stunting in children aged 5-9. Among stunted children, 70.2% lived with an overweight or obese adult. Among adults, increased dietary diversity increased the risk of overweight and obesity.

Conclusion

Dietary diversity can be used as a proxy for poor nutritional status among children<5 years and adolescents but the relationship between dietary diversity and adult obesity is more complex. Given the double burden of malnutrition in many low- and middle-income countries, indicators of dietary quality remain important. These tools can be further refined to include an extra category for processed foods. Given the relative simplicity to collect this data, national surveys would be improved by its inclusion.

5.2 Introduction

Stunting in children remains an urgent public health problem in low- and middle-income countries (LMIC). Research suggests that stunting is consistently associated with poorer cognitive function, schooling outcomes and reduced earning potential (1–3). However, stunting is a multifaceted problem associated with a variety of factors including chronic malnutrition, infectious diseases in early childhood and adverse birth and pregnancy outcomes like low birthweight and intrauterine growth restriction (3–6).

In many LMIC, there is an obesity epidemic occurring alongside high rates of stunting. This is primarily driven by fundamental changes in the food system including the ease and availability of cheap processed foods, reduced physical activity and the high cost of healthy varied diets (7,8). Childhood stunting and adult overweight and obesity often occur in the same household, the so called double burden of malnutrition (DBM) (3,7,9–11)(12).

In recent years, food security measurement has shifted away from the measurement of anthropometry to self-reported experiential measures. These measures, focused on individual perceptions of hunger and anxiety around access to food (13,14), are premised on the concept that hunger and food insecurity are universal experiences that exist along a spectrum of severity (15). However, such measures do not capture the nutritional quality of food consumed. One indicator that has potential as an effective proxy for malnutrition are dietary diversity indicators. These have been found to be an effective proxy for overall dietary quality in some studies and are often associated with child anthropometry outcomes (16,17).

A systematic review of household food insecurity and dietary diversity in relation to stunting in Sub-Saharan Africa (SSA) noted that two thirds of the included studies found that household food insecurity and low dietary diversity were linked to stunting (6). Another

systematic review that examined dietary diversity and undernutrition across 32 demographic and health surveys in SSA found that children with adequate dietary diversity had a 12% lower likelihood of being stunted than those with inadequate dietary diversity (18). A study from Nigeria found that children's age, maternal age, and food expenditure were among the significant determinants of children's dietary diversity (19). Although the prevalence of food insecurity, low dietary diversity and stunting are subject to geographical variations, the linkages between them are often observed across regions. These findings suggest that both food insecurity and low dietary diversity are common in Sub-Saharan Africa and have adverse implications for growth and development, particularly among young children.

In South Africa, an estimated 27% of children under five years are stunted as a result of chronic malnutrition and a generally deficient growth environment (2,3). The prevalence of stunting has remained virtually unchanged in the past two decades, despite a decrease in reported hunger in national statistics and one of the largest social protection systems in the world (2,3,20,21). National surveys in South Africa currently rely primarily on experiential measures of food security that measure hunger, skipping meals and running out of money to purchase food (the most severe forms of food insecurity). However, such measures may miss households that don't necessarily experience hunger but where child growth is faltering due to poor quality diets

The findings from two recent national surveys suggest that food insecurity remains a serious problem in South Africa. Results from the 2017 general household survey (GHS) noted that about 13.4 million households had inadequate or severely inadequate access to food and about 1,6 million households experienced hunger (22). The NIDS coronavirus rapid mobile survey found that a lack of money to buy food remained high in 2020, due to the protracted nature of the Covid 19 pandemic and the subsequent economic and social impact (23,24).

In this paper we estimate the prevalence of malnutrition among children, adolescents and adults and describe the proportion of double burden of malnutrition (DBM) households. Then, we examine whether different food security indicators are associated with adult BMI categories (normal weight, underweight, overweight or obese) and child height (normal height or stunted/severely stunted) and child BMI (normal weight, wasted/severely wasted and overweight/obese) and whether dietary diversity is an effective proxy for nutritional status.

5.3 Methods

5.3.1 Primary study

The National Income Dynamics Study

The South African National Income Dynamics Study (SA-NIDS) is a nationally representative panel survey of over 28000 individuals in 7300 households across South Africa. A stratified, two-stage cluster sample design was used in sampling the households to be included in the first wave (2008). In the first stage, 400 primary sampling units (PSUs) were selected from Stats SA's 2003 master sample of 3000 PSUs. This master sample was the sample used by Stats SA for its Labour Force Surveys and General Household Surveys between 2004 and 2007. The surveys were conducted on non-overlapping samples drawn within each PSU to ensure that households did not have to participate in both surveys (25). NIDS is a government funded survey to track inequality over time and examines several exposures (e.g. social capital, labour market participation, household composition and structure) in relation to poverty and inequality. Data on health outcomes, fertility and mortality were also collected. The survey is conducted by the Southern Africa Labour and Development Research Unit based at the University of Cape Town. Food security indicators were dropped in subsequent waves of the NIDS study and in this paper, we therefore use data from the baseline wave, conducted in 2008Food Security Indicators

Household hunger

Data on adult and child hunger were collected separately using the following question: In the past year did an adult/child go hungry? never, seldom, sometimes, often, always. These are questions from the Household Food Insecurity Access Scale (HFIAS). We created a binary hunger indicator for adult and child hunger with households that reported never or seldom experiencing hunger scoring a 0 and households that reported sometimes, often or always experiencing hunger scoring a 1, using the same methodology as Statistics South Africa (26).

Food Sufficiency

Respondents were also asked a question about household food consumption in relation to the household's needs in the past 12 months. Respondents reported if food consumption was less than adequate, just adequate or more than adequate for household needs. The data was

converted into a binary indicator, with households who reported more than adequate or just adequate scored a 0 and households that reported less than adequate scored a 1.

Dietary diversity

We calculated household dietary diversity score (HDDS) from the NIDS data using the Food and Agriculture Organization (FAO) guidelines (27). The HDDS is comprised of 32 individual food types and 12 different food groups with a minimum score of 1 and a maximum score of 12. The twelve food groups are; (i) cereals and grain produces (ii) starchy roots and tubers (iii) Legumes (iv) vegetables (v) Fruits and nuts (vi) Sugars (vii) Meat and poultry (viii) Eggs (ix) Fish and shellfish (x) Milk and dairy products (xi) Oils and fats (xii) Miscellaneous (including beverages). Dietary diversity scores (DDS) was summed up by counting each of the 12-food groups, and classified as low (≤4), medium (5–8) and high (9–12) with high dietary diversity being the reference standard. There is no gold standard for dietary diversity cut-offs and we used these cut-offs based on a recent study that examined stunting and dietary diversity in South Africa (28). We also included dietary diversity as a continuous variable (ascending order from 1-12).

Food expenditure

Food expenditure was calculated by dividing the amount spent on food each month by total household expenditure. A cut-off of total monthly expenditure above 60% was used to define a household as food insecure, as recommended by the FAO (29,30).

There were a total of 7 271 households in wave 1. Information on household food security indicators was relatively complete in this Wave with dietary diversity scores for 7 263 households (99%) food expenditure information for 100% of the household sample, data on adult hunger was 7 271 100(%) of the sample. Data on childhood hunger was available for 5 361 households (73.7% of the sample) but it is important to bear in mind that not all households had children present. As such, we do not feel that the level of missingness of the various food security indicators would have substantially altered our results.

5.3.2 Child and adult anthropometry

Child anthropometry for children up to the age of 5 years was classified according to the WHO child growth standards, weight for age, weight for height, BMI for age, and height-for-age (HAZ) scores. A HAZ score of -2SD of the mean is classified as stunted and a HAZ

score of -3SD is classified as severely stunted. Child wasting and overweight/obesity was also classified according to the WHO growth standards with BMI for age below -2SD classified as wasted and BMI above 2SD classified as overweight (31). For children older than 5 years the WHO growth standards for school aged children and adolescents were used as a reference in the calculation of z-scores for height for age, BMI for age and weight for age (32). Due to the low proportion of children who were severely stunted, we grouped stunted and severely stunted children together in the regression model. We also grouped wasted and severely wasted children together, and overweight and obese children together for the multinomial model. Child anthropometry data were calculated by the NIDS team (25). Children were grouped according to the following age categories: <5 years, 5-9 years and 10-17 years. Children were aged between 0 and 17 at the time of data collection with a mean age of 9.5 years. People aged 18 and older were classified as adults and their BMI measurements were categorized according to the WHO growth standards and considered underweight (BMI<18.5), normal weight, (BMI 18.5-24.9) overweight (BMI 25-29.9) and obese (BMI >29.9) with normal weight used as the reference standard (33).

5.4 Data Analysis

Logistic and multinomial regression models were used to examine child stunting and BMI status in relation to food indicators. The explanatory variables were dietary diversity both as a continuous score and as a categorical indicator, food expenditure greater than 60% of total monthly expenditure, child hunger in the past year and household food sufficiency in the past year. For the stunting model, the response variable was children's stunting status (normal height or stunted/severely stunted). For children's BMI the response variables were normal weight, wasted or overweight. We examined each explanatory variable individually for both the stunting and BMI models (Table 4 & 5). Analyses were clustered at the household level on the assumption that children in the same household had similar access to food.

Multinomial regression models were used to examine adult BMI (underweight, normal weight, overweight and obese) in relation to food indicators. The explanatory variables for both models were identical to the child variables except for hunger. The adult model used adult hunger as an explanatory variable in place of child hunger. For adult BMI, the response variable was adult BMI status (underweight, normal weight, overweight or obese). These results are presented in Table 6.

There were a total of 7 271 households in wave 1. Information on household food security indicators was relatively complete in this Wave with dietary diversity scores for 7 263 households (99%) food expenditure information for 100% of the household sample, data on adult hunger was 7 271 100(%) of the sample. Data on childhood hunger was available for 5 361 households (73.7% of the sample) but it is important to bear in mind that not all households had children present. As such, we do not feel that the level of missingness of the various food security indicators would have substantially altered our results.

Food indicators and outcome categories were generated from datasets with imputation values created by the NIDS data team (18). All analyses were conducted using Stata 15.1 (Stata Corporation, College Station, TX).

5.5 Results

Insufficient food over the past 12 months was the most frequently reported food insecurity indicator (38.1%) followed by medium household dietary diversity scores (30.7 %). Low dietary diversity scores were the least common indicator (4.1%) followed by child hunger in the past 12 months (14.9%) (see Table 5-1**)**

Table 5-1: Prevalence of household food insecurity by each item

Indicator (n households)	Percentage who reported food insecurity % (n) (95% CI)
High dietary diversity (9-12)	65.2 (4 724) (64-66%)
Medium dietary diversity (5-8)	30.7 (2 219) (30-32%)
Low dietary diversity (1-4)	4.1 (297) (3-4%)
Food expenditure	17.3 (7 291) (16-18%)
Adult hunger	23 (7 266) (22-24%)
Child hunger	14.5 (5 359) (13%-15%)
Food Insufficiency	38.1 (7 291) (37-39%)

Height for age scores were available for 8 777 children across 3 831 household clusters as shown in Table 5.2. Children of normal height (n=7 139) were the reference category. A total of 18.66% of children (n=1 638) were classified as stunted as seen in Table 5-2. Children aged less than 5 years had the highest proportion of stunting (28.2%) followed by adolescents (17.9%). Children in the 5–9-year age category had the lowest prevalence of stunting (13.5%).

Table 5-2: Prevalence of childhood stunting by age category

Category	>5 years % (n)	5-9 yrs % (n)	10-17 yrs % (n)	Total % (n)
Normal height (HAZ≥-2SD)	73.8 (1 526)	86.5 (2 156)	82.1 (3 457)	81.3 (7 139)
Stunted/severely stunted (HAZ<-2SD)	28.2 (543)	13.5 (338)	17.9 (757)	18.7 (1 638)
Total	100 (2 069)	100 (2 494)	100 (4 214)	100 (8 777)

BMI scores were available for 7 385 children across 3 559 household clusters as shown in Table 5.3. Children of normal weight (n=6 118) were the reference category. A total of 6.8% of children were classified as wasted or severely wasted (n=500) and 10.4% of children were classified as overweight or obese (n=767). The prevalence of wasting was highest among adolescents (7.7%) while the prevalence of overweight and obesity was highest among children aged less than 5 years (17.5%) (see Table 5-3)

Table 5-3: Prevalence of childhood wasting and overweight by age category

Category	<5 years % (n)	5-9 yrs % (n)	10-17 yrs % (n)	Total) % (n)
Normal weight (BMI ≥-1)	77.2 (1 373)	85.7 (1 756)	84 (2 989)	82.8 (6 118)
Wasted/severely wasted (BMI <-2)	5.3 (95)	6.5 (133)	7.7 (272)	6.8 (500)
Overweight/obese (BMI ≥2)	17.5 (311)	7.8 (160)	8.3 (296)	10.4 (767)
Total	100 (1 779)	100 (2 049)	100 (3 557)	100 (7 385)

Anthropometry measures were available for 8 777 children and adolescents aged 0-17 across 3 831 household clusters. There were a total of 1 638 stunted or severely stunted children. Children of normal height (n=7 608) were the reference category. For the full sample, each unit increase of dietary diversity offered a protective effect against stunting and reduced the risk by 5% and children and adolescents in the medium dietary diversity were significantly more likely to be stunted than children with high dietary diversity (OR 1.35). When we stratified the children by age group, medium dietary diversity was significantly associated with stunting for children aged <5 years and adolescents. Low dietary diversity scores were not associated with stunting among any of the age groups but the prevalence of low dietary diversity was only 3.9% in this sample which likely contributed to the null finding. Medium dietary diversity and food expenditure >60% of monthly expenditure were associated with stunting among the adolescent group. None of the experiential indicators (child hunger and household food insufficiency) were associated with stunting for any age group in the sample (see

Table.5-4).

Table.5-4: Logistic regression model of food security in relation to childhood stunting

Indicators	Odds ratio of being stunted (p value) Bivariate regressions			
	<5 years n=2069	5-9 years n=2494	10-17 years n=4214	Full sample n=8777
Dietary diversity (continuous)	0.97 (0.195)	0.96 (0.153)	0.91 (P<0.000)	0.94 (P<0.000)
Medium dietary diversity (5-8)	1.27 (0.028)	1.12 (0.386)	1.53 (P<0.000)	1.35 P<0.000)
Low dietary diversity 1-4	0.86 (0.628)	0.87 (0.667)	1.88 (0.002)	1.29 (0.115)
Food expenditure (>0.6)	1.26 (0.056)	1.09 (0.576)	1.24 (P<0.000)	1.24 (P<0.000)
Child hunger	0.97 (0.774)	0.99 (0.926)	0.97 (0.713)	0.97 (0.642)
Food insufficiency	1.08 (0.453)	0.89 (0.380)	1.14 (0.100)	1.07 (0.276)

BMI scores were available for 7 385 children across 3 559 household clusters. Children of normal weight (n=6 118) were the reference category. Medium dietary diversity and child hunger was associated with wasting in children <5 as shown in Table 5-5.

Child hunger represents the most severe form of food insecurity and households that reported children going hungry in the past year likely represent the most poor and deprived households. Each unit increase of dietary diversity decreased the risk of wasting in adolescents. Child hunger and food insufficiency decreased the risk of obesity among children in the 5–9-year age group and adolescents.

Table 5-5: Multinomial regression model of food security in relation to childhood wasting and overweight

Indicators				
	Relative risk ratio of being wasted or severely wasted (n =500)			
	<5 years n=1 779	**5-9 years** n=2 049	**10-19 years** N=3 557	***Full sample** n= 7 385
Dietary diversity (continuous)	0.93 (0.145)	0.96 (0.387)	**0.93 (0.017)**	**0.94 (0.008)**
Medium dietary diversity (5-8)	**1.76 (0.014)**	0.88 (0.541)	1.23 (0.160)	1.22 (0.086)
Low dietary diversity (1-4)	2.28 (0.071)	1.05 (0.802)	1.37 (0.389)	**1.88 (0.011)**
Food expenditure>0.6	1.51 (0.087)	0.81 (0.387)	0.81 (0.244)	0.92 (0.594)
Child hunger	**2.0 (0.003)**	1.11 (0.651)	0.97 (0.842)	1.17 (0.216)
Food insufficiency	1.0 (0.984)	1.16 (0.444)	0.95 (0.690)	1.01 (0.945)
	Relative risk ratio of being overweight or obese (n =767)			
Dietary diversity (continuous)	0.98 (0.496)	1.06 (0.147)	1.05 (0.088)	1.03 (0.143)
Medium dietary diversity (5-8)	0.96 (0.782)	0.83(0.329)	0.87 (0.330)	0.89 (0.183)
Low dietary diversity (1-4)	1.35 (0.352)	0.84 (0.335)	0.93 (0.841)	1.04 (0.883)
Food expenditure>0.6	1.21 (0.189)	0.89 (0.607)	0.75 (0.098)	0.98 (0.841)
Child hunger	0.87 (0.392)	**0.50 (0.005)**	**0.56 (0.002)**	**0.66 (P<0.000)**
Food insufficiency	0.92 (0.541)	**0.63 (0.011)**	**0.62 (0.001)**	**0.74 (P<0.000)**

Anthropometry measurements were available for 12 199 adults aged 18 and above across 6 483 household clusters. The prevalence of underweight, overweight and obesity was 7.6%, 23.4% and 26.3% (respectively) (see Table 5-6).

Adult hunger and household food insufficiency were the indicators most strongly associated with an increased risk of underweight (RR 1.25 & 1.34). Other food security indicators followed a similar pattern with an increased risk for underweight among adults and a decreased risk for overweight and obesity. However, each unit increase of dietary diversity increased the risk of overweight and obesity, but a reduction in dietary diversity was not associated with being underweight.

Table 5-6: Multinomial regression model of food security in relation to adult anthropometry

Indicators	**Relative risk ratios (95% CI) Bivariate regressions**	**p value**
Relative risk ratio of being underweight (n=927)		
Dietary diversity (continuous)	0.98 (0.96-1.01)	0.214
Medium dietary diversity (5-8)	1.09	0.321
Low dietary diversity (1-4)	0.94 (0.89-1.17)	0.730
Food expenditure>0.6	0.99 (0.85-1.19)	0.942
Adult hunger	**1.25 (1.10-1.45)**	**0.007**
Food insufficiency	**1.34 (1.10-1.43)**	**P<0.000**
Relative risk ratio of being overweight (n=2 857)		
Dietary diversity (continuous)	**1.05 (1.03-1.07)**	**P<0.000**
Medium dietary diversity (5-8)	**0.86**	**0.003**
Low dietary diversity (1-4)	**0.70 (0.76-0.92)**	**0.004**
Food expenditure>0.6	0.90 (0.81-1.01)	0.087
Adult hunger	**0.67 (0.61-0.75)**	**P<0.000**
Food insufficiency	**0.81 (0.74-0.90)**	**P<0.000**
Relative risk ratio of being obese (n=3 219)		
Dietary diversity (continuous)	**1.11 (1.07-1.14)**	**P<0.000**
Medium dietary diversity (5-8)	**0.69**	**P<0.000**
Low dietary diversity (1-4)	**0.57 (0.52-0.65)**	**P<0.000**
Food expenditure>0.6	**0.81 (0.71-0.91)**	**0.001**
Adult hunger	**0.71 (0.64-0.78)**	**P<0.000**
Food insufficiency	**0.90 (0.80-0.96)**	**0.022**

The reference category was adults of normal weight N=5 229

There was a total of 3720 households that had anthropometry measurements for both adults and children in the household and 850 (22.8%) of these households included stunted children as well as obese adults (Table 5-7). The DBM describes the coexistence of overnutrition (overweight and obesity) with undernutrition (stunting). In this sample, among households with stunted children, 70.2% of stunted children lived with overweight or obese adults. For ease of interpretation, we have grouped overweight and obese adults together as well as stunted and severely stunted children.

When examining the double burden of malnutrition, households with one or more stunted child and one or more overweight or obese adults were classified as double burden households while households with stunted children and normal weight adults were classified as single burden households.

Table 5-7: Prevalence of the double burden of malnutrition by household

Category	Normal/underweight BMI	Overweight/Obese adult	Total
	% (n)		
Normal height child/ren	24% (602)	76% (1 908)	100 (2 510)
Stunted or severely stunted child/ren	29.8% (360)	**70.2% (850)**	100 (1 210)
Total	25.9% (962)	74.1 (2 758)	100 (3 720)

5.6 **Discussion**

Our results show that 18.43% of children are stunted, and that the double burden of malnutrition is evident in our sample with over 70% of stunted children living in the same household as an overweight or obese adult. Among children aged <5 years, children with medium dietary diversity are significantly more likely to be stunted than children with high dietary diversity. Among adolescents, medium dietary diversity, low dietary diversity and food expenditure are associated with stunting. Child hunger in the household and medium dietary diversity are significantly associated with wasting among children aged <5 years.

We did not find any of the food security indicators to be associated with stunting in children aged 5-9 years. There are several potential reasons for this. Children aged 5-9 had the lowest prevalence of stunting (13.5%) across age groups, with 28.2% of children <5yrs and 18.6% of adolescents classified as stunted. The primary drivers of stunting among <5yrs may be different (ie. diarrhea and other infectious diseases or babies born small for gestational age) to those among older children. Moreover, stunting is a cumulative process and the consequence of chronic malnutrition and a deficient growth environment over time (3), hence

the greater prevalence among adolescents. Thus, stunting in adolescence is a continuation from stunting in early childhood for most stunted adolescents. Adolescence is a critical period of development as 15-20% of total height is achieved during this phase. This may present the final opportunity to increase adult height but there is a lack of high-quality longitudinal evidence on whether catch up growth during adolescence is even possible (34). A South African cohort study found that found that less than 2% of children experienced late incident stunting between the ages of 2 and 5 (35). In other words, most of the linear growth deficit had already occurred by the age of 2 years. In addition, only a quarter of children who were stunted at age 2 experienced enough catch up growth to no longer be stunted by age 5 (35). Interventions to increase dietary diversity among vulnerable groups can still improve nutritional outcomes and wellbeing but this may not necessarily translate into a meaningful reduction in stunting (36).

Neither hunger nor food insufficiency were associated with stunting for any age group, highlighting the limitations of experiential indicators in relation to stunting. The South African General Household Survey (GHS) uses the Household Food Insecurity Access Scale (HFIAS), an experiential scale which classifies households into three separate categories of severity (food secure, moderately food insecure or severely food insecure) for monitoring food security at a population level (37,38). The HFIAS was originally developed for food security surveys in the US population, where child stunting is very low and not considered a public health problem, unlike South Africa. Furthermore, responses to experiential scales like the HFIAS may vary dependent upon cultural and social contexts and this limits comparison of food insecurity prevalence across countries (16,39). However, there is substantial evidence for the protective effect of household dietary diversity against childhood stunting and this has been observed in numerous studies from LMIC (6,17,40,41). We found that medium dietary diversity was moderately associated with stunting among children <5 years and strongly associated with stunting among adolescents (OR 1.27 and 1.53). This suggests that children in the low to medium dietary diversity category are more likely to be malnourished and dietary diversity is an effective proxy for malnutrition.

While we did find that high proportion of food expenditure was associated with stunting among adolescents and reduced the risk of obesity among adults, expenditure data has several limitations as an indicator. These include that it is challenging to collect, and may be subject to recall bias and lacks generalizability across different regions and currency systems (16).

However, food expenditure is associated with both children's linear growth and dietary diversity in a number of studies (19,42). Furthermore, such data are routinely included in national surveys in many LMIC and so the association between longitudinal household food expenditure patterns, dietary diversity and children's linear growth could be the subject of more detailed research.

Although South Africa does not have public policies designed specifically to address childhood stunting, South Africa has an extensive Child Support Grant (CSG) program with over 12 million monthly disbursements to the caregivers of children aged 18 and under. The CSG is an unconditional cash transfer of R 400 (25 USD) per month to the primary caregiver. The CSG is intended to purchase food, school supplies and other essentials for low-income children. However, the CSG has not been effective in reducing the burden of stunting in South Africa. One potential reason for this is that the funds are insufficient to purchase even a basic food basket or that the funds are not used to purchase food (43,44). However, some studies have found that when coupled with maternal education (grade 8 or higher) the CSG has a small but significant impact on increasing children's HAZ scores (45). These findings suggest that the CSG may be more effective over time if maternal education level improve. A study from Mexico also found that maternal education mitigated the effects of child stunting and maternal overweight in a rural area (46).

However, the existing evidence suggests that even if they do experience catch up growth, children who were stunted at age two years perform almost as poorly in cognitive tests as children who remained stunted (35). This suggests that the first two years of life are critical for both linear growth and cognitive development and reinforces the need for interventions that can mitigate stunting in the first 1000 days of life (35). Thus, improvements in household dietary diversity may mitigate stunting during this critical period of development. However, dietary diversity needs to be consistently measured at the population level if policymakers are to identify vulnerable groups and develop effective interventions.

The double burden of malnutrition (DBM) is particularly common in LMIC countries like South Africa that have undergone a nutrition transition characterized by rapid changes in the food system and the availability of cheap and highly processed foods (7,47). Of the stunted children in this study, over 70% lived in households with overweight or obese adults (Table 7). Many stunted children may not experience hunger but will still be malnourished by a nutrient poor diet that consists primarily of starchy staples. This 'hidden hunger' may also

extend to many of their overweight or obese parents. The double burden of malnutrition is also visible among stunted children who are also overweight or obese. Although this study found that *low* dietary diversity was associated with stunting, we also found an inverse relationship with adult BMI whereby *increased* dietary diversity was associated with being overweight or obese. However, increased dietary diversity did not increase the risk of overweight/obesity among children or adolescents. As the direction of the associations go in opposite directions for stunting and obesity, further research is also needed to elucidate the relationship between dietary diversity and anthropometry across the full income range.

A longitudinal analysis of NIDS data that examined changes in BMI found that higher household income per capita was associated with a higher rate of change in weight gain (48). Thus, an improvement in living standards and economic progress is also a driver of the obesity epidemic in South Africa. Cultural preferences around different body types, sedentary lifestyles as well as a lack of knowledge and education around healthy foods and nutrition also play a role (49–52). However, the inclusion of three energy dense categories in the measure of dietary diversity as well as the 30 day recall period may also have contributed to this finding. Discerning to what extent rising obesity rates are driven by higher income and broader choices of food, or food insecurity coping strategies such as increased consumption of cheap processed foods requires rigorous longitudinal research (7,47).

Limitations

While dietary diversity is a good proxy for dietary quality and micronutrient adequacy, it also has limitations, as most dietary diversity measures do not include a separate category for processed foods, an important risk factor for overweight and obesity (16,53,54). In addition, dietary diversity does not capture the quantities of the diverse foods consumed and there is a lack of formal cut-offs or theory that links a number of food groups consumed to nutrient adequacy or overall sufficient quantity of food (13). Currently, there is no gold standard dietary diversity measure and the most widely used scales vary from between 7 and 15 food different food groups (16). The dietary diversity measure in this study had a 30 day recall period which may have falsely inflated the household scores. In addition, the measure also included sweets and syrups, oils and fats and beverages. These are energy dense but nutrient poor foods.

5.7 Conclusion

Stunting is a cumulative process and interventions to mitigate stunting at the beginning of the life course may be most effective for long term growth and developmental outcomes. Accurate monitoring of food and nutritional security at a population level is essential if LMIC hope to improve nutritional outcomes, particularly among vulnerable children. However, measures that are focused on hunger fail to capture important dimensions of dietary quality. Given the time and budget constraints of conducting large surveys, household dietary diversity data are relatively simple to collect and national surveys would be improved by their inclusion in addition to existing measures of food security.

This chapter has highlighted the importance of dietary diversity as an indicator for overall nutritional quality as well as its association with both adult and anthropometry. The association between various nutritional indicators and mental health is an emerging research interest and in recent years studies that examine mental health and nutrition have proliferated. The following chapter utilizes longitudinal data from NIDS and uses a composite measure of food insecurity to examine if maternal depression and food insecurity (both separately and in combination) are associated with continuous measures of birthweight and linear growth.

5.8 References

1. Dewey KG, Begum K. Long-term consequences of stunting in early life. Matern Child Nutr [Internet]. 2011 Oct [cited 2013 Nov 19];7 Suppl 3:5–18. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21929633
2. May J, Witten C, Lake L. South African Child Gauge 2020: Food and nutrition security. Cape Town; 2020.
3. Leroy JL, Frongillo EA. Perspective: What Does Stunting Really Mean? A Critical Review of the Evidence. Adv Nutr. 2019;10(2):196–204.
4. Mosites E, Dawson-Hahn E, Walson J, Rowhani-Rahbar A, Neuhouser ML. Piecing together the stunting puzzle: a framework for attributable factors of child stunting. Paediatr Int Child Health. 2017;37(3):158–65.
5. Prendergast AJ, Humphrey JH. The stunting syndrome in developing countries. Paediatr Int Child Health. 2014;34(4):250–65.
6. Gassara G, Chen J. Household food insecurity, dietary diversity, and stunting in sub-saharan africa: A systematic review. Nutrients. 2021;13(12).
7. Popkin BM, Corvalan C, Grummer-Strawn LM. Dynamics of the double burden of malnutrition and the changing nutrition reality. Lancet [Internet]. 2020;395(10217):65–74. Available from: http://dx.doi.org/10.1016/S0140-6736(19)32497-3
8. FAO. The State of Food Security and Nutrition in the World. Transforming food systems for food security, improved nutrition and affordable healthy diets for all [Internet]. Rome; 2021. Available from: https://doi.org/10.4060/ca9692en
9. Pourmotabbed A, Moradi S, Babaei A, Ghavami A, Mohammadi H, Jalili C, et al. Food insecurity and mental health: A systematic review and meta-analysis. Public Health Nutr. 2020;23(10):1778–90.

10. Leung CW, Epel ES, Willett WC, Rimm EB, Laraia BA. Household Food Insecurity Is Positively Associated with Depression among Low-Income Supplemental Nutrition Assistance Program Participants and Income-Eligible Nonparticipants. J Nutr. 2015;145(3):622–7.

11. Laraia B, Vinikoor-Imler LC, Siega-Riz AM. Food insecurity during pregnancy leads to stress, disordered eating, and greater postpartum weight among overweight women. Obesity. 2015;23(6):1303–11.

12. FAO. Food Security and Nutrition in the World. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing. 2018. 202 p.

13. Cafiero C, Melgar-Quiñonez HR, Ballard TJ, Kepple AW. Validity and reliability of food security measures. Ann N Y Acad Sci. 2014;1331(1):230–48.

14. Maxwell S. Food Security: A Post-modern Perspective. Brighton, England; 1994. Report No.: ISSN 1353-6141.

15. Nord M. Introduction to Item Response Theory applied to Food Security Measurement: Basic Concepts, Parameters and Statistics. 2014.

16. Headey D, Ecker O. Rethinking the measurement of food security: From first principles to best practice. Food Secur. 2013;5(3):327–43.

17. Steyn NP, Nel JH, Nantel G, Kennedy G, Labadarios D. Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy? Public Health Nutr. 2006;9(5):644–50.

18. Aboagye RG, Seidu A, Ahinkorah BO, Arthur-holmes F, Cadri A, Dadzie LK, et al. Dietary Diversity and Undernutrition in Children Aged 6-23 Months in Sub-Saharan Africa. 2021;1–22.

19. Otekunrin OA, Otekunrin OA, Ayinde IA, Sanusi RA, Onabanjo OO, Ariyo O. Dietary diversity , environment and health - related factors of under - five children : evidence from cassava commercialization households in rural. Environ Sci Pollut Res [Internet]. 2022;19432–46. Available from: https://doi.org/10.1007/s11356-021-17221-y

20. Hunter W, Patel L, Sugiyama NB. How family and child cash transfers can empower women: Comparative lessons from Brazil and South Africa. Glob Soc Policy. 2021;21(2):258–77.

21. Steyn NP, Nel JH, Drummond L, Malczyk S, Senekal M. Has Food Security and Nutritional Status Improved in Children 1–<10 Years in Two Provinces of South Africa between 1999 (National Food Consumption Survey) and 2018 (Provincial Dietary Intake Study (PDIS)). Int J Environ Res Public Health. 2022;19(3):1–21.

22. Stats SA. Towards measuring food security in South Africa: An examination of hunger and food inadequacy [Internet]. Pretoria: Statistics South Africa, Private Bag X44, Pretoria 0001; 2019. 26 p. Available from: www.statssa.gov.za

23. van der Berg S, Patel L, Bridgman G. Hunger in South Africa: Results from Wave 4 of NIDS-CRAM. 2021.

24. Spaull N, Tomlinson M. Feeding a Family on $ 300 a Month. Business Live.

25. Leibbrandt M, Woolard I, De Villiers L. Methodology : Report on NIDS Wave 1. 2009.

26. Lehohla P. Food security and agriculture 2002 – 2011: In-depth analysis of the General Household Survey data [Internet]. Vol. IV. Pretoria, South AFrica: Statistics South Africa, Private Bag X44, Pretoria 0001; 2012. Available from: http://www.statssa.gov.za/Publications2/Report-03-18-03/Report-03-18-032011.pdf

27. Gina Kennedy, Terri Ballard MD. Guidelines for measuring household and individual dietary diversity. FAO. 2010. 1–60 p.

28. Modjadji P, Molokwane D. Dietary Diversity and Nutritional Status of Preschool Children in North West Province , South Africa : 2020;1–14.

29. Smith LC, Subandoro A. Measuring Food Security Using Household Expenditure Surveys. Measuring Food Security Using Household Expenditure Surveys. International Food Policy Research Institute; 2007.

30. Ryan J, Leibbrandt M. Multidimensional Food Insecurity Measurement. SALDRU Working Paper No. 160. [Internet]. 2015. Available from: http://localhost:8080/handle/11090/793

31. WHO. WHO Child Growth Standards. Vol. 7, World Health Organization. Geneva; 2008.

32. De Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organ. 2007;85(9):660–7.

33. World Health Organization (WHO). Obesity and overweight. Vol. 13. 2020.

34. Campisi SC, Carducci B, Söder O, Bhutta ZA. The Intricate Relationship between Chronic Undernutrition , Impaired Linear Growth and Delayed Puberty : Is ‘ catch-up ’ growth possible during adolescence ? 2018.

35. Casale D, Desmond C, Richter LM. Catch-up growth in height and cognitive function: Why definitions matter. Econ Hum Biol. 2020;37.

36. USAID Nutrition Activities. Beyond Stunting Complementary Indicators for Monitoring and Evaluating USAID Nutrition Activities. 2021;(March). Available from: https://www.advancingnutrition.org/resources/beyond-stunting-complementary-indicators-monitoring-and-evaluating-usaid-nutrition

37. Coates J, Frongillo EA, Rogers BL, Webb P, Wilde PE, Houser R, et al. What Are We Assessing When We Measure Food Security? A Compendium and Review of Current Metrics. Adv Nutr [Internet]. 2013;4(February):481–505. Available from: http://www.elgaronline.com/view/9780857939371.xml

38. Cafiero C, Viviani S, Nord M. Food security measurement in a global context: The food insecurity experience scale. Meas J Int Meas Confed [Internet]. 2018;116(November):146–52. Available from: http://dx.doi.org/10.1016/j.measurement.2017.10.065

39. Leroy JL, Ruel M, Frongillo EA, Harris J, Ballard TJ. Measuring the food access dimension of food security: A critical review and mapping of indicators. Food Nutr Bull. 2015;36(2):167–95.

40. Kaibi FKM, Steyn NP, Ochola SA, Plessis L Du. The relationship between agricultural biodiversity , dietary diversity , household food security , and stunting of children in rural Kenya. 2016;243–54.

41. Chandrasekhar S, Aguayo VM, Krishna V, Nair R. Household food insecurity and children’s dietary diversity and nutrition in India. Evidence from the comprehensive nutrition survey in Maharashtra. Matern Child Nutr. 2017;13(October 2016):1–8.

42. Weingarten SE, Dearden KA, Crookston BT, Penny ME, Behrman JR, Humphries DL. Are household expenditures on food groups associated with children’s future heights in Ethiopia, India, Peru, and Vietnam? Int J Environ Res Public Health. 2020;17(13):1–23.

43. Devereux S, Waidler J. Why does malnutrition persist in South Africa despite social grants? Food Security SA Working Paper Series No. 001. 2017.

44. Khosa P, Kaseke E. The Utilisation of the Child Support Grant by caregivers: The case of Ba-Phalaborwa Municipality in Limpopo Province. Soc Work. 2014;50(4):504–15.

45. DSD, SASSA, UNICEF. The South African Child Support Grant Impact Assessment: Evidence form a survey of children [Internet]. 2012. Available from: https://www.unicef.org/evaldatabase/files/The_South_African_Child_Support_Grant_Impact_Assessment.pdf

46. Leroy JL, Habicht J-P, González de Cossío T, Ruel MT. Maternal Education Mitigates the Negative Effects of Higher Income on the Double Burden of Child Stunting and Maternal Overweight in Rural Mexico. J Nutr. 2014;144(5):765–70.

47. Popkin BM, Gordon-Larsen P. The nutrition transition: worldwide obesity dynamics and their determinants. Int J Obes Relat Metab Disord [Internet]. 2004;28 Suppl 3(Suppl 3):S2-9. Available from: http://www.researchgate.net/publication/8184173_Popkin_BM_Gordon-Larsen_P._The_nutrition_transition_worldwide_obesity_dynamics_and_their_determinants._Int_J_Obes_Relat_Metab_Disord_28(Suppl)_S2-S9

48. Cois A, Day C. Obesity trends and risk factors in the South African adult population. BMC Obes. 2015;2(1):1–10.

49. Venter F, Walsh C, Slabber M, Bester C. Body size perception of African women (25-44 years) in Manguang. J Fam Ecol Consum Sci /Tydskrif vir Gesinsekologie en Verbruikerswetenskappe. 2009;37(1).

50. Mwaka1 NPSMLNNM, Affiliations: Nutrition knowledge , attitudes and practices o f primary school children in Tshwane. African J Prim Heal Care Fam Med. 2019;1–7.

51. Van Den Berg VL, Okeyo AP, Dannhauser A, Nel M. Body weight, eating practices and nutritional knowledge amongst university nursing students, Eastern Cape, South Africa. African J Prim Heal Care Fam Med. 2012;4(1):1–9.

52. Shisana O, Labadarios D, Rehle T, Simbayi L, Zuma K, Dhansay A, Reddy P, Parker W, Hoosain E, Naidoo P, Hogoro C, Mchiza Z S. The South African National Health and Nutrition Examination Survey, 2012 SANHANES-1. CAPiTiLPRESS; 2014. 423 p.

53. Purushotham A, Mittal N, Ashwini BC, Umesh KB, Taubadel S von C-, Vollmer S. A quantile regression analysis of dietary diversity and health outcomes among children and women in the rural-urban interface of India Anjali. Food Policy [Internet]. 2003;107(1):6–8. Available from: https://doi.org/10.1016/j.foodpol.2021.102216

54. Steyn N, Nel J, Nantel G, Kennedy G, Labadarios D. Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy? Public Health Nutr. 2006;9(5):644–50.

Chapter 6 MATERNAL DEPRESSION, BIRTHWEIGHT AND LINEAR GROWTH

6.1 Abstract

Background

Literature is inconclusive regarding an association with maternal depression, low birthweight (LBW) and stunting in early childhood. While some studies have found an association, others have not. Maternal food insecurity is a risk factor for both maternal depression and reduced linear growth in early childhood.

Objectives

This study examined the relationship between maternal depression, food insecurity, LBW and stunting in the first five years of life. The study employed longitudinal data of South African women and children from the National Income Dynamics Study (NIDS).

Methods

The primary outcomes were a comparison of means for birthweight and height-for-age (HAZ) scores. Mothers were classified into four groups (food insecure and depressed, food insecure only, depressed only, and neither food insecure nor depressed). During data collection, 22% of women were pre-conception and the remaining 78% were pre-pregnancy. Generalised Linear Mixed (GLM) Effects models were used to account for women having more than one child. GLM with a Gaussian link function was used to compare mean differences in birthweight and height-for-age scores. Multiple regression models were used to examine factors associated with depression.

Results

Food insecurity was significantly associated with depression in the pre-pregnancy and pre-conception period. There was no statistically significant difference in birthweight or linear growth across groups, but this may be influenced by proximity of depression measurement in relation to outcomes.

Conclusions

Food insecurity is a potentially modifiable risk factor for depression and may be a confounding factor in studies that have found associations between depression and child health outcomes.

6.2 Background

There is mixed evidence regarding an association between maternal depression in the pre-pregnancy and pre-conception periods with both maternal and child health outcomes. Some studies find associations with outcomes that include pregnancy complications and reduced birthweight while other studies fail to do so (1–5). Potential biological causal pathways for these associations include the release of stress hormones that may reduce placental blood flow and lead to subsequent restricted foetal growth and possible preterm birth (3).

The evidence on maternal depression and stunting is also mixed with some studies observing an association with maternal depression in the postnatal period and stunting in early childhood while other studies find no association (6–8). A review of the evidence base that examined the relationship between maternal depression and stunting in studies from Africa, South America and Asia, suggested a moderate statistically significant relationship between maternal depression and linear growth in children (7). Although the causal pathways for this relationship remain unclear it has been suggested that depressed mothers are less likely to breastfeed and that the children of depressed mothers experience more frequent episodes of childhood illnesses that may compromise linear growth (7).

Numerous studies have noted an association between food insecurity and maternal depression in the pre-conception period (9–11). Other risk factors for maternal depression include intimate partner violence, low educational attainment, and a lack of social support (9). In addition to individual exposures, observational epidemiological studies suggest that household level traumatic events could be associated with maternal depression. These include food insecurity or the illness of a household member that can be related to the onset of depressive symptoms, suggesting a complex causal pathway (10,12).There has been little research that has explored the role of these factors in relation to both maternal depression and child health outcomes in LMIC countries. This study sought to fill a gap in the literature by utilizing cohort data of South African women and their offspring to address two aims. These are: 1. To examine household stressors and other factors associated with maternal depression

in the pre-pregnancy and pre-conception period and 2. To examine the relationship between pre-pregnancy and pre-conception maternal depression and food security in relation to birthweight and linear growth in early childhood.

6.3 Methods

Study Design and Sample

This study analysed publicly available data from Wave 1 (2008) and Wave 3 (2012) of the South African National Income Dynamics Study (SA-NIDS), a nationally representative panel survey of households in South Africa (13). The study used a retrospective cohort method and focused on early childhood health outcomes among 1431 children in relation to maternal exposures of food insecurity and depression among 1208 women who gave birth between Wave 1 and Wave 2 of NIDS (2008-2011). During data collection in Wave 1, most women were pre-pregnancy (78%) and 22% were pre-conception.

Data collection

Food insecurity information was only available in Wave 1 of NIDS (2008). Depression data and individual maternal characteristics were also collected in Wave 1. Maternal data from Wave 1 were matched with child data from Wave 3 (2012).

Ethics Approval

The SA-NIDS was approved by the Ethics Committee of the Commerce Faculty, University of Cape Town, and the de-identified datasets are publicly available. Ethics approval for this secondary analysis, which is part of a doctoral thesis of the first author was obtained from the University of the Witwatersrand Research Ethics Committee (protocol number M1909101, see Appendix 1).

The components of the secondary analysis on which this paper is based are described below:

Inclusion and exclusion criteria

We limited our analysis to women aged between 15 and 44 as younger adolescents and older mothers are both at increased risk of obstetric complications and LBW and may differ systematically from the average woman in the pre-conception period (14). We excluded women who had recently given birth as the aetiology and consequences of postnatal

depression may differ from that in the pre-pregnancy or pre-conception period. Children were aged between one and five years at the time of data collection in Wave 3 with a mean age of 30.7 months.

Measures

Depression

Depression was both an outcome and an exposure in this study. Maternal depressive symptoms were measured using the CES-D scale. This 10-item Likert scale questionnaire measures depressive symptoms in the past week (13). The instrument includes three items on depressed affect, five items on somatic symptoms, and two on positive affect. Total scores can range from 0 to 30 with increased scores indicative of more severe symptoms. A recent validation study recommended a cut-off between 11 and 13 for a South African population depending on the language of the CES-D translation used in the survey (Afrikaans, Zulu or Xhosa) (15). This study sample consisted of predominantly Zulu and Xhosa speakers and we therefore used a cut-off of 12 to define maternal depression.

Food Insecurity

The severity of food insecurity was described using a continuous score between 0 and 6, utilizing a methodology of multidimensional poverty measurement. This adapted composite measure of food insecurity includes three separate domains (anxiety about food supply, food quality and food utilization). Individual indicators include adult and child hunger, household food sufficiency, dietary diversity, proportion of household expenditure on food and maternal underweight BMI (16). Each indicator is assigned a value of 0 or 1, with the final score being a minimum of 0 (food secure) and a maximum of 6 (severely food insecure). The final score was examined as a continuous and binary (domain insecure) variable.

Maternal and household characteristics associated with depression

The NIDS questionnaire includes self-reported household stressors such as a household member becoming ill, crop failure or a social grant ending in the past 24 months and the authors examined these as well as maternal socio-demographic characteristics for associations with depression. Demographic characteristics include maternal age categories pre-defined by the NIDS investigators, years of education, employment status, marital status, having ever given birth before and social grant status.

Outcomes

The primary outcomes are a comparison of means of infant birthweight in grams and a comparison of means of childhood height-for-age scores (HAZ) in the first five years of life. Children's Z scores were calculated using the WHO child growth standards (17) .

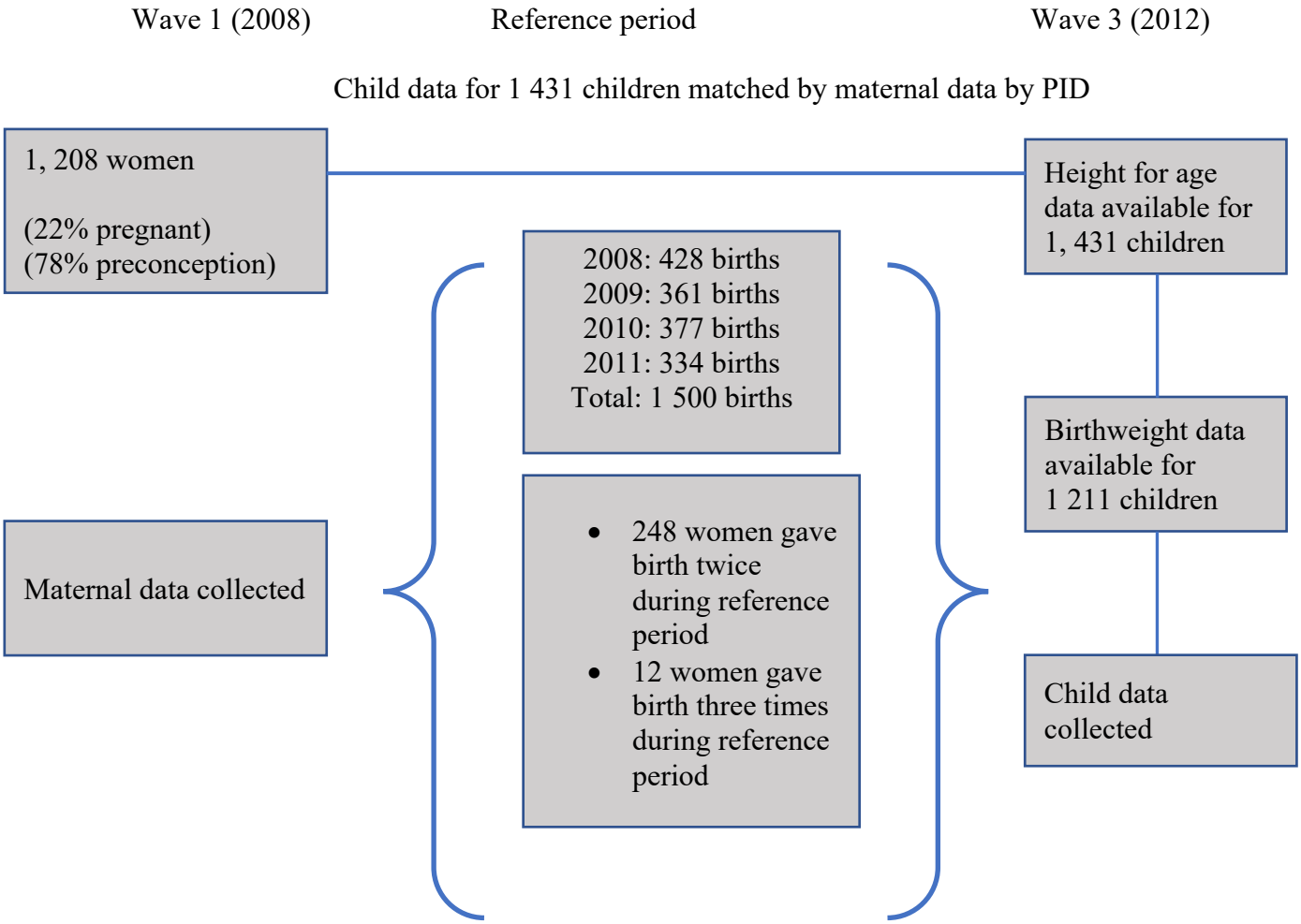
Data Analysis

Descriptive Analysis

Generalized Linear Mixed (GLM) effects models were used to account for clustering due to multiple births or mothers who gave birth more than once during the reference period. Generalized Linear Mixed effects model with a logit link function was used to explore food security indicators, household stressors and maternal characteristics associated with depression. Significant variables were included in the final multivariate regression model. To avoid collinearity in the final model, the authors included only the composite food security score and excluded individual indicators.

In the second part of analyses that focused on child health outcomes, children were classified according to the following four maternal categories: mother depressed only, mother food insecure only, mother both food insecure and depressed, and mother neither depressed nor food insecure (reference category) in Wave 1. Generalized Linear Mixed Effects Model with a Gaussian link function was used to compare differences in mean birthweight and height-for-age scores among children. Analyses were conducted using post stratification weights to adjust for the panel design of the study.

Figure 6.1: Consort Diagram of Study Participants



6.4 Results

Table 6.1 and Table 6.2 present results of bivariate and multivariate characteristics associated with depression. We matched data from 1208 mothers with 1431 children. Birthweight data were available for 1211 children and height-for-age scores were available for 1254 children. Depression data as well as food security scores were available for the full sample of women in the study. There were a total of 1500 births during the reference period. Height for age scores were available for 1 431 children (95% of the total sample) and birthweight was available for 1 211 children (81% of the total sample). The large percentage of children missing birthweight data (almost 20%) may have caused an under or overestimation of the true prevalence of low birthweight in the sample. However, the prevalence of low birthweight in the study was 14.67% which is closely aligned with other large cohorts that have examined birthweight in South Africa.

Table 6-3 presents the mean birthweight in grams and Table 6-4 presents height-for-age scores with maternal depression and food insecurity as exposures. For both birthweight and height-for-age scores, the reference category (neither food insecure or depressed) had the most children followed by children of mothers who were food insecure only and then children whose mothers were depressed only. The smallest group was comprised of children whose mothers were both food insecure and depressed.

Table 6-1: Logistic regression model of food security indicators and maternal characteristics associated with depression during the pre-pregnancy and pre-conception period

Household Characteristics associated with depression	Unadjusted OR (95% Confidence Intervals)	p value
Food security score (N=1208)	1.25 (1.13 – 1.37)	P<0.001
Hungry child in household (N=1115)	1.70 (1.20 – 2.40)	0.003
Hungry adult in household (N=1204)	1.62 (1.18 – 2.24)	0.003
Domain insecure (N=1208)	1.44 (1.05 -1.98)	0.022
Dietary diversity (continuous) (N=1205)	0.90 (0.85 – 0.96)	0.002
Maternal Characteristics associated with depression	Unadjusted OR (95% Confidence Intervals)	p value
Maternal age 35-39 (N=1205)	1.82 (1.01-3.28)	0.046
Previously given birth (N=1148)	1.64 (1.19-2.26)	0.003
Maternal education in years (continuous) (N=1207)	0.91 (0.86 – 0.96)	P<0.001

The results of initial bivariate logistic regression analyses find that most of the food insecurity indicators as well as the composite score were significantly associated with

maternal depression. The food security indicators most strongly associated with depression were self-reported adult and child hunger in the household in the past 12 months. The maternal characteristics most strongly associated with depression were maternal age between 35 and 39 and having previously given birth. Increased years of maternal education had a protective effect. The household stressors were significant in unadjusted analyses but lost significance when the panel design of the study was adjusted for.

Table 6-2: Multivariable model of factors associated with depression during the pre-pregnancy and pre-conception period

Depression (N=223) 18.46% prevalence	Adjusted Coefficient (95% Confidence Intervals)	p value
Composite food security score	1.28 (1.14-1.45)	P<0.001
Maternal education	0.90 (0.84-0.97)	0.008

In the final multivariable model, the food insecurity score and years of maternal education were the only factors significantly associated with depression, with each additional year of education reducing the risk of depression.

Table 6-3 Mean birthweight by exposures to maternal depression and food insecurity

Maternal Status	Mean Birthweight (grams), (95% CI)	Coefficient and SE	p-value
Depressed only (N=147)	3051g., (2962-3141)	-7.33 (52.71)	0.889
Domain Food insecure only (N=259)	3045 g., (2945-3146)	22.69 (38.75)	0.558
Food insecure and depressed (N=69)	3117 g., (3002-3233)	83.76 (71.35)	0.240
Not depressed or food insecure (N=736)	3115 g., (3045-3182)	Reference group	

There was no statistically or clinically significant difference in birthweight between groups. Of the four categories, the lowest mean birthweight was found among women who were food insecure only, followed by women who were depressed only.

Table 6-4: Mean and height-for-age scores (HAZ) by exposures to maternal depression and food insecurity

Maternal Status	Mean HAZ, (95% CI)	Coefficient and SE	p-value
Depressed only (N=148)	-1.03 (-1.52 - -0.64)	0.058 (0.18)	0.747
Domain Food insecure only N=261	-1.27 (.-1.55- -1.00)	0.032 (0.132)	0.807
Food insecure and depressed N=76	-1.46 (-2.04- -0.89)	-0.138 (0.226)	0.542
Not depressed or food insecure N=769	-1.03 (-2.04- -0.89)	Reference Group	

The highest mean birthweight was found among women who were both depressed and food insecure but this group was very small (5.7% of the total sample). Notably, mean birthweight in depressed and/or food insecure groups were all above 3000g, well above the cut-off for LBW.

There was no statistically or clinically significant difference in height-for-age-scores between the groups. The lowest height-for-age scores were found among the children of women who were both depressed and food insecure, on average, their height differed by 0.43 SD from that of children in the reference category. The children in the reference category had the highest height-for-age scores.

6.5 Discussion

This study has yielded several important findings, both significant and non-significant. Significant findings include; prevalence estimates of food insecurity and depression of 27% and 18.46% respectively. Most of the food security indicators were significantly associated with an increased risk of depression while each additional year of maternal education offered a protective effect as presented in Table 1 and 2. The study found no significant differences in birthweight or height-for-age scores across groups in relation to maternal depression. These data are presented in in Table 6-3 and Table 6-4.

The prevalence estimates of food insecurity and depression are not unsurprising when compared to previous studies albeit use of different measures. Depression prevalence was 18.46%, a similar finding to other studies that have examined antenatal depression in South African women (2,10). In our final multivariable analysis model, each unit increase of the food insecurity score was associated with a 28% increased likelihood of depression. This association has been well described in several studies from LMIC and high-income settings and remains across studies despite the use of different measures for both food insecurity and depression (10,18,19). Notably, each unit increase of dietary diversity reduced the risk of depression by 10% in this sample, highlighting that the causal pathway between food insecurity and depression may be twofold. The stress and anxiety of insufficient food as well as the adverse physiological outcomes of a poor-quality diet and insufficient micronutrients may both contribute to low mood. In the final model, each additional year of maternal education offered a protective effect against depression, an effect that has been observed in

studies of the pre-conception and postnatal period and reinforces the value of investing in education for girls (20).

The finding that maternal depression was not associated with a statistically significant decrease in birthweight as presented in Table 3 has been observed in several studies from South Africa, Pakistan, the US and Korea (2,21–23). However, some studies have suggested an association between depression and gestational age, a factor not measured in this study (23,24). In contrast to our findings, another study using NIDS data did find an association with LBW in mothers who were depressed prior to their pregnancies but some differences may be attributable to methodological differences. For example, the study was conducted prior to the validation study cited earlier and used a cutoff of 10 to define depressive symptoms as well as examining birthweight as a binary outcome (1,15). Two studies that found associations with LBW and maternal depression noted that the size of the effect varied depending upon the instrument used to measure depression as well as geographical location, with women in developing countries at greater risk for LBW and preterm birth , a risk factor for LBW (3,25). Notably, the children of women in the food insecure group had the lowest mean birthweight but depression did not appear to play an additional role. In the case of HAZ scores, the combination of depression and food insecurity had the greatest deviations from the norm, partly due to the small sample size of this group. The authors of the study examined the outcomes of interest across four different groups and dividing the food insecure into two separate categories may have reduced sample size to the degree that differences were no longer statistically significant.

The impact of maternal depression on birthweight and child growth outcomes is complex as the severity, time of assessment and length of depressive symptoms must be considered through consistent repeated measurement and longitudinal designs. Our study did not include repeated assessments of depression and may therefore have missed women with chronic depression. In addition, the use of a cutoff limits information on the severity of depression between women. Research in a low income community in South Africa found that depressive symptoms in the pre-conception phase subsided during the postpartum phase for over 90% of women, suggesting that pre-conception depression tends to be episodic for the majority of women (11). The finding of the CES-D validation study in South Africa that different cut-offs across language groups maximize sensitivity and specificity highlights the complexity of

interpreting depression prevalence estimates in ethnically and culturally diverse populations like South Africa (15).

We found no significant association between maternal depression and linear growth in early childhood, as presented in Table 4. This may be partially due to the proximity of depression measurement in relation to the outcome as our study did not examine postnatal depression. However, these findings are consistent with another study that explored post-partum depression at 2 and 18 months in relation to early childhood growth in an informal settlement in South Africa and did not find an association (8). In contrast to our findings, some studies from South Asia and Africa have found a significant association with early childhood stunting and maternal depression (7,26). The LMIC where associations between maternal depression and reduced linear growth have been found include Ethiopia, Pakistan, India and Zambia, all countries where food and diet, household food security, socioeconomic status and breastfeeding practices may vary considerably from those in South Africa. Food insecurity in particular may be an important confounding factor that can contribute to maternal depression as well as birthweight and linear growth but is not sufficiently explored or adjusted for in systematic reviews on stunting or birthweight (3,7,25).

In the final model, each additional year of maternal education offered a protective effect against depression, an effect that has been observed in studies of the pre-conception and postnatal period and reinforces the value of investing in education for girls (20). The finding that parity as well as the presence of a hungry child in the household increases the risk of depression among women in the pre-conception period has been observed in two other South African studies (11,14). Initial bivariate analyses noted that women who had previously given birth were more likely to be depressed than first time mothers. Thus, the addition of more children in the household puts a greater strain on scarce resources and increases the risk of household food insecurity and depression among women in LMIC settings.

6.6 Limitations

Longitudinal information was not available on food security and the authors assumed that food security and/or depression status would continue pre-conception and postnatally for some women in the sample. Depression data for most of this sample were collected preconception and this may limit inferences about depression and child outcomes. The CES-D is a general screening tool, not specifically related to pre-conception or postnatal

depression and does not constitute a clinical diagnosis of depression. The data does not include information on preterm birth, an important risk factor for LBW.

6.7 Conclusion

This study highlighted the profound impact of food insecurity on maternal depression but found no statistically significant difference in relation to birthweight or linear growth across groups. We suggest rigorous longitudinal research to examine both the relationships between food insecurity and antenatal depression and to clarify the effect of the latter on child growth. Furthermore, intervention research designs should be used to examine the effects of strategies that alleviate maternal food insecurity during the pre-conception period such as a proposed extension of the child support grant (CSG) into pregnancy. Such interventions may reduce the incidence of depression and improve maternal mental health outcomes in the South African context.

Using baseline maternal data from the Recession in 2008, the following chapter examines categorical measures of birthweight (the primary outcome) and stunting and severe stunting (the secondary outcome) in relation to individual food security indicators as well as other maternal and demographic characteristics associated with low birthweight and stunting in the literature.

6.8 References

1. Tomita A, Labys CA, Burns JK. Depressive Symptoms Prior to Pregnancy and Infant Low Birth Weight in South Africa. Matern Child Health J. 2015;19(10):2179–86.
2. MacGinty RP, Kariuki SM, Barnett W, Wedderburn CJ, Hardy A, Hoffman N, et al. Associations of antenatal maternal psychological distress with infant birth and development outcomes: Results from a South African birth cohort. Compr Psychiatry [Internet]. 2020;96:152128. Available from: https://doi.org/10.1016/j.comppsych.2019.152128
3. Grote, N.K. Bridge, J.A. Gavin, A.R. Melville, J.L. Iyengar, S. Katon WJ. A meta-analysis of depression during pregnancy and the risk of preterm birth, low birth weight, and intrauterine growth restriction. Arch Womens Ment Health [Internet]. 2011;14(10):S26. Available from: http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L70557360%5Cnhttp://dx.doi.org/10.1007/s00737-010-0203-1
4. Nasreen HE, Kabir ZN, Forsell Y, Edhborg M. Low birth weight in offspring of women with depressive and anxiety symptoms during pregnancy: Results from a population based study in Bangladesh. BMC Public Health. 2010;10.
5. Accortt EE, Cheadle ACD, Dunkel Schetter C. Prenatal Depression and Adverse Birth Outcomes: An Updated Systematic Review. Vol. 19, Maternal and Child Health Journal. 2015. 1306–1337 p.
6. Wemakor A, Mensah KA. Association between maternal depression and child stunting in Northern Ghana: A cross-sectional study. BMC Public Health [Internet]. 2016;16(1):1–7. Available from: http://dx.doi.org/10.1186/s12889-016-3558-z

7. Surkan PJ, Kennedy CE, Hurley KM, Black MM. Maternal depression and early childhood growth in developing countries: systematic review and meta-analysis. Bull World Health Organ. 2011;89(8):607–15.

8. Tomlinson M, Cooper PJ, Stein A, Swartz L, Molteno C. Post-partum depression and infant growth in a South African peri-urban settlement. Child Care Health Dev. 2006;32(1):81–6.

9. Fisher J, de Mello MC, Patel V, Rahman A, Tran T, Holton S, et al. Prevalence and determinants of common perinatal mental disorders in women in low-and lower-middle-income countries: A systematic review. Bull World Health Organ. 2012;90(2):139–49.

10. Abrahams Z, Lund C, Field S, Honikman S. Factors associated with household food insecurity and depression in pregnant South African women from a low socio-economic setting: a cross-sectional study. Soc Psychiatry Psychiatr Epidemiol [Internet]. 2018;0(0):0. Available from: http://www.ncbi.nlm.nih.gov/pubmed/29445850%0Ahttp://link.springer.com/10.1007/s00127-018-1497-y

11. Garman EC, Schneider M, Lund C. Perinatal depressive symptoms among low-income South African women at risk of depression: Trajectories and predictors. BMC Pregnancy Childbirth. 2019;19(1):1–11.

12. Hadley C, Tegegn A, Tessema F, Cowan JA, Asefa M, Galea S. Food insecurity, stressful life events and symptoms of anxietry and depression in east Africa: Evidence from the Gilgel Gibe growth and development study. J Epidemiol Community Health. 2008;62(11):980–6.

13. Leibbrandt M, Woolard I, De Villiers L. Methodology : Report on NIDS Wave 1. 2009.

14. Blencowe H, Krasevec J, de Onis M, Black RE, An X, Stevens GA, et al. National, regional, and worldwide estimates of low birthweight in 2015, with trends from 2000: a systematic analysis. Lancet Glob Heal [Internet]. 2019;7(7):e849–60. Available from: http://dx.doi.org/10.1016/S2214-109X(18)30565-5

15. Baron EC, Davies T, Lund C. Validation of the 10-item Centre for Epidemiological Studies Depression Scale (CES-D-10) in Zulu, Xhosa and Afrikaans populations in South Africa. BMC Psychiatry [Internet]. 2017;17(1):1–14. Available from: http://dx.doi.org/10.1186/s12888-016-1178-x

16. Ryan J, Leibbrandt M. Multidimensional Food Insecurity Measurement. SALDRU Working Paper No. 160. [Internet]. 2015. Available from: http://localhost:8080/handle/11090/793

17. WHO. WHO Child Growth Standards. Vol. 7, World Health Organization. Geneva; 2008.

18. Ayano G, Tesfaw G, Shumet S. Prevalence and determinants of antenatal depression in Ethiopia: A systematic review and meta-analysis. PLoS One. 2019;14(2):e0211764.

19. van Heyningen T, Myer L, Onah M, Tomlinson M, Field S, Honikman S, et al. Antenatal depression and adversity in urban South Africa. J Affect Disord [Internet]. 2016;203:121–9. Available from: http://dx.doi.org/10.1016/j.jad.2016.05.052

20. Gelaye B, Rondon M, Araya R, Williams M. Epidemiology of maternal depression, risk factors, and child outcomes in low-income and middle-income countries. Lancet Psychiatr. 2016;3(10):1562–72.

21. Husain N, Munshi T, Jafri F, Husain M, Parveen A, Saeed Q, et al. Antenatal depression is not associated with low birth weight: A study from urban Pakistan. Front Psychiatry. 2014;5(NOV):1–5.

22. M. Christopher AMLS. Depression During Pregnancy and Adverse Birth Outcomes Among Predominantly Puerto Rican Women. Physiol Behav. 2016;176(1):100–106.

23. Chang HY, Keyes KM, Lee K, Choi IA, Joo S, Kim KW, et al. Prenatal maternal depression is associated with low birth weight through shorter gestational age in term infants in Korea. Early Hum Dev. 2014;90(1):15–20.

24. Dadi AF, Miller ER, Mwanri L. Antenatal depression and its association with adverse birth outcomes in low and middleincome countries: A systematic review and meta-analysis. PLoS One [Internet]. 2020;15(1):1–23. Available from: http://dx.doi.org/10.1371/journal.pone.0227323

25. Ghimire U, Papabathini SS, Kawuki J, Obore N, Musa TH. Depression during pregnancy and the risk of low birth weight, preterm birth and intrauterine growth restriction- an updated meta-analysis. Early Hum Dev [Internet]. 2021;152(October 2020):105243. Available from: https://doi.org/10.1016/j.earlhumdev.2020.105243

26. Tomlinson M, Rotheram-Borus MJ, Scheffler A, le Roux I. Antenatal depressed mood and child cognitive and physical growth at 18-months in South Africa: a cluster randomised controlled trial of home visiting by community health workers. Epidemiol Psychiatr Sci. 2018 Dec;27(6):601–10.

Chapter 7 HOUSEHOLD FOOD INSECURITY & BIRTH AND GROWTH OUTCOMES

7.1 Abstract

Background

Low birthweight (LBW) as well as early childhood stunting are risk factors for increased childhood morbidity in low-and middle-income countries (LMIC). The Covid 19 pandemic has exacerbated food insecurity and unemployment globally, prompting concerns for maternal and child health.

Objectives

We used data from the great recession of 2008 to examine the relationship between household food security and other risk factors with LBW and stunting using a longitudinal sample of South African women and their offspring.

Methods

Food security indicators, alcohol use, blood pressure and other characteristics were examined in relation to LBW (≤2500g), stunting (height for age ≤2SD) and severe stunting (height for age ≤3SD). Regression modelling with clustering at maternal ID level were employed to adjust for maternal characteristics and women who gave birth more than once during the reference period.

Results

Birthweight data were available for 1 173 children and height for age 1 216 children. The prevalence of LBW was 14.7 % while stunting and severe stunting was 17.8% and 14.5%. Child hunger in the household, maternal hypertension and alcohol use were associated with low birthweight. Food expenditure below the Stats SA poverty line and low dietary diversity was associated with stunting and severe stunting respectively. Maternal height and low birthweight were associated with both stunting and severe stunting.

Conclusion

Interventions that can improve periconceptional and antenatal food security and nutritional status may reduce the prevalence of low birthweight and subsequent stunting in low- and middle-income countries. Further research is needed to elucidate these relationships.

Significance

What is already known on this subject?

Household food insecurity is associated with stunting in cross-sectional studies but less is known about the impact of periconceptional and antenatal food insecurity in relation to low birthweight.

What this study adds?

Utilizing longitudinal data, this study found that women who reported a child in the household going hungry were significantly more likely to deliver a low birthweight infant. Low food expenditure and low dietary diversity in the periconceptional period were also associated with stunting and severe stunting among children five years later. Interventions to improve periconceptional food security may reduce LBW and subsequent stunting.

Key words: dietary diversity, food insecurity, linear growth, low birthweight, food expenditure, LMIC

7.2 Introduction

Pregnancy and the postpartum period are vulnerable times for women in both high and low and middle income (LMIC) countries. In LMIC many pregnant women live in poverty and may experience a number of stressors including intimate partner violence, economic hardship and food insecurity (1,2). The Covid 19 pandemic and the subsequent economic fallout has increased rates of food insecurity and unemployment globally but the long-term implications for maternal and child health are still unfolding. A recent study of pregnancy and birth outcomes in LMIC during the pandemic noted a decrease in antenatal care but no increase in low birthweight (3) Data from the recession in 2008 may provide some insights into how social and economic shocks impact maternal and child health. Studies from

Portugal and Spain both observed a significant increase in low birthweight during the years of the recession (4,5).

In the South African context, studies of two longitudinal cohorts have observed associations with LBW in mothers who smoke or drink alcohol as well as those with overweight or obese BMI (6,7). A study among pregnant women in an urban area of South Africa found no association with household food insecurity and low birthweight while another birth cohort study in South Africa found that food insecurity was associated with lower infant gestational age (8,9). In South Africa and other countries undergoing a nutrition transition, the association between food insecurity and birth outcomes is further complicated by high levels of maternal overweight and obesity, a separate risk factor for pregnancy and birth complications.

These findings, albeit inconsistent, suggest that preconception and antenatal food insecurity may be related to adverse child health outcomes. A review of the literature suggests that there are few longitudinal data on preconception food insecurity and low birthweight in South Africa. This study examined the relationship between maternal demographic and antenatal characteristics including household food insecurity indicators during the periconceptional and antenatal period with birthweight and stunting in the first five years of life using data from a longitudinal population-based survey.

7.3 Methods

The South African National Income Dynamics Study (SA-NIDS) is a nationally representative government funded panel survey of over 28000 individuals in 7300 households across South Africa. The study aims to track post-apartheid inequality and poverty over time. NIDS utilized a stratified two-stage cluster sample design to randomly select 400 of Statistics South Africa's 3000 primary sampling units (PSUs) for inclusion in the surveys (10). The components of the secondary analysis on which this paper is based are described below:

Sample

The current paper utilized data from Wave 1 and 3 of NIDS. Maternal data was collected in wave 1 (2008). The data from women who became pregnant between Wave 1 and 2 of the study were linked with the data of their children from Wave 3 conducted in 2012. Brief intervals between pregnancies and delivery are a risk factor for low birthweight so we chose

to include women who gave birth more than once during the reference period (11,12). We linked data of 1208 women with 1 391 children born between 2008 and 2011. During data collection, most women (78%) were periconceptional while 21% were in the antenatal stage. The mean time to birth from data collection in 2008 was 21 months.

Inclusion and exclusion criteria

We limited our analysis to singleton births of women between 15 and 44 because younger adolescents and older mothers are both at increased risk of obstetric complications and LBW (13). Data on children were limited to those born between 2008 and 2011 to ensure proximity to the time of exposure. We excluded children who had already been born at the time of data collection in Wave 1 (2008) and multiple births. At the time of data collection in Wave 3, children were aged between 4 months and 55 months with a mean age of 30 months.

Ethical Statement

The SA-NIDS was approved by the Ethics Committee of the Commerce Faculty, University of Cape Town, and the de-identified datasets are publicly available. Ethics approval for this secondary analysis was obtained from the University of the Witwatersrand Research Ethics Committee protocol number M1909101 (See Appendix 1).

Measures

Food Insecurity

The definition of food security is evolving over time and the past two decades have seen a shift from indicators like anthropometry to more subjective measures of food security such as hunger (14). Although this study did not include a validated measure of food security, it did examine several household level indicators that literature suggests exist on a spectrum of food security. We will hereinafter refer to these as food security indicators for brevity. The five indicators are: adult and child hunger in the household, household food sufficiency, dietary diversity and monthly per capita food expenditure below the Stats SA food poverty line of R274. In 2021, this inflation adjusted amount was equivalent to R 624 or roughly 43.3 USD.

Hunger and nutrition indicators

Adult and child hunger

Questions on household hunger were asked separately for adults and children. In the past 12 month did an adult/child in the household go hungry? Responses were never, seldom, sometimes, often or always.

Household food sufficiency

In the past 12 months please describe the household food consumption in relation to household's needs. It was less than adequate, it was just adequate, it was more than adequate.

Dietary diversity

A household dietary diversity score (HDDS) based on 30-day recall was calculated using the Food and Agriculture Organization (FAO) guidelines (15). The HDDS is comprised of 32 individual food types and 12 different food groups. We examined dietary diversity as both a continuous variable and binary variable.

Food Expenditure

Per capita food expenditure was calculated by dividing total household monthly food expenditure by the number of household members. Income and expenditure data were imputed by the NIDS team. We used the Statistics South Africa food poverty line cut off of R 274 per capita for 2008 (equivalent to 42.16 USD using Stats SA most recent food poverty line for 2021).

Covariates for the birthweight model

In addition to the primary exposures of food security indicators, we included maternal demographic factors associated with LBW in the literature. These included maternal age categories, parity, maternal height, BMI categories, years of education, alcohol and tobacco use, depression status, employment and blood pressure (12). At the household level we included geotype.

Alcohol use

Respondents were asked how often they consumed alcohol. Due to the low number of responses among women who reported drinking alcohol in any quantity, we created a binary indicator by combining women who reported that they never drank or no longer drink into a single category that we classified as not consuming alcohol. Women who reported drinking in any quantity were classified as consuming alcohol, regardless of their pregnancy status.

Tobacco use

Respondents were asked if they smoked cigarettes and we used this binary indicator to classify women as smokers or non-smokers, regardless of their pregnancy status.

Depression

Depressive symptoms were measured using the CES-D (Center for Epidemiologic Studies Depression Scale). We used a cut-off of 12 to define depression in this sample (16).

Employment

Women were categorized as employed or unemployed. Women who were classified as not economically active or seeking employment were also classified as unemployed.

Education

Maternal education was examined as a continuous variable with each unit representing one year of education. Maternal education in this sample ranged between 9 and 18 years with a mean of 9.86 years.

Covariates for the stunting model

In addition to the food security indicators we examined maternal height, years of education, low birthweight, household size, geotype, child's age in months, child's sex and whether child received a child support grant (CSG). This is a government funded monthly disbursement of R 480 ZAR (equivalent to 28.8 USD in 2022) to the primary caregivers of children and is intended to purchase food, school supplies and other essentials.

Primary Outcomes

The primary outcome is a binary measure of LBW (≤2500g). We included births that were recorded as 2500 grams because although birthweight data are normally distributed, heaping birthweight measurement at 2500 grams is common practice in the public sector in LMIC to avoid the need for further interventions among LBW infants. In addition, this rounding of birthweight data also occurs due to digit bias for numbers that end in 0 or 5 (13,17). The secondary outcome is childhood stunting (height for age ≤2SD) and severe stunting (height for age ≤3SD) in the first five years of life calculated using the WHO child growth standards (18).

Statistical Analyses

Several steps were undertaken to complete the analyses. These accounted for both individual and household level data. Logistic regression modelling was used to examine relationship between low birthweight or stunting and maternal risk actors.

The standard errors in the logistic regression models were estimated using the clustered robust method to account for the clustering due to multiple births. Initial bivariate analyses were conducted to explore covariates associated with LBW, stunting and severe stunting. All variables in the bivariate analyses were added to the model and the variables that were no longer significant were removed from the final model. Time to birth from the time of data collection was adjusted for in the final birthweight model. We conducted separate analyses among women who gave birth more than once during the reference period to examine if pregnancy spacing was associated with low birthweight but we found no relationship and all women were thus included in the final model.

We used logistic regression for the final LBW model and multivariable regression for the final stunting model in children aged 4-55 months. All analyses were conducted using Stata Version 15).

7.4 Results

Sample characteristics

We linked the data from 1208 mothers with the data from their children (N= 1 391) who were born between Wave 1 and 2 (2008-2011). Of this sample, 84.5% (1173) children had

birthweight data, 87.4% (1216) had height for age data and 86.1% (1 198) had weight for height data (see Figure 7.1). Both birthweight and weight for height scores were available for 71.7% (998) children. Maternal characteristics are presented in Table 7-1.

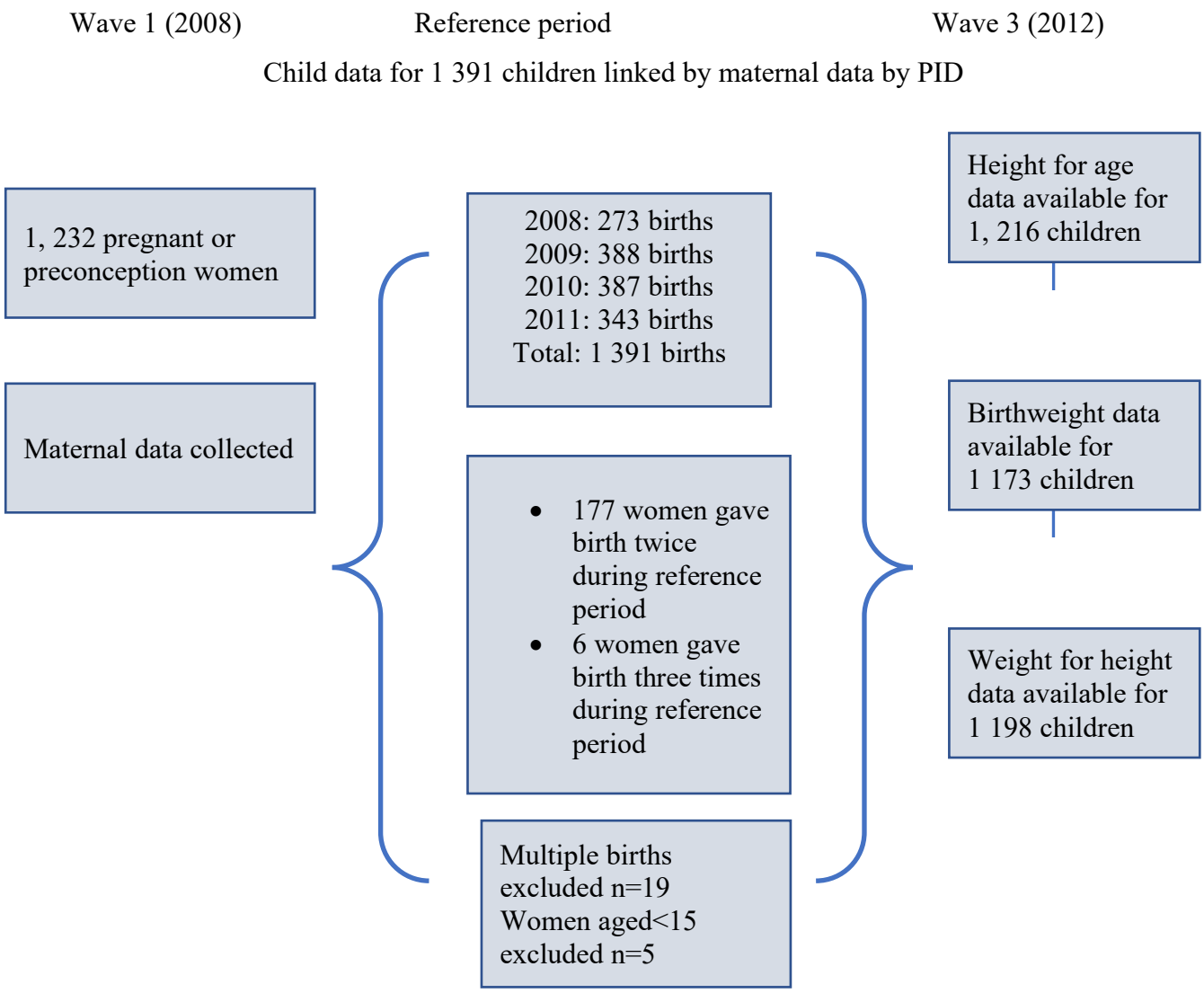


Figure 7.1: Participant flowchart

Most women in the sample were of Black African ethnicity and resided in urban areas. The multiple social and economic vulnerabilities of our sample are visible in the high proportion of adolescents (30%) and unemployment (73.5%) among these women. In addition, most respondents were unmarried (74.1%) and did not live with a partner. Almost half of respondents were overweight or obese (BMI>= 25) (47.4%) and 59.5% had previously given birth.

Table 7-1: Maternal and child socio-demographic characteristics of the sample with birthweight data

Maternal Variable (Wave 1)	**Categories**	**Overall % (n)**
Race* (N=1016)	Black	82.2 (835)
	Mixed Race	15.3 (156)
	Indian and White	1.5 (25)
Age Intervals (N=1016)	15-19	30 (302)
	20-29	46.2 (470)
	30-39	22.2 (225)
	40+	1.7 (17)
Geotype (N=1016)	Traditional*	42.3 (430)
	Urban	49.7 (505)
	Farm	8 (81)
Employment Status (N=948)	Unemployed/not economically active	73.5 (697)
	Employed	26.5 (251)
Marital Status (N=962)	Married/living with partner	24.6 (236)
	Divorced or widowed	1.2 (13)
	Never married	74.1 (713)
Maternal BMI (N=1016)	Underweight (BMI<18.5)	9.5 (96)
	Normal (BMI 18.5-24.9)	43.2 (439)
	Overweight (BMI 25-29.9)	27.1 (275)
	Obese (BMI >30)	20.3 (206)
Ever given birth (N=965)	Yes	59.5 (574)
	No	40.5 (391)
Depressed (N=1 016)	Yes	16.1 (164)
	No	83.9 (852)
Child Variable (Wave 3)		
Gender (N=1173)	Male	47.3 (618)
	Female	52.7 (618)
Child grant recipient (N=1213)	Yes	77.3 (907)
	No	22.7 (266)

* We use these categories developed by the South African Apartheid System. Our intention is not to reinforce the differences between races but rather awareness that there are disparities in health reflected by race. Traditional geotype denotes communally-owned land under the jurisdiction of traditional leaders. Settlements within these areas are villages.

Table 7-2 presents the various food security indicators for households with birthweight data. Among these, the most reported food security indicator was per capita food expenditure

below the Stats SA poverty with 81.2% of households falling into this category. Mean food expenditure was R215 per capita, considerably below the poverty line.

Table 7-2: Food security indicators for the sample with birthweight data

Indicator	**% (n)**
Child hunger in the past year	
Never	68.7 (745)
Seldom	8.6 (93)
Sometimes	18.6 (202)
Often	3.6 (39)
Always	0.5 (5)
Adult hunger in the past year	**% (n)**
Never	65.6 (767)
Seldom	8.4 (98)
Sometimes	21.5 (251)
Often	4.1 (48)
Always	0.4 (5)
Household food adequacy	**% (n)**
Less than adequate	44 (513)
It was just adequate	43 (501)
It was more than adequate	13 (152)
Food Expenditure	**% (n)**
Below poverty line	81.2 (953)
Above poverty line	18.8 (220)
Dietary diversity	**Mean, SD**
Continuous score 1-12	9.1 (2.2)
	% (n)
Low dietary diversity <9	35.7 (418)

The next most common indicator was insufficient household food adequacy in the past 12 months which was reported in 44% of households. The mean dietary diversity score was 9.1 with a standard deviation of 2.2 and 35.7% of households had low dietary diversity (a score of less than 9).

The most severe growth restriction as well as the highest proportion of overweight and obesity occurred in the 4–24-month age range and subsequently declined. Among children in the 4–24-month category, 15.1% were stunted and 24.7% were severely stunted. More than a quarter (26%) of children in this age group were also overweight or obese (see Table 7-3).

Table 7-3: Child anthropometry by age category

Indicator	**Child age category**			
Height for age	4-24 months % (n)	25-48 months % (n)	49-55 months % (n)	Total % (n)
Normal height (HAZ >-2SD)	60.2 (231)	71.6 (537)	68.3 (56)	67.8 (824)
Stunted (HAZ<-2SD)	15.1 (58)	19.2 (144)	17.1 (14)	17.8 (216)
Severely stunted (HAZ<-3SD)	24.7 (95)	9.2 (69)	14.6 (12)	14.4 (176)
Total	100 (384)	100 (750)	100 (82)	100 (1 216)
Indicator	**Child age category**			
Weight for height	4-24 months % (n)	25-48 months % (n)	49-60 months % (n)	Total % (n)
Normal weight (WAZ >-2)	66.9 (263)	79.5 (582)	83.6 (61)	75.6 (906)
Wasted or severely wasted (WAZ<-2)	7.1 (28)	5.5 (40)	5.5 (4)	6 (72)
Overweight or obese	26 (102)	15 (110)	10.9 (8)	18.4 (220)
Total	100 (393)	100 (732)	100 (73)	100 (1 198)

Birthweight information was available for 1 173 children. Mean birthweight was 3 102 grams with a SD of 531 grams. The prevalence of LBW in the sample was 14.7 % (a total of 172 babies).

Variables that remained significant in the final model were households that reported a child ‘sometimes’ going hungry, Stage 1 maternal blood pressure, and women who reported drinking alcohol in any quantity. These findings are presented in Table 7.4 presents the anthropometric characteristics of children measured in Wave 3. Height-for-age scores were available for 1216 children and weight-for-height scores were available for 1198 children. The prevalence of stunting and severe stunting was 17.8% and 14.4% respectively with 216 children classified as stunted (height for age score <-2 SD) and 176 as severely stunted (height for age score <-3 SD). A total of 18.4% of children classified as overweight or obese (weight for height Z score>2 SD) while 6% of children were wasted (weight for height Z score <-2 SD).

The most severe growth restriction as well as the highest proportion of overweight and obesity occurred in the 4–24-month age range and subsequently declined. Among children in the 4–24-month category, 15.1% were stunted and 24.7% were severely stunted. More than a quarter (26%) of children in this age group were also overweight or obese.

Birthweight information was available for 1 173 children. Mean birthweight was 3 102 grams with a SD of 531 grams. The prevalence of LBW in the sample was 14.7 % (a total of 172 babies).

Variables that remained significant in the final model were households that reported a child 'sometimes' going hungry, Stage 1 maternal blood pressure, and women who reported drinking alcohol in any quantity. These findings are presented in Table 7-4.

Table 7-4: Unadjusted and adjusted measures of the effect of maternal characteristics on low birthweight logistic regression model

Bivariate regression model	**% (n)**	**Unadjusted OR, Confidence Intervals**	**p value**
Overweight BMI	27.1 (275)	0.52 (0.29-0.90)	0.021
Stage 1 maternal blood pressure	18.1 (252)	1.60 (1.06-2.40)	0.025
Child hunger in household	18.8 (243)	1.59 (1.06-2.38)	0.029
Adult hunger in household	21.5 (251)	1.29 (0.87-1.91)	0.199
Household food less than adequate	44 (513)	1.50 (0.85-2.65)	0.162
Smokes tobacco	7.6 (84)	1.76 (1.03-2.98)	0.042
Drinks alcohol	10.8 (143)	1.57 (0.96 – 2.56)	0.070
Rural Geotype	42.3 (430)	1.00 (0.71-1.41)	0.995
Maternal height	NA	0.99 (0.97-1.01)	0.295
Parity	NA	0.98 (0.86-1.10)	0.687
Multiple regression model		**Adjusted OR, Confidence Intervals**	**p value**
Drinks alcohol	10.8 (143)	1.78 (1.08-2.94)	0.023
Stage 1 maternal blood pressure	18.1 (252)	1.61 (1.02-2.51)	0.038
Child hunger in household	18.8 (243)	1.53 (1.01-2.35)	0.049

Bivariate analyses

In bivariate analyses, food expenditure below the poverty line doubled the risk of stunting (RRR= 1.97) while low dietary diversity increased the risk of severe stunting (RRR 1.87). Male children were more likely to be severely stunted than female children although there were no gender differences among stunted children. Somewhat surprisingly, child hunger in the household was not associated with stunting. Low birthweight was associated with stunting but not severe stunting.

Children who received a child support grant were significantly more likely to be stunted than children who received no grant. This suggests that the children in this sample who do receive a grant are more disadvantaged and experience a generally deficient growth environment (see Table 7-5).

Table 7-5: Unadjusted bivariate analyses of the effect of independent variables on stunting and severe stunting in children aged 4–55 months with relative risk ratios

Stunting (ZHFA<-2SD)	**Unadjusted relative risk ratio, Confidence Intervals**	**p value**
Food Poverty Line (R274)	1.97 (1.24-3.11)	0.004
Dietary Diversity score (continuous)	0.97 (0.91-1.04)	0.362
Low Dietary Diversity (score<9)	1.07 (0.77-1.47)	0.647
Child hunger in household	1.09 (0.73-1.62)	0.814
Maternal height in cm	0.94 (0.92-0.96)	0.000
Maternal education	0.97 (0.92-1.02)	0.277
Male child	1.21 (0.90-1.62)	0.217
Receives child grant	1.67 (1.11-2.50)	0.013
Low birthweight (≤2500g)	1.85 (1.21-2.84)	0.005
Childs age in months	0.94 (0.92-0.96)	0.000
Maternal education	0.97 (0.92-1.02)	0.277
Household size	1.02 (0.97-1.06)	0.469
Severe Stunting (ZHFA<-3SD)	**Unadjusted relative risk ratio, Confidence Intervals**	**p value**
Food poverty line (R274)	1.73 (1.06-2.81)	0.028
Dietary Diversity score (continuous)	0.90 (0.84-0.97)	0.003
Low Dietary Diversity (score<9)	1.87 (1.30-2.55)	P<0.000
Child hunger in household	1.19 (0.76-1.85)	0.445
Maternal height in cm	0.96 (0.93-0.99)	0.009
Maternal education	0.93 (0.87-0.98)	0.013
Male child	1.54 (1.11-2.12)	0.009
Receives child grant	1.13 (0.76-1.68)	0.534
Low birthweight (≤2500g)	1.52 (0.94-2.44)	0.085
Childs age in months	0.97 (0.96-0.98)	0.000
Maternal education	0.93 (0.87-0.98)	0.013
Household size	1.00 (0.96-1.06)	0.862

Variables associated with stunting and severe stunting were combined in a final multivariable regression model. In the final model, maternal height and low birthweight were the only

variables associated with both stunting and severe stunting with increased maternal height offering a protective effect.

Table 7-6: Multivariable models of adjusted measures of the effect of independent variables on stunting and severe stunting in children aged 4–55 months with relative risk ratios

Stunting (ZHFA<-2SD)	**Adjusted relative risk ratio, Confidence Intervals Multinomial regression model**	**p value**
Low dietary diversity	0.74 (0.50-1.11)	0.145
Food poverty line (R274)	2.31 (1.27-4.22)	0.006
Low birthweight (≤2500g)	1.71 (1.05-2.78)	0.030
Maternal height	0.95 (0.92-0.97)	P<0.000
Childs age in months	1.00 (0.99-1.02)	0.762
Male child	1.17 (0.81-1.68)	0.398
Severe Stunting (ZHFA<-3SD)	**Adjusted relative risk ratio, Confidence Intervals Multinomial regression model**	**p value**
Low dietary diversity	1.57 (1.05 -2.34)	0.027
Food poverty line (R274)	1.21 (0.69-2.12)	0.498
Low birthweight (≤2500g)	1.76 (1.06-2.93)	0.028
Maternal height	0.96 (0.94-0.99)	0.008
Childs age in months	0.97 (0.96-0.99)	0.002
Male child	1.57 (1.08-2.29)	0.018

The food security indicators that remained significant in the final model were household food expenditure below the poverty line which increased the risk of stunting and low household dietary diversity which increased the risk of severe stunting. Boys were more likely to be severely stunted than girls and the risk of severe stunting decreased with each month of children's age (see Table 7-6).

7.5 Discussion

This study has revealed important findings about household food insecurity during the preconception and antenatal periods and its association with child health outcomes in the first five years of life. We found that women who reported a child in the household sometimes going hungry were significantly more likely to give birth to a low birthweight infant during the reference period. Furthermore, LBW was a significant risk factor for stunting as children aged. These findings highlight the importance of adequate maternal nutrition during the first 1000 days to mitigate the prevalence of low birthweight and subsequent stunting in LMIC.

The prevalence of LBW in the sample was 14.7 % and is closely aligned with recent cohort studies of birthweight in South Africa (6,7). We found that child hunger in the household was significantly associated with low birthweight but adult hunger was not. Food insecurity is a managed process and longitudinal data suggests that adults will often forego meals themselves to shield their children from hunger (19). Thus, women that reported children going hungry may represent the most disadvantaged and nutritionally deprived households. We also found that the prevalence of low birthweight in this sample was highest during the recession in 2008 (16.4%) and subsequently declined each year to 12.9% by 2011. These differences were not statistically significant, but this may be due to the relatively low sample size. Given that an increase in low birthweight was observed in high income countries it seems plausible that South Africa would also have experienced an increase in LBW as a result of the recession (4,5).

Although maternal alcohol use was not significantly associated with LBW in bivariate analysis (P 0.07), once it was added to the final model and we adjusted for the time lag between data collection and birth, women who reported drinking alcohol in any quantity were significantly more likely to deliver a low birthweight infant. In this study, 10.8% of women reported drinking alcohol, a result that is comparable to a cohort study in the Western Cape that observed antenatal alcohol use among 18% of women (6). Although our study included both periconceptional and pregnant women, South Africa has one of the highest rates of Fetal Alcohol Syndrome (FAS) globally which suggests that alcohol use continues into the antenatal period for some women. Food insecurity may also increase the risk of drinking among women who face multiple social and economic adversities. A study among urban mothers in South Africa found that food insecurity was strongly associated with postnatal depression as well as hazardous drinking. These findings reinforce the importance of food security for psychological well-being as well being a potential risk factor for hazardous drinking, thereby compounding the risk of low birthweight (20).

Our final model also found that maternal hypertension was significantly associated with LBW, an association that has been observed in a systematic review (21). Hypertension has been linked to food security, obesity and increased BMI as well as poor quality diets, higher salt intake and chronic stress (22). Thus, hypertension may lie on the causal pathway between food insecurity and low birthweight.

Our study found a similar stunting prevalence to other South African cohorts that examined linear growth in children age 24-60 months and noted prevalence estimates between 26% and 34% (6,23). The link between LBW and stunting has been well described in previous literature with an analysis of cohort data from LMIC estimating 2.5-3.5 higher odds of stunting among LBW infants (24). In our final multivariable stunting model we found that LBW increased the risk of stunting (RRR 1.71) and severe stunting (RRR 1.76). These findings suggest that some aspects of childhood undernutrition and subsequent linear growth have origins in the foetal period and highlight the importance of maternal nutrition both preconceptionally and antenatally (13,24). Increased maternal height also offered a protective effect against stunting and severe stunting in the final model. This is well documented as stunting is a recurrent process and mothers who were themselves stunted are more likely to have stunted offspring (25).

Food expenditure below the poverty line was associated with stunting in the final mode. Such data are a useful proxy for food security although these results are less precise than some other measures of food insecurity (14). In the final model, low dietary diversity was associated with severe stunting. This has emerged as a risk factor for stunting in studies from LMIC is often associated with child anthropometry across geographical regions (26). Somewhat surprisingly, child and adult hunger were not associated with stunting in this sample. This is of as interest as most large surveys currently employ access and hunger-based measures to measure food security at the national scale.

Although food security is not static and subject to change, the use of longitudinal data is one of the strengths of this study and these findings indicate that chronic household food insecurity during the periconceptional and antenatal period likely extends into the early years of childhood and is associated with both low birthweight and restricted linear growth. These findings are reinforced by a study in Bangladesh with a five year recall period which found that household food security tended to be relatively stable and preconception food insecurity continued into the antenatal period (27). Maternal malnutrition (both underweight and obesity) is associated with adverse child growth outcomes including low birthweight, macrosomia, foetal growth as well as child HAZ at two years of age (28,29).

We also found that the prevalence of severe stunting decreased as children grew older, this is not surprising as previous studies suggest that stunting tends to peak around 24 months and subsequently decrease (Prendergast & Humphrey, 2014). In addition, boys were more likely

to be severely stunted than girls. This finding has been observed in a a systematic review of sex related differences in undernutrition (33). The reasons for this may be both social as well as biological. Girls may spend more time at home and have more regular access to food than boys and boys may be weaned earlier than girls (33). Biologically, boy infants are also more susceptible to infections and birth complications in early childhood which can predispose them to stunting as they age (34).

The emphasis on child growth and development in the first thousand days is based not only on the magnitude of growth restriction that occurs in this time period but on the adverse consequences throughout the life course including reduced cognitive function and an increased risk of chronic disease in adulthood (25). In this sample, 25% of children aged 24 months and under were severely stunted and many will never reach their full growth potential as a result. Thus, interventions that improve periconceptional maternal nutritional status are particularly important in settings where stunting is prevalent (35).

7.6 Limitations

Data on gestational age were not available and preterm birth (a leading cause of LBW) could not be included in our analyses (13,24). In the absence of a validated measure for food insecurity this study examined the relationship between various food security indicators and child health outcomes. These indicators were collected at the household level and the questionnaire was answered by oldest woman in the household. This is standard for household level surveys and given that data was not collected at the individual level we don't feel that this would have introduced substantial bias.

7.7 Conclusion

Reducing the high prevalence of stunting in South Africa and other LMIC is an enormous challenge given the multiple social and biological determinants of linear growth restriction. However, interventions that can improve household food insecurity and maternal nutritional status in the periconceptional period may reduce the prevalence of low birthweight and subsequent stunting (35,36). Improving maternal nutritional status in the first 1000 days is an important first step to mitigate the intergenerational transfer of poor health and developmental outcomes.

Given the adverse consequences of household food insecurity for maternal and child health alike, the following chapter focused on maternal depression and food insecurity in relation to Covid-19. This study used data from Momconnect, a government database of pregnant women and new mothers across South Africa. Data were collected in June and July of 2020, shortly after the hard lockdown was implemented. This study also includes a qualitative component where women were asked to share their main worries at the time of data collection.

7.8 References

1. Fisher J, de Mello MC, Patel V, Rahman A, Tran T, Holton S, et al. Prevalence and determinants of common perinatal mental disorders in women in low-and lower-middle-income countries: A systematic review. Bull World Health Organ. 2012;90(2):139–49.
2. van Heyningen T, Myer L, Onah M, Tomlinson M, Field S, Honikman S, et al. Antenatal depression and adversity in urban South Africa. J Affect Disord [Internet]. 2016;203:121–9. Available from: http://dx.doi.org/10.1016/j.jad.2016.05.052
3. Naqvi S, Naqvi F, Saleem S, Thorsten VR, Figueroa L, Mazariegos M, et al. Health care in pregnancy during the COVID- - 19 pandemic and pregnancy outcomes in six low- - and- - income countries : Evidence from a prospective , observational registry of the Global Network for Women ' s and Children ' s Health. 2022;2019(March):1298–307.
4. Kana MA, Correia S, Peleteiro B, Severo M, Barros H. Impact of the global fi nancial crisis on low birth weight in Portugal : a time-trend analysis. 2017;(October 2008):1–11.
5. Teran JM, Varea C, Juarez S, Bernis C, Bogin B. Social disparities in low birth weight among Spanish mothers during the economic crisis (2007-2015). Nutr Hosp. 2018;129–41.
6. Budree S, Stein DJ, Brittain K, Goddard E, Koen N, Barnett W, et al. Maternal and infant factors had a significant impact on birthweight and longitudinal growth in a South African birth cohort. Acta Paediatr Int J Paediatr. 2017;106(11):1793–801.
7. Jeena PM, Asharam K, Mitku AA, Naidoo P, Naidoo RN. Maternal demographic and antenatal factors, low birth weight and preterm birth: findings from the mother and child in the environment (MACE) birth cohort, Durban, South Africa. BMC Pregnancy Childbirth. 2020;20(1):1–11.
8. Madlala S. The dietary diversity, household food security status and presence of depression in relation to pregnancy pattern of weight gain and infant birth weight. University of KwaZulu-Natal; 2017.
9. Zar HJ, Pellowski JA, Cohen S, Barnett W, Vanker A, Koen N, et al. Maternal health and birth outcomes in a South African birth cohort study. PLoS One. 2019;14(11):e0222399.
10. Leibbrandt M, Woolard I, De Villiers L. Methodology : Report on NIDS Wave 1. 2009.
11. Bauserman M, Nowak K, Nolen TL, Patterson J, Lokangaka A, Tshefu A, et al. The relationship between birth intervals and adverse maternal and neonatal outcomes in six low and lower-middle income countries. Reprod Health [Internet]. 2020;17(Suppl 2):1–10. Available from: http://dx.doi.org/10.1186/s12978-020-01008-4
12. Blencowe H, Krasevec J, de Onis M, Black RE, An X, Stevens GA, et al. National, regional, and worldwide estimates of low birthweight in 2015, with trends from 2000: a systematic analysis. Lancet Glob Heal. 2019;7(7):e849–60.
13. Blencowe H, Krasevec J, de Onis M, Black RE, An X, Stevens GA, et al. National, regional, and worldwide estimates of low birthweight in 2015, with trends from 2000: a systematic analysis. Lancet Glob Heal [Internet]. 2019;7(7):e849–60. Available from: http://dx.doi.org/10.1016/S2214-109X(18)30565-5

14. Coates J, Frongillo EA, Rogers BL, Webb P, Wilde PE, Houser R, et al. What Are We Assessing When We Measure Food Security? A Compendium and Review of Current Metrics. Adv Nutr [Internet]. 2013;4(February):481–505. Available from: http://www.elgaronline.com/view/9780857939371.xml

15. Gina Kennedy, Terri Ballard MD. Guidelines for measuring household and individual dietary diversity. FAO. 2010. 1–60 p.

16. Baron EC, Davies T, Lund C. Validation of the 10-item Centre for Epidemiological Studies Depression Scale (CES-D-10) in Zulu, Xhosa and Afrikaans populations in South Africa. BMC Psychiatry [Internet]. 2017;17(1):1–14. Available from: http://dx.doi.org/10.1186/s12888-016-1178-x

17. Gladstone ME, Salim N, Ogillo K, Shamba D, Gore-Langton GR, Day LT, et al. Birthweight measurement processes and perceived value: qualitative research in one EN-BIRTH study hospital in Tanzania. BMC Pregnancy Childbirth [Internet]. 2021;21(Suppl 1):1–11. Available from: http://dx.doi.org/10.1186/s12884-020-03356-2

18. WHO. WHO Child Growth Standards. Vol. 7, World Health Organization. Geneva; 2008.

19. Radimer KL, Olson CM, Greene JC, Campbell CC, Habicht J-P. Understanding hunger and developing indicators to assess it in women and children. J Nutr Educ [Internet]. 1992;24(1, Supplement 1):36S-44S. Available from: https://www.sciencedirect.com/science/article/pii/S0022318212801373

20. Dewing S, Tomlinson M, Le Roux IM, Chopra M, Tsai AC. Food insecurity and its association with co-occurring postnatal depression, hazardous drinking, and suicidality among women in peri-urban South Africa. J Affect Disord [Internet]. 2013;150(2):460–5. Available from: http://dx.doi.org/10.1016/j.jad.2013.04.040

21. Getaneh T, Negesse A, Dessie G, Desta M. The impact of pregnancy induced hypertension on low birth weight in Ethiopia: systematic review and meta-analysis. Ital J Pediatr. 2020;46(1):1–11.

22. Cois A, Ehrlich R. Analysing the socioeconomic determinants of hypertension in South Africa: A structural equation modelling approach. BMC Public Health. 2014;14(1).

23. Casale D, Espi G, Norris SA. Estimating the pathways through which maternal education affects stunting: Evidence from an urban cohort in South Africa. Public Health Nutr. 2018;21(10):1810–8.

24. Christian P, Lee SE, Angel MD, Adair LS, Arifeen SE, Ashorn P, et al. Risk of childhood undernutrition related to small-for-gestational age and preterm birth in low- and middle-income countries. Int J Epidemiol. 2013;42(5):1340–55.

25. de Onis M, Branca F. Childhood stunting: A global perspective. Matern Child Nutr. 2016;12:12–26.

26. Headey D, Ecker O. Rethinking the measurement of food security: From first principles to best practice. Food Secur. 2013;5(3):327–43.

27. Chowdhury M, Dibley MJ, Alam A, Huda TM, Raynes-Greenow C. Household Food Security and Birth Size of Infants: Analysis of the Bangladesh Demographic and Health Survey 2011. Curr Dev Nutr [Internet]. 2018;2(3):1–8. Available from: https://academic.oup.com/cdn/article/doi/10.1093/cdn/nzy003/4851100

28. Young MF, Nguyen PH, Casanova IG, Addo OY, Tran LM, Nguyen S, et al. Role of maternal preconception nutrition on offspring growth and risk of stunting across the first 1000 days in Vietnam : A prospective cohort study. 2018;1–13.

29. Melchor I, Burgos J, Campo A, Aiartzaguena A, Gutiérrez J, Melchor JC. Effect of maternal obesity on pregnancy outcomes in women delivering singleton babies : a historical cohort study. 2019;47(6):625–30.

30. Black RE, Allen LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M, et al. Maternal and child undernutrition: global and regional exposures and health consequences. Lancet. 2008;371(9608):243–60.

31. Casale D, Desmond C, Richter LM. Catch-up growth in height and cognitive function: Why definitions matter. Econ Hum Biol. 2020;37.

32. Prendergast AJ, Humphrey JH. The stunting syndrome in developing countries. Paediatr Int Child Health. 2014;34(4):250–65.

33. Thurstans S, Opondo C, Seal A, Wells J, Khara T, Dolan C, et al. Boys are more likely to be undernourished than girls: A systematic review and meta-analysis of sex differences in undernutrition. BMJ Glob Heal. 2020;5(12):1–17.

34. Sawyer CC. Child Mortality Estimation: Estimating Sex Differences in Childhood Mortality since the 1970s. PLoS Med. 2012;9(8).

35. Krebs NF, Hambidge KM, Westcott JL, Garc AL, Figueroa L, Tsefu AK, et al. Growth from Birth Through Six Months for Infants of Mothers in the. 2020;

36. Lassi ZS, Kedzior SGE, Tariq W, Jadoon Y, Das JK. Effects of Preconception Care and Periconception Birth Outcomes in Low- and Middle-Income. Nutrients. 2020;12(606).

Chapter 8 "GIVING MY BABY THE LIFE SHE DESERVES AND PROTECTING HER FROM COVID-19": HOUSEHOLD SHOCKS, FOOD INSECURITY AND MATERNAL DEPRESSIVE SYMPTOMS AMONGST SOUTH AFRICAN MOTHERS

8.1 Abstract

Background

Social and economic shocks expose pregnant women and new mothers to hunger and distress, with those residing in low- and middle-income countries being more vulnerable. The recent pandemic provided a window to study reactions to a major shock, enabling policy makers and health practitioners to understand how such shocks impact maternal mental health, and how to mitigate this impact in the future. This study uses data from a mobile survey of mothers and pregnant women in South Africa conducted in June and July of 2020.

Objectives

This study reports the prevalence of maternal depressive symptoms (as measured by the Patient Health Questionnaire-2 (PHQ-2)) and household hunger, and examines maternal characteristics associated with depressive symptoms. We study the association between district-level COVID-19 prevalence, maternal depression, and household hunger. We asked respondents to share their main worry to provide insight into this vulnerable group of women at the height of the pandemic.

Methods

A short message system (SMS) survey of pregnant women and new mothers was conducted via the MomConnect platform, an initiative of the South African Department of Health to support maternal health using mobile technology. The survey was conducted in two rounds, in June and July 2020. The second round of the survey included an open-ended question about respondents' main worry answered in their own words, which was then categorised thematically.

Results

The prevalence of maternal depressive symptoms was 16%. The prevalence of child and adult hunger was 10.5% and 15.7% respectively. Both child and adult hunger had a significant and positive association with depressive symptoms in mothers. In mixed effects models, the district-level prevalence of COVID-19 in the month of the survey had a positive and significant association with child and adult hunger, and with depressive symptoms in mothers. The main concerns among surveyed women were hunger, unemployment, and the risk of COVID-19 infection.

Conclusion

Interventions that improve maternal food security may be more effective than those that focus strictly on mental health. Pregnant women and new mothers are particularly vulnerable to social and economic shocks like the COVID-19 pandemic and should be prioritised for social protection programs.

8.2 Introduction

Maternal depression during the antenatal and postpartum period is a common psychological disorder with negative consequences for mothers and children alike (1–5). Evidence from systematic reviews has suggested a higher prevalence of maternal depression among women in low- and middle-income countries (LMIC) (6,7). Women in resource-poor settings face numerous adversities associated with poverty including food insecurity, low education levels, and poor-quality healthcare, all of which may contribute to maternal depression. In the South African context, studies among low-income women have noted prevalence estimates of food insecurity between 30% and 59% (8–10). Cross-sectional studies have also observed a prevalence of maternal depression between 21% and 31%, and noted the consistent association between food insecurity and depression (8,9,11).

Contemporary societies are marked by an ever-increasing range, and frequency of shocks, including natural disasters (12), forced migration (13), infectious disease outbreaks (14), and conflicts (12). These shocks have well-documented negative impacts upon women, particularly women of child-bearing age (15,16). In addition, vulnerable women in LMIC are more likely to be exposed to psychosocial stressors such as gender-based violence, addiction, and a lack of social support (6,8,9), which can increase mental health problems, and undermine resilience.

The recent COVID-19 pandemic is a salient example of a shock which negatively affected women and children in a variety of ways, including health and educational outcomes as well as social and economic security (17,18). In many LMICs, the pandemic had far-reaching consequences for maternal and child health including decreased access to antenatal care and basic childhood vaccinations for babies and young children (19,20). A large surge in unemployment further reduced access to food and placed additional strain on vulnerable mothers (21). Surveys show that women in South Africa were severely affected by the "hard" lockdown in April and May of 2020 and the subsequent economic fallout. The National Income Dynamic Survey Coronavirus Rapid Mobile Survey (NIDS-CRAM) showed that in June 2020, women represented 2 out of every 3 jobs lost during the pandemic but received only one third of COVID-19 Social Relief of Distress grants.[1] In South Africa, there was considerable concern amongst social advocacy organisations, policymakers and researchers to learn more about how vulnerable women and children were affected by the pandemic. Such knowledge was vital to inform urgently needed pandemic policy responses and to protect vulnerable women against future shocks.

8.3 Methods

Study design

The SMS survey invitation was sent to a sample of pregnant women and mothers with babies younger than 12 months selected from the MomConnect platform's database of updated mobile numbers. MomConnect is a South African National Department of Health initiative that aims to support maternal and child health through mobile technology (22). Earlier research has shown that more than half of the women attending public sector antenatal care services were registered on the MomConnect platform, and it is the largest database of pregnant women and new mothers in the country (22, 23). To avoid excluding any mothers from MomConnect, the Department enabled users to access the service through either WhatsApp or USSD, with the latter requiring neither a smartphone nor a positive data balance.

[1] This finding was reported on the WITS University website: https://www.wits.ac.za/news/latest-news/opinion/2020/2020-07/covid-19-women-are-bearing-more-costs-and-receiving-fewer-benefits.html. The article was dated 20 July 2020, titled Covid-19: Women are bearing more costs and receiving fewer benefits and authored by Nic Spaull, Daniela Casale and Dorrit Posel. The analysis was based on the NIDS-CRAM data set. South African government attempted to cushion the shock of the pandemic by providing COVID-19 Social Relief of Distress grants to those who did not qualify for other support and intended to cover informal sector workers. The Child Support Grant was increased by R300 per grant for May 2020 but R500 per caregiver (irrespective of the number of eligible children) from June to November. All other grants, apart from the Child Support Grant, including old-age pensions and disability grants, were increased by R250 per month from May to November.

From the database of MomConnect users, we drew a random sample of 15 000 women from across South Africa who were either pregnant or had given birth in the previous year. The sample was stratified according to province, gestational stage or age in months of their baby, and their mobile device type. Stratification was used in the survey design to ensure that these groups were equally represented in the sample. To avoid misunderstandings, the survey questions used colloquial English and avoided ambiguous or technical terms.

To ensure accessibility we opted to conduct our survey via SMS. On 24 June 2020, 15 000 women received the first invitation to join the text message survey. They could respond by text message with "JOIN" to participate in the survey or "STOP" to opt out, and "MORE" if they needed more information. In the invitation, we informed mothers that they would not use their own data to participate in the survey and that we would pay them R10 (US 60c) in airtime for participating in the survey. The costs of the users was covered via reversed billing. We sent the same sample of 3 140 women an invitation to a follow-up survey on 2 July 2020.

At the time of the first and second rounds of this survey, South African COVID-19 restrictions of movement were reduced to “alert level 3,” which meant increased freedom of movement, open schools, and resumed economic activity following two months of a "hard" lockdown. During the first round of the survey, the country experienced its first steep rise in COVID-19 cases, and the second round of the survey coincided with the crest of the country’s first wave.

Survey non-response and follow-up survey attrition

Assuming a response rate of 20% from the targeted sample of 15 000 women, we aimed to achieve a survey sample of 3 000. The MomConnect sample was derived from women who used public healthcare, and therefore excluded more affluent women who would typically use private healthcare, and have access to more resources. Two-in-three of our respondents (67.8%) were living in households that were receiving either a child support grant or an old age pension.

We tracked survey non-response and found that it was largely balanced across provinces, but with significantly lower responses in one of the nine provinces (Eastern Cape), one of the four stages (babies 0–3 months), and for women who accessed the MomConnect platform over WhatsApp rather than USSD. There was no significant difference in the response rates of the women based on the socioeconomic quintile of the primary care facility where they registered for MomConnect.

A sample of 3 140 was achieved for the first round of the survey (21% response rate). Responses were accepted from 24–30 June and 2–5 July 2020 for the first and second round of the survey respectively.

Of the 3 140 women who responded to the first survey, 2 287 responded to the follow-up survey, with attrition of 27% of the first round respondents. We found no systematic bias in the attrition based on province, stage of pregnancy, age of child, reported child or adult hunger, or depressive symptoms. We chose to sample from a database that excluded the most affluent women; therefore, the sample was not nationally representative and there was no rationale for reweighing to increase representativity.[2]

Ethics

We received permission from the National Department of Health to survey their patients and ethics approval for this work from the University of Stellenbosch's Research Ethics Committee for Social, Behavioural and Education Research (project 14 926 on 15 June 2020) as part of the rapid coronavirus research stream.

Measures

Depressive symptoms

The PHQ-2 tool was selected to measure depressive symptoms because of its brevity and because it has been validated in South Africa (24). PHQ-2 questions were included in the first round of the survey and had to be shortened slightly to comply with the 160-character limit for SMSes. We simplified response options to ensure clarity and excluded the top end of the scale (experiencing symptoms nearly every day). Respondents were asked two questions about negative feelings in the previous week: “In the past seven days have you felt hopeless, down or depressed?” and, “In the past seven days have you felt little interest or pleasure in doing things?” Respondents rated the regularity with which they had experienced these feelings on a three-point scale: “No” (0), “Yes, a few days” (1), or “Yes, most days” (2). They were then assigned a score between 0 and 4 (because of the exclusion of the top category our scale does not have 5 or 6). As with the PHQ 6-point scale, each increased unit indicating increased severity of symptoms. We used this variable both as a count variable and

[2] Additionally, we have very little information on the women who did not respond to the survey (i.e. province, gestational stage or age in month and type of phone) and the available variables are unlikely to be important predictors of nonresponse.

a binary variable (using a cut-off of 3 or more to indicate the likelihood of significant depressive symptoms).

Hunger

The surveys included questions about adult hunger in the household (first round), child hunger in the household (both rounds), and whether the respondents themselves were hungry (second round). The survey question enquired whether household members had "gone to bed hungry in the past week" (yes or no). A similar question is widely used in household and nutrition surveys, but in order to determine how the lockdown was affecting food security, the recall period was shortened to seven days.

Open-ended question about respondents' main concern

In the second round of the survey, we asked respondents to share their main worry. This was an open-ended question and respondents could respond in their own words, restricted only by the character limit for SMSes.

District-level COVID-19 prevalence

Using district location information for the district where the respondent registered for MomConnect, we included district-level COVID-19 prevalence (cases per 100 000 population), collated by Media Hack during the pandemic.

Maternal characteristics associated with depressive symptoms

Based on evidence from previous studies (6,25), we examined the relationship of depressive symptoms with maternal employment status, maternal age categories, grant status, and maternal stage (pregnant or postpartum).

Statistical analyses

We used univariate and bivariate analysis (logistic regressions), employing a 5% significance level as a cut-off for statistical significance. We applied a mixed effects regression model to examine associations with district-level COVID-19 prevalence, hunger, and maternal depression symptoms with the maternal depressive symptoms, defined as a count variable ranging from 0 to 4. All analyses were conducted using Stata 16.0.

Results

The sociodemographic characteristics of respondents are presented in Table 1 below. Among survey respondents, 46% used a basic mobile phone while the remaining 54% had access to a smartphone. The mean age of respondents was 27 years but over 35% were in their late teens and early twenties. Most women (71%) in this sample of respondents were in the postpartum phase while the remaining 29% were pregnant. More than two-thirds (77%) of pregnant respondents reported that they had neither earned any income nor had any job in June. Encouragingly, 70% of respondents with babies said they had applied for a child grant. Of the 907 who said they had applied for a child support grant, 9 in 10 reported that they had started receiving it.

The sociodemographic characteristics of respondents are presented below in Table 8-1.

Table 8-1: Sociodemographic characteristics of study participants

Phone type	**N (%)**
Basic mobile phone	1435 (45.7%)
Smartphone with Whatsapp	1 705 (54.3%)
Maternal Stage	
Postpartum	2 230 (71%)
Pregnant	910 (29%)
Maternal age category	
18-24 yrs	1 120 (35.7%)
25-30 yrs	1 150 (36.6%)
31-36 yrs	659 (21%)
37+yrs	211 (6.7%)
Maternal educational attainment	
Some secondary school	662 (30.5%)
Completed secondary school	1 506 (69.5%)
Mother has applied for child grant (postpartum women only)	
Yes	907 (70%)
No	388 (30%)
Any kind of job or earned any income in June 2020	
No	957 (76.9%)
Yes	287 (23.1%)

Among survey respondents, 46% used a basic mobile phone while the remaining 54.3% had access to a smartphone. The mean age of respondents was 27 years but over 35% were in their late teens and early twenties. Most women (71%) in this sample of respondents were in the postpartum phase while the remaining 29% were pregnant. Over 75% of respondents

reported that they had neither earned any income nor had any job in June, highlighting the precarious existence of many women in South Africa who rely heavily on social grants or financial support from family. Encouragingly, 70% of respondents with babies said they had applied for a child grant. Of the 907 who said they had applied for a child support grant, almost 9 in 10 (89.8%) reported that they had started receiving it.

In this sample, the experience of hunger is associated with maternal depressive symptoms both during pregnancy and in the postpartum period. Table 8-2 shows that 16% (95% CI, 14.6–17.2) of respondents reported an adult in the household going to bed hungry in the previous seven days, and 11% (95% CI, 9.4-11.6) reported a child in the household going to bed hungry – an indication that in many households, adults may forego meals to shield their children from hunger. While there was a large and significant overlap in the probability of being hungry in the first survey and the second (Chi-sq Pr = 0.000), we also found a significant amount of churning: in the first round survey, 316 mothers reported that their children went to bed hungry in the previous seven days, and of these mothers, 43% again reported in the second round of the survey that their children went to bed hungry.

Table 8-2: Prevalence of hunger in June 2020

	N	Mean	95% CI
Child in household went to bed hungry in previous week (first round)	2821	11%	9.4–11.6
Child in household went to bed hungry in previous week (second round)	2187	9%	8.0–10.4
Adult in household went to bed hungry in previous week (first round)	2990	16%	14.6–17.2
Respondent went to bed hungry in previous week (second round)	2237	18%	16.7–19.9

Notes: The sample sizes vary between the initial survey and follow-up survey due to attrition. Sample sizes between adult and child hunger in the same wave vary due to households who responded that they had no children living in the household. In both surveys a very small proportion of respondents (<1%) refused to answer questions regarding child hunger.

Table 8-3 presents the regression analysis of child hunger and depressive symptoms controlling for gestational age, maternal age, grant receipt and district-level COVID-19 prevalence. Among respondents in our sample, we found a 16% prevalence (95% CI, 14–17) of depressive symptom scores of 3 or 4. Hunger amongst children was strongly associated with an increased likelihood of mothers reporting depressive symptoms, with coefficients ranging between 0.68 and 0.71. Mothers with infants who were already 10 to 12 months old were more likely to report depressive symptoms. Increased maternal age had a protective

effect against depressive symptoms with women 30 and older significantly less likely to report depressive symptoms. District-level COVID-19 prevalence was significantly associated with an increase in maternal depressive symptoms. The coefficient size is small at 0.0002, when interpreted against the mean and standard deviation of the COVID-19 prevalence variable (measured as cases per 100 000 population) of 148 and 252 respectively. Mothers who lived in households who received grants were not significantly more or less likely to report depressive symptoms.

Table 8-3: Regression analysis of PHQ-2 depression scores and child hunger, round 1 survey sample

	(1)	(2)	(3)
Child in household went to bed hungry in previous week	0.707**	0.705**	0.678**
	(9.84)	(9.81)	(9.15)
Infant 0-3 months (ref: Pregnant)	0.0438	0.0413	0.0310
	(0.76)	(0.71)	(0.53)
Infant 4-6 months (ref: Pregnant)	0.101	0.0973	0.0813
	(1.36)	(1.32)	(1.08)
Infant 7-9 months (ref: Pregnant)	0.0462	0.0381	0.0435
	(0.86)	(0.69)	(0.79)
Infant 10-12 months (ref: Pregnant)	0.214*	0.205	0.231*
	(2.01)	(1.93)	(2.12)
Mother 25-29 years old (ref: Mother 18-24 years old)	-0.0294	-0.0296	-0.0370
	(-0.56)	(-0.57)	(-0.70)
Mother 30-34 years old (ref: Mother 18-24 years old)	-0.119*	-0.119*	-0.132*
	(-2.10)	(-2.10)	(-2.28)
Mother 35 years or older (ref: Mother 18-24 years old)	-0.211**	-0.211**	-0.219**
	(-3.05)	(-3.06)	(-3.08)
Receipt of Child Support Grant or Old Age Pension		0.0325	
		(0.70)	
District-level COVID-19 prevalence			0.0002*
			(2.52)
Constant	1.310**	1.272**	1.300**
	(27.51)	(17.72)	(26.67)
Observations	2714	2714	2608

*Note: t statistics in parentheses; * p<0.05, ** p<0.01*

Table 8-4 reports further analysis, which confirms these findings. We consider the robustness of these findings by adding the round 2 variables to the regression model. Note that due to the attrition between round 1 and 2 of the survey, the observations for these regressions decline from 2714 to 2131 for the comparable first row models in Table 8-3 and Table 8-4. The latter shows that the association between depressive symptoms and child hunger remains significant and of a similar size in a comparable model specification with the smaller round 2 sample.

Table 8-4: Regression analysis of PHQ-2 depression scores and child hunger, round 2 survey sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Child in household went to bed hungry in previous week (round 1 survey)	0.688***	0.593***	0.552***	0.549***	0.529***	0.590***	0.588***
	(8.68)	(6.62)	(6.53)	(6.51)	(6.05)	(6.84)	(5.10)
Child in household went to bed hungry in previous week (round 2 survey)		0.267***					
		(2.85)					
Mother went to bed hungry in previous week (round 2 survey)			0.365**	0.360**	0.380**	0.362**	0.311**
			(5.39)	(5.35)	(5.47)	(5.27)	(3.33)
Baby 0-3 months (ref: pregnant?)	0.0715	0.0886	0.0772	0.0724	0.0733	0.0915	0.0584
	(1.11)	(1.37)	(1.20)	(1.12)	(1.11)	(1.39)	(0.84)
Baby 4-6 months (ref: unborn baby)	0.0776	0.0877	0.0617	0.0532	0.0410	0.0948	0.0977
	(0.95)	(1.05)	(0.75)	(0.65)	(0.49)	(1.13)	(1.07)
Baby 7-9 months (ref: unborn baby)	0.0597	0.0814	0.0766	0.0563	0.0672	0.0713	
	(0.99)	(1.35)	(1.27)	(0.92)	(1.09)	(1.18)	
Baby 10-12 months (ref: unborn baby)	0.242*	0.250*	0.219	0.201	0.200	0.231	
	(1.99)	(2.04)	(1.83)	(1.66)	(1.61)	(1.92)	
Mother 25-29 years old (ref: mother 18-24 years old)	-0.0375	-0.0530	-0.0467	-0.0474	-0.0605	-0.0366	-0.0293
	(-0.66)	(-0.93)	(-0.82)	(-0.84)	(-1.04)	(-0.63)	(-0.39)
Mother 30-34 years old (ref: mother 18-24 years old)	-0.108	-0.113*	-0.110*	-0.111*	-0.103	-0.101	-0.0113
	(-1.68)	(-1.73)	(-1.70)	(-1.71)	(-1.54)	(-1.52)	(-0.13)
Mother 35 years or older (ref: mother 18-24 years old)	-0.182*	-0.211**	-0.199*	-0.198*	-0.208*	-0.182*	-0.195
	(-2.27)	(-2.59)	(-2.48)	(-2.46)	(-2.50)	(-2.23)	(-1.82)
Receipt of Child Support Grant or Old Age Pension				0.0865			
				(1.66)			
District-level COVID-19 prevalence					0.00008		
					(0.79)		
Some secondary schooling						-0.0592	
						(-0.40)	
Completed secondary schooling						0.0476	
						(0.33)	
Tertiary qualification						-0.0404	
						(-0.27)	
Mother had job or earned income in June 2020							0.0848
							(1.16)
Constant	1.283**	1.254**	1.230**	1.128**	1.234**	1.219**	1.145**
	(24.49)	(23.70)	(23.25)	(13.86)	(22.77)	(8.13)	(13.62)
Observations	2131	2060	2089	2089	2009	2015	1138

As expected, child hunger in the round 2 of the survey has no significant relationship with depressive symptoms reported in round 1 of the survey. However, when maternal hunger from round 2 of the survey is added to the regression, it lowers the coefficient size on child

hunger to range between 0.53 and 0.59 with the maternal hunger coefficient ranging between 0.36 and 0.38.

The positive and significant association between older infants and depressive symptoms remains for the first two models, but disappears when maternal hunger is added to the regressions. The significant protective effect of maternal age between 30 and 34 is only significant in some of the regressions, but the significant protective effective of being 35 or older remains robust. The regressions find no significant association between depressive symptoms and household grant receipt, district-level COVID-19 prevalence, maternal schooling or maternal earnings.

Open-ended responses to questions about main concerns

The qualitative responses to the question about what women were most worried about, were thematically analysed and categorised into three broad themes: the fear of COVID-19, hunger, and unemployment. These responses add value because they provide insight into the respondents' state of mind, the reports of depressive symptoms, and concerns about hungry children.

A large proportion of women expressed severe anxiety around the threat of COVID-19 infection and how it might affect them and their children. One woman's response typified the concerns of the group; her main worry was "Giving my baby the life she deserves and protecting her from COVID-19." Most women were more concerned with their children contracting the virus than themselves, one woman responded, "Me and my family contracting coronavirus. Especially my baby boy since he's so little." Some women also expressed fears that they might get coronavirus and leave their children behind: "I don't want to be sick because no-one can love my baby as I can and she need me," or, "I'm worried about the COVID-19 disease, that I can get infected then pass it to my baby." Pregnant women also expressed concerns about contracting coronavirus in the hospital and giving birth during a pandemic "I am worried because anytime soon I am going to hospital labour so maybe I can get COVID-19."

Unemployment also emerged as a primary theme. One woman said she was unemployed and could not provide for a family at home. She said, "There is nothing in the fridge." Another said: "I don't have a job and any income. I need to feed my children. I need help urgently please help." Another responded "I can't get a job and I don't want my child to go to bed

hungry." The links between hunger and maternal mental health are evident from the concerns that mothers share about providing food for their children and feeding themselves. Women shared they were "worried about not being able to provide proper food" for their children and that they feared that their children would die of hunger.

8.4 Discussion

This survey of mothers and pregnant women was conducted after the lockdown in South Africa as the country was approaching the apex of its first COVID-19 wave. As expected, both the qualitative and quantitative survey responses highlight the vulnerability of pregnant women and new mothers in South Africa during the peak of the COVID-19 period. We find that approximately one in six respondents (16%) screened positive for depressive symptoms. Our findings further emphasise the importance of hunger and food insecurity as a potentially modifiable risk factor for depressive symptoms among women. The socioeconomic and psychosocial hardships of the pandemic and the lockdown have further disadvantaged pregnant women and new mothers, and deepened existing inequalities in healthcare and health outcomes (17,26).

Due to the emphasis on clear comprehension as well as the character limitations for SMSes, respondents were only asked about hunger because it is the most severe form of food insecurity, and not about access to food. It is expected that household food insecurity and distress about access to food would be higher than the prevalence of household members going to bed hungry (18.3%).

The relationship between child hunger and depressive symptoms can reinforce and deepen socio-economic and health shocks. We found that mothers who reported a child in the household going hungry were significantly more likely to be depressed than those who did not (OR 2.18). Analysis of the third wave of NIDS-CRAM support this finding, showing that in November and December 2020 there was a positive association between household hunger and poor mental health (13). The survey showed that among those who experienced hunger every day in the previous 7 days, 67% had depressive symptoms.

Many South African women remain vulnerable to hunger and unemployment, and the informal nature of female employment contributes to this vulnerability (21). The prevalence of hunger as well as depressive symptoms among pregnant women and new mothers was higher amongst poor black African women with children than among the general population (27). Qualitative research among depressed mothers in South Africa found that women frequently referred to the emotional distress caused by hungry children and that the pleas of hungry children evoked a feeling described as "madness" by low-income mothers (28). These women experience a variety of emotions including sadness, hopelessness, guilt and shame about their inability to fulfil their maternal responsibilities. (28).

The study finds that women with older children were more likely to report depressive symptoms than pregnant women (OR 1.2). This stands in contrast to findings from an earlier study of 384 mothers living in Khayelitsha, showing that the risk for depression ranged between 21% and 39% for pregnant women and was lower in the postnatal period, ranging between 16% and 32% (12).

We also found that older mothers were less likely to report depressive symptoms than younger mothers. Previous studies showed mixed evidence on the association between maternal depression and age, with some studies observing an increased likelihood of depression among younger mothers (especially if they were under 18), some finding a higher likelihood of depression amongst older mothers and others finding no association (6,29,30,31,32, 33).

District-level COVID-19 prevalence were associated with an increase in maternal depressive symptoms. This finding resonates with evidence from the US showing strong associations between psychological distress and the spread of COVID-19, geographically and over time (34). In this study, the authors ascribed the higher levels of anxiety and depression symptoms to the elevated threat of COVID-19 morbidity and mortality. Such an interpretation also aligns with some of the concerns reported by women in response to the open-ended question about their main worries.

In a world marked by multiple shocks, understanding how the pandemic affected pregnant women and new mothers is vitally important: lessons learned from one crisis can strengthen policy responses to protect vulnerable women against such shocks in the future. Despite increased recognition of its debilitating effects, maternal depression has not been prioritised

as part of routine antenatal care in LMIC countries as the primary focus has been on reducing maternal and neonatal mortality. Untreated depression has adverse consequences for both maternal and child health, particularly in resource-poor countries. A review on the prevalence of depression in relation to birth outcomes noted that the risk of intrauterine growth restriction, preterm birth and low birthweight were substantially increased for women living in LMIC countries (7).

There is mixed evidence on how to successfully integrate antenatal mental healthcare into routine maternal care in under-resourced healthcare settings (34). Extended and improved social protection for both pregnant women and new mothers may be an important intervention to alleviate food insecurity and improve mental health outcomes among this vulnerable group (25). An extension of the existing childcare grant to include the antenatal period has been a topic of discussion for policymakers in South Africa and may alleviate depressive symptoms and food insecurity during pregnancy (35). The COVID-19 pandemic represented an opportunity to enhance social resilience and expand social security.

8.5 Limitations

The SMS format limited the number and type of questions that could be asked. The questionnaire was administered in English, which was not the first language of the respondents. Respondents from the Eastern Cape were significantly less likely to respond, so the survey may exclude some of the poorest women in rural areas in South Africa. The survey did not include a question on whether the most recent pregnancy was planned and/or wanted, a factor that has been associated with maternal depression in some studies (29). It is also important to note the limitations of ultra-short measures like the PHQ-2 to detect depression.

8.6 Conclusion

Pregnant women and new mothers are vulnerable to socio-economic and health shocks and should be prioritised for government assistance. The mental state of pregnant women and mothers with very young children is critical, because this is the period of development in which children form attachments and establish their sense of belonging and acceptance. In turn, such attachments influence children's health, growth, and development (5,36).

Furthermore, the evidence shown here of the link between child hunger and maternal depressive symptoms, indicates that interventions which lower the risk of child hunger can have the added benefit of lowering the risk of maternal depression. Treatment with

pharmacotherapy is unlikely to be successful if the primary drivers of maternal depression are related to the social determinants of health like food insecurity, unemployment, and the daily realities of poverty. Given the high cost of depression-specific interventions, it may be more cost-effective to prioritise preventative programmes that improve social protection and food security among vulnerable households (25,37).

8.7 References

1. Walker SP, Wachs TD, Meeks Gardner J, Lozoff B, Wasserman GA, Pollitt E, et al. Child development: risk factors for adverse outcomes in developing countries. Lancet. 2016;369(9556):145–57.
2. Surkan PJ, Kennedy CE, Hurley KM, Black MM. Maternal depression and early childhood growth in developing countries: systematic review and meta-analysis. Bull World Health Organ. 2011;89(8):607–15.
3. Anato A, Baye K, Tafese Z, Stoecker BJ. Maternal depression is associated with child undernutrition: A cross-sectional study in Ethiopia. Matern Child Nutr [Internet]. 2020;16(3). Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85076362450&doi=10.1111%2Fmcn.12934&partnerID=40&md5=1444f446b5ec60673e78a28e0792d157
4. Miller LC, Neupane S, Sparling TM, Shrestha M, Joshi N, Lohani M, et al. Maternal depression is associated with less dietary diversity among rural Nepali children. Matern Child Nutr [Internet]. 2021; Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85107831785&doi=10.1111%2Fmcn.13221&partnerID=40&md5=d55c50b01bb09c89975413ac555b947c
5. Dadi AF, Miller ER, Mwanri L. Antenatal depression and its association with adverse birth outcomes in low and middleincome countries: A systematic review and meta-analysis. PLoS One [Internet]. 2020;15(1):1–23. Available from: http://dx.doi.org/10.1371/journal.pone.0227323
6. Fisher J, de Mello MC, Patel V, Rahman A, Tran T, Holton S, et al. Prevalence and determinants of common perinatal mental disorders in women in low-and lower-middle-income countries: A systematic review. Bull World Health Organ. 2012;90(2):139–49.
7. Grote, N.K. Bridge, J.A. Gavin, A.R. Melville, J.L. Iyengar, S. Katon WJ. A meta-analysis of depression during pregnancy and the risk of preterm birth, low birth weight, and intrauterine growth restriction. Arch Womens Ment Health [Internet]. 2011;14(10):S26. Available from: http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L70557360%5Cnhttp://dx.doi.org/10.1007/s00737-010-0203-1
8. Van Heyningen T, Myer L, Onah M, Tomlinson M, Field S, Honikman S, et al. Antenatal depression and adversity in urban South Africa. J Affect Disord [Internet]. 2016;203:121–9. Available from: http://dx.doi.org/10.1016/j.jad.2016.05.052
9. Abrahams Z, Lund C, Field S, Honikman S. Factors associated with household food insecurity and depression in pregnant South African women from a low socio-economic setting: a cross-sectional study. Soc Psychiatry Psychiatr Epidemiol [Internet]. 2018;0(0):0. Available from: http://www.ncbi.nlm.nih.gov/pubmed/29445850%0Ahttp://link.springer.com/10.1007/s00127-018-1497-y
10. Barnett W, Pellowski J, Kuo C, Koen N, Donald KA, Zar HJ, et al. Food-insecure pregnant women in South Africa: A cross-sectional exploration of maternal depression as a mediator of violence and trauma risk factors. BMJ Open. 2019;9(3):1–11.
11. Dewing S, Tomlinson M, Le Roux IM, Chopra M, Tsai AC. Food insecurity and its association with co-occurring postnatal depression, hazardous drinking, and suicidality among women in peri-urban South Africa. J Affect Disord [Internet]. 2013;150(2):460–5. Available from: http://dx.doi.org/10.1016/j.jad.2013.04.040
12. Liu J. Effects of global shocks on the evolution of an interconnected world. 2023;95–106.
13. Haukka J, Suvisaari J, Sarvimäki M, Martikainen P. The impact of forced migration on mortality. Epidemiology. 2017;28(4):587–93.
14. Esterwood E, Saeed SA. Past Epidemics , Natural Disasters , COVID19 , and Mental Health : Learning from History as we Deal with the Present and Prepare for the Future. 2020;1121–33.
15. Darnton-hill I, Cogill B. Maternal and Young Child Nutrition Adversely Affected by External Shocks Such As Increasing Global Food Prices 1 , 2. 2010;

16. United Nations. Policy Brief: The Impact of Covid-19 on Women. 2020. Available from: https://www.un.org/sexualviolenceinconflict/wp-content/uploads/2020/06/report/policy-brief-the-impact-of-covid-19-on-women/policy-brief-the-impact-of-covid-19-on-women-en-1.pdf
17. Van Bruwaene L, Goga A, Green RJ. What are we doing to the children of South Africa under the guise of COVID-19 lockdown ? South African Med J. 2020;15–6.
18. Davenport MH, Meyer S, Meah VL, Strynadka MC, Khurana R. Moms Are Not OK: COVID-19 and Maternal Mental Health. Front Glob Women's Heal. 2020;1(June):1–6.
19. WHO. COVID-19 pandemic leads to major backsliding on childhood vaccinations , new WHO , UNICEF data shows [Internet]. 2021. Available from: https://www.unicef.org/press-releases/covid-19-pandemic-leads-major-backsliding-childhood-vaccinations-new-who-unicef-data
20. Burger R, Nkonki L, Rensburg R, Smith A, van Schalkwyk C. Examining the unintended health consequences of the COVID-19 pandemic in South Africa. 2015.
21. Casale D, Posel D. Gender and the early effects of the Covid-19 crisis in the paid and unpaid economies in South Africa. 2020.
22. LeFevre AE, Dane P, Copley CJ, Pienaar C, Parsons AN, Engelhard M, et al. Unpacking the performance of a mobile health information messaging program for mothers (MomConnect) in South Africa: Evidence on program reach and messaging exposure. BMJ Glob Heal. 2018;3:1–12.
23. Spaull N, Tomlinson M. Feeding a Family on $ 300 a Month. Business Live. 2020;4.
24. Bhana A, Rathod SD, Selohilwe O, Kathree T, Petersen I. The validity of the Patient Health Questionnaire for screening depression in chronic care patients in primary health care in South Africa. BMC Psychiatry. 2015;15(1):1–9.
25. Hunt X, Stein DJ, Spaull N, Tomlinson M. Hunger as a driver of depressive symptoms: Optimising responses to mental health aspects of the COVID-19 pandemic. South African Med J. 2021;111(7):604–5.
26. Van der Berg S, Zuze L, Bridgman G. The impact of hte Coronavirus and lockdown on children's welfare in South Africa; Evidence from NIDS-CRAM Wave 1. 2020.
27. Van der Berg S, Patel L, Bridgman G. Hunger in South Africa: Results from Wave 4 of NIDS-CRAM Working Paper 11. 2021.
28. Kruger LM, Lourens M. Motherhood and the "Madness of Hunger": "…Want Almal Vra vir My vir 'n Stukkie Brood" ("…Because Everyone Asks Me for a Little Piece of Bread"). Cult Med Psychiatry. 2016;40(1):124–43.
29. Gelaye B, Rondon M, Araya R, Williams M. Epidemiology of maternal depression, risk factors, and child outcomes in low-income and middle-income countries. Lancet Psychiatr. 2016;3(10):1562–72.
30. Biaggi A, Conroy S, Pawlby S, Pariante CM. Identifying the women at risk of antenatal anxiety and depression: A systematic review. J Affect Disord [Internet]. 2016;191:62–77. Available from: http://dx.doi.org/10.1016/j.jad.2015.11.014
31. Suárez-Rico BV, Estrada-Gutierrez G, Sánchez-Martínez M, Perichart-Perera O, Rodríguez-Hernández C., González-Leyva C, et al. Prevalence of depression, anxiety, and perceived stress in postpartum Mexican women during the COVID-19 lockdown. Int J Environ Res Public Health [Internet]. 2021;18(9):4627. Available from 10.3390/ijerph18094627.
32. Gibbs CM, Wendt A, Peters S. and Hogue CJ, 2012. The impact of early age at first childbirth on maternal and infant health. Paediatr Perinat 2012;26(Suppl 1):259-284.
33. Verkuijl NE, Richter L, Norris SA, Stein A, Avan, B, Ramchandani PG. Postnatal depressive symptoms and child psychological development at 10 years: a prospective study of longitudinal data from the South African Birth to Twenty cohort. Lancet Psychiatry.2014;1(6):454-460.
34. Prom MC, Denduluri A, Philpotts LL, Rondon MB, Borba CPC, Gelaye B, et al. A Systematic Review of Interventions That Integrate Perinatal Mental Health Care Into Routine Maternal Care in Low- and Middle-Income Countries. Front Psychiatry. 2022;13:859341.Available from: 10.3389/fpsyt.2022.859341.
35. Chersich MF, Luchters S, Blaauw D, Scorgie F, Kern E, Van den Heever A, et al. Safeguarding maternal and child health in South Africa by starting the Child Support Grant before birth: Design lessons from pregnancy support programmes in 27 countries. S Afr Med J; 2016:106(12):1208-1210.
36. Patel V, DeSouza N, Rodrigues M. Postnatal depression and infant growth and development in low income countries: A cohort study from Goa, India. Arch Dis Child. 2003;88(1):34–7.
37. Reesor-Oyer L, Cepni AB, Lee CY, Zhao X, Hernandez DC. Disentangling food insecurity and maternal depression: Which comes first? Public Health Nutr. 2021;24(16):5506–13.

Chapter 9 DISCUSSION

9.1 Discussion

This thesis aimed to investigate the relationship between antenatal and periconceptional food insecurity with a number of outcomes including: maternal depression, LBW and stunting using data from the NIDS.

Specific objectives were: a) to conduct a scoping review of the evidence base on maternal dietary diversity (one potential measure of food security I wanted to examine) and depression; b) to examine if dietary diversity is an effective proxy for dietary quality and to examine if dietary diversity is associated with stunting among children and adult anthropometry using cross-sectional data from Wave 1 (2008) of the NIDS study; c) to examine maternal food insecurity and depression in the antenatal and periconceptional period in relation to LBW and stunting using longitudinal NIDS data (2008 & 2012); d) to examine maternal food security indicators and other maternal and environmental characteristics in relation to LBW and stunting using longitudinal NIDS data (2008 & 2012); and e) to describe the impact of the Coronavirus pandemic on hunger and mental health among pregnant women and new mothers using mobile survey data from the MomConnect platform, the largest database of pregnant women and new mothers in South Africa.

The purpose of this discussion chapter is to discuss the recurring themes and primary findings of the preceding chapters and to situate these in the context of previous literature. I also describe how each study contributes to the evidence base on maternal food insecurity, depression and birth and growth outcomes and whether they fill any gaps in the literature. In conclusion, I discuss the implications of the PhD findings for maternal food insecurity and mental health research and potential interventions in the South African context.

9.1.1 Nutritional Surveys in South Africa

Fundamental to addressing food insecurity and improving child and adult health outcomes alike, is understanding the true scale of the problem we face. However, our understanding in this regard may be hampered by the current measurement instrument (the HFIAS) used by Statistics South Africa in addition to a paucity of nationally representative nutritional surveys. The most recent Stats SA report from 2018 recorded that 78.7% of the South African population was food secure in 2017. Given the stunting prevalence of almost 30% among

children under five years of age, these statistics may underestimate the true extent of the problem. By contrast, the most recent data report from the FAO found a much higher prevalence of food insecurity in South Africa. Using data collected from the GWP using the FIES tool, the report noted that 19.3% of the population were severely food insecure in 2020 and 44.9% of the population were either moderately or severely food insecure (29). These numbers intuitively feel closer to the truth given the high burden of malnutrition in South Africa. The FIES tool is also an experiential measure of food insecurity that uses 8 different questions to gauge an individual or households' level of food insecurity but unlike the HFIAS it has more questions about coping strategies and two questions that focus on dietary quality 'You ate only a few kinds of foods?' as well as 'You were unable to eat healthy and nutritious food?'. These questions offer more nuance than simply asking about household hunger as they capture other important aspects of food insecurity, namely dietary quality and food preferences beyond the experience of hunger.

Although the GWP data is used to compile the annual FAO reports and the tool has been validated in LMIC settings, the FIES tool has seldom been adopted by academic researchers and the GHS continues to use the older HFIAS tool. The use of various food security measures limits comparisons and monitoring and evaluation of food security at a national level as well as changes in food security status (i.e. increased food insecurity resulting from the Coronavirus pandemic). Another difficulty is that the GWP and the GHS do not collect anthropometry data and researchers have not been able to examine associations between food security measures and indicators with childhood stunting, wasting or adult overweight and obesity.

The most recent survey that collected dietary diversity data at the national level in South Africa was the South African National Health and Nutritional Examination Survey (SANHANES), which took place in 2012 (30). This was intended to be a longitudinal cohort that tracked the nutritional status of South Africans at a population level, but unfortunately no further rounds of the survey were conducted. In the absence of more recent national level data, researchers and policymakers must rely on older data or smaller surveys and cohort studies to learn about the nutritional status of South Africans.

Among children, the Provincial Dietary Intake Study (PDIS) was conducted among children in two provinces (Gauteng and the Western Cape) in 2018 and the results were compared with those of the 1999 NFCS (31). The survey found that food shortage prevalence decreased

in both urban informal areas and rural areas. One surprising, and sobering finding of the study was that 7–10-year-olds in Gauteng were significantly more likely to be wasted in 2018 than in 1999. Among children living in the Western Cape, 1–3-year-olds were significantly more likely to be obese in 2018 than in 1999 and 7–10 year olds were less likely to be stunted. This decline in stunting was only observed among children in the Western Cape with the stunting prevalence remaining virtually unchanged in the rest of the country. The study concluded that food security overall has improved for South African children in period between the two surveys but the increase in unhealthy foods as well as wasting among older children and overweight and obesity among younger children is cause for concern (31). These findings further emphasise the need for measuring dietary quality at the household level and using indicators and tools that capture micronutrients and quantities of food consumed. The PDIS also found that children whose biological parents were the head of household/caregiver and those with parents who had an education level above grade 12 had better nutritional outcomes. The experiential food security tools are premised on the idea that people instinctively know and understand what a healthy diet is, and that questions about 'enough healthy and nutritious food to eat' will be correctly interpreted by respondents. I am sceptical about this premise as qualitative studies in South Africa have found that even nursing students did not have good knowledge of what constituted healthy foods, and knowledge about healthy nutrition was even worse among school aged children (32,33). Individual and societal perceptions regarding healthy food and nutrition are certainly a topic that requires further qualitative and quantitative research. In addition, public messaging campaigns are needed to educate the broader public about healthy eating habits and the consequences of overweight and obesity.

In the context of household surveys, a review by Leroy et al. found that household dietary diversity scores (HDDS) have not been validated for dietary quality, and recommend the use of experience-based indicators to asses household access to dietary quality and individual DDSs for women or children to assess the quality of individual dietary intake (34). However, given the consistent associations between HDDS and child anthropometry measures, these are sufficient for gauging household food insecurity at the national level. In addition, questions on both household and child DDSs are both answered by the mother or primary caregiver in the household and will therefore have a similar level of respondent bias. Furthermore, the time and cost involved in conducting large surveys calls for a single measure to capture dietary diversity within the household. Questions about individual food

groups are less sensitive than questions about coping strategies and consuming cheaper and less appealing foods and may be less subject to bias (35).

9.1.2 Overall findings: Food insecurity and maternal depression

Food insecurity and dietary diversity emerged as important and potentially modifiable risk factors for maternal depression in Chapter 5, Chapter 6 and Chapter 8. The relationship between child hunger and maternal distress is reinforced by qualitative research among low-income women in South Africa by Kruger et al. The inability to provide food for infants and young children causes great distress to mothers who feel that they are failing in their maternal caregiving role (47). Kruger argues that mothers' complex emotional response to their failure to feed their children are not adequately captured by the term depression and 'to simply link food insecurity to maternal depression, is to obscure women's anger (and potential aggression) and their anomie (their felt lack of agency). The literature suggests that both angry women and anomic women elicit social disapproval. While this may in the first place partly be the reason for the obscuring of anger and anomie in the psychological literature concerned with poverty, it also means that impoverished women are kept captive in complex and vicious cycles of hungry children, sadness and anxiety, shame, anger and anomie, negative judgement, and more shame'(p.39).

Food expenditure and food insecurity

Two recent papers that examined food expenditure across four LMIC found that expenditures on specific food groups were significantly associated with children's linear growth but that the magnitude of effect varied between countries (55,56). Thus, food expenditure can also be a useful metric for gauging food insecurity and malnutrition among households with young children, although using a proportional variable may be simpler for generalisability and comparative research purposes than poverty lines which are currency specific. Expenditure data are routinely collected as part of GHS in SSA and warrants further research, particularly in cases where anthropometry or nutrition indicators are not available (57). Social grants and malnutrition in South Africa

In South Africa, the child grant system may have improved access to food and reduced hunger, but this does not necessarily translate into better quality diets or subsequent improvements in children's nutritional status (58). I also found in Chapter 7 that child who received a child grant were significantly more likely to be stunted than those who did not

receive a grant (OR 1.67). This suggests that children living in households that receive a social grant are likely disadvantaged in multiple domains (ie poor housing and healthcare and inadequate nutrition).

The failure of the existing grant system (currently the largest in the world) to meaningfully reduce the stunting prevalence in South Africa suggests that a multi-faceted approach is needed (58). In the case of a proposed grant into the antenatal period as well as the existing CSG, the assumption is that women will spend the money on food or items for children. Unfortunately, this is not always the case. For example, a qualitative study among caregivers in Limpopo province found that many caregivers used the childcare grant to pay for funeral policies and burial societies instead of food or other necessities for children (59) Anecdotal evidence also suggests that some use the grant for drugs or alcohol, although social desirability bias would likely prevent caregivers from disclosing as much in a research study (60).

9.1.3 Nutritional Surveys in South Africa

Fundamental to addressing food insecurity and improving child and adult health outcomes alike, is understanding the true scale of the problem we face. However, our understanding in this regard may be hampered by the current measurement instrument (the HFIAS) used by Statistics South Africa in addition to a paucity of nationally representative nutritional surveys. The most recent Stats SA report from 2018 recorded that 78.7% of the South African population was food secure in 2017. Given the stunting prevalence of almost 30% among children under five years of age, these statistics may underestimate the true extent of the problem. By contrast, the most recent data report from the FAO found a much higher prevalence of food insecurity in South Africa. Using data collected from the GWP using the FIES tool, the report noted that 19.3% of the population were severely food insecure in 2020 and 44.9% of the population were either moderately or severely food insecure (29). These numbers intuitively feel closer to the truth given the high burden of malnutrition in South Africa. The FIES tool is also an experiential measure of food insecurity that uses 8 different questions to gauge an individual or households' level of food insecurity but unlike the HFIAS it has more questions about coping strategies and two questions that focus on dietary quality 'You ate only a few kinds of foods?' as well as 'You were unable to eat healthy and nutritious food?'. These questions offer more nuance than simply asking about household

hunger as they capture other important aspects of food insecurity, namely dietary quality and food preferences beyond the experience of hunger.

Although the GWP data is used to compile the annual FAO reports and the tool has been validated in LMIC settings, the FIES tool has seldom been adopted by academic researchers and the GHS continues to use the older HFIAS tool. The use of various food security measures limits comparisons and monitoring and evaluation of food security at a national level as well as changes in food security status (i.e. increased food insecurity resulting from the Coronavirus pandemic). Another difficulty is that the GWP and the GHS do not collect anthropometry data and researchers have not been able to examine associations between food security measures and indicators with childhood stunting, wasting or adult overweight and obesity.

The most recent survey that collected dietary diversity data at the national level in South Africa was the South African National Health and Nutritional Examination Survey (SANHANES), which took place in 2012 (30). This was intended to be a longitudinal cohort that tracked the nutritional status of South Africans at a population level, but unfortunately no further rounds of the survey were conducted. In the absence of more recent national level data, researchers and policymakers must rely on older data or smaller surveys and cohort studies to learn about the nutritional status of South Africans.

Among children, the Provincial Dietary Intake Study (PDIS) was conducted among children in two provinces (Gauteng and the Western Cape) in 2018 and the results were compared with those of the 1999 NFCS (31). The survey found that food shortage prevalence decreased in both urban informal areas and rural areas. One surprising, and sobering finding of the study was that 7–10-year-olds in Gauteng were significantly more likely to be wasted in 2018 than in 1999. Among children living in the Western Cape, 1–3-year-olds were significantly more likely to be obese in 2018 than in 1999 and 7–10 year olds were less likely to be stunted. This decline in stunting was only observed among children in the Western Cape with the stunting prevalence remaining virtually unchanged in the rest of the country. The study concluded that food security overall has improved for South African children in period between the two surveys but the increase in unhealthy foods as well as wasting among older children and overweight and obesity among younger children is cause for concern (31). These findings further emphasise the need for measuring dietary quality at the household level and using indicators and tools that capture micronutrients and quantities of food

consumed. The experiential food security tools are premised on the idea that people instinctively know and understand what a healthy diet is, and that questions about 'enough healthy and nutritious food to eat' will be correctly interpreted by respondents. I am sceptical about this premise as qualitative studies in South Africa have found that even nursing students did not have good knowledge of what constituted healthy foods, and knowledge about healthy nutrition was even worse among school aged children (32,33). Individual and societal perceptions regarding healthy food and nutrition are certainly a topic that requires further qualitative and quantitative research. In addition, public messaging campaigns are needed to educate the broader public about healthy eating habits and the consequences of overweight and obesity.

In the context of household surveys, a review by Leroy et al. found that household dietary diversity scores (HDDS) have not been validated for dietary quality, and recommend the use of experience-based indicators to asses household access to dietary quality and individual DDSs for women or children to assess the quality of individual dietary intake (34). However, given the consistent associations between HDDS and child anthropometry measures, these are sufficient for gauging household food insecurity at the national level. In addition, questions on both household and child DDSs are both answered by the mother or primary caregiver in the household and will therefore have a similar level of respondent bias. Furthermore, the time and cost involved in conducting large surveys calls for a single measure to capture dietary diversity within the household. Questions about individual food groups are less sensitive than questions about coping strategies and consuming cheaper and less appealing foods and may be less subject to bias (35).

9.1.4 Overall findings: Food insecurity and maternal depression

Food insecurity and dietary diversity emerged as important and potentially modifiable risk factors for maternal depression in Chapter 5, Chapter 6 and Chapter 8. The relationship between child hunger and maternal distress is reinforced by qualitative research among low-income women in South Africa by Kruger et al. The inability to provide food for infants and young children causes great distress to mothers who feel that they are failing in their maternal caregiving role (47). Kruger argues that mothers' complex emotional response to their failure to feed their children are not adequately captured by the term depression and 'to simply link food insecurity to maternal depression, is to obscure women's anger (and potential aggression) and their anomie (their felt lack of agency). The literature suggests that both

angry women and anomic women elicit social disapproval. While this may in the first place partly be the reason for the obscuring of anger and anomie in the psychological literature concerned with poverty, it also means that impoverished women are kept captive in complex and vicious cycles of hungry children, sadness and anxiety, shame, anger and anomie, negative judgement, and more shame'(p.39).

I also examined individual food groups from the dietary diversity questions to determine if the consumption of a single food group was associated with a decrease in depression as this has been observed in some studies, but I did not find a significant relationship (48). The high prevalence of overweight and obese women in my NIDS sample and the very low proportion of women with underweight BMI suggest that food insecurity and hunger is not severe enough among most South African women to cause wasting and undernutrition. However, many women may still be malnourished and experience hidden hunger due to nutrient poor diets. A systematic review and meta-analysis that examined food insecurity and anaemia found that food insecurity was positively associated with anaemia risk (OR 1.27) and that infants, toddlers and adult women in food insecure households were the most at risk (49). Obesity has also been found to be a risk factor for depression in some studies but I did not find an association with BMI and mental health in this study (16). Another analysis of SANHANES data that examined BMI and mental health among South African adults did not find an association with obesity and depression but did observe that poor mental health increased the risk of being underweight (50).

9.1.5 Food expenditure and food insecurity

Two recent papers that examined food expenditure across four LMIC found that expenditures on specific food groups were significantly associated with children's linear growth but that the magnitude of effect varied between countries (55,56). I examined food expenditure as a proportion of total monthly expenditure (Chapter 5 & 6) and per capita food expenditure below the poverty line (Chapter 7). In Chapter 7, food expenditure below the poverty line was associated with an increased risk of stunting (OR 2.31), and in Chapter 5 food expenditure >0.6 of total monthly expenditure was also associated with an increased risk of stunting (OR 1.24) in the full sample of children and adolescents age 0–17. Thus, food expenditure can also be a useful metric for gauging food insecurity and malnutrition among households with young children, although using a proportional variable may be simpler for generalisability and comparative research purposes than poverty lines which are currency

specific. Expenditure data are routinely collected as part of GHS in SSA and warrants further research, particularly in cases where anthropometry or nutrition indicators are not available (57). In addition, research that elucidates the relationship between food expenditure and dietary quality may be useful in the context of household surveys.

9.1.5.1 Social grants and malnutrition in South Africa

In South Africa, the child grant system may have improved access to food and reduced hunger, but this does not necessarily translate into better quality diets or subsequent improvements in children's nutritional status (58). I also found in Chapter 7 that child who received a child grant were significantly more likely to be stunted than those who did not receive a grant (OR 1.67). This suggests that children living in households that receive a social grant are likely disadvantaged in multiple domains (ie poor housing and healthcare and inadequate nutrition).

'A child support grant for pregnant women would help prevent stunting in our future generations'; this optimistic opinion piece recently ran in the Daily Maverick but I am sceptical that a 400 ZAR (25.62 USD in 2022) monthly disbursement will reduce stunting at all. The failure of the existing grant system (currently the largest in the world) to meaningfully reduce the stunting prevalence in South Africa suggests that a multi-faceted approach is needed (58). In the case of a proposed grant into the antenatal period as well as the existing CSG, the assumption is that women will spend the money on food or items for children. Unfortunately, this is not always the case. For example, a qualitative study among caregivers in Limpopo province found that many caregivers used the childcare grant to pay for funeral policies and burial societies instead of food or other necessities for children (59) Anecdotal evidence also suggests that some use the grant for drugs or alcohol, although social desirability bias would likely prevent caregivers from disclosing as much in a research study (60).

9.1.6 Limitations of stunting as an indicator

It is also critical to keep in mind that stunting is an indicator of a generally deficient growth environment and there is no panacea or single intervention that will solve the problem, as the causes include suboptimal nutrition, inadequate care, a poor hygiene and sanitation environment and repeated infections in early childhood (24,61). A path analysis by Prado et al. of 42 different indicators examined in relation to stunting across four prospective African

cohorts found that overall maternal and child factors (such as maternal height and child length at birth) showed stronger and more consistent associations with child LAZ scores than environmental and caregiving factors, even when analyses were adjusted for both indirect and direct effects (11).

The metrics for stunting are also limited and should not be the only standard by which child growth and nutritional status is measured. Stunting is an intergenerational process, whereby shorter mothers are more likely to give birth to shorter offspring, SGA and preterm infants. A meta-analysis of SGA and preterm births in LMICs estimated that approximately 6.5 million SGA and/or preterm births (16.5% of the global total) may be related to short maternal stature (62). Thus, mothers pass on the consequences of their own deficient foetal or early childhood growth environment (63). Short maternal stature is consistently found to be a robust indicator for stunting, and I also found in Chapter 7 that short maternal stature and birthweight were the only two variables associated with both stunting and severe stunting among children. As these exposures (maternal height and birthweight) have already occurred, current policies and interventions cannot change the stature of the mother or alter her past deprivations (63). The current stunting metric includes some degree of this intergenerational exposure and is therefore limited in measuring the progress of current policies and interventions (63). Furthermore, in an ideal scenario, the national prevalence of stunting should be around 2.3%, countries like South Africa are clearly far from this prevalence estimate and, given the nature of stunting measurement the entire HAZ distribution will be shifted to the left, which implies that an even larger percentage of children are stunted and suffer from a deficient growth environment (24).

Although malnutrition is often implicated as a primary cause of stunting, an analysis of 39 GHS datasets from LMIC found that increasing dietary diversity and animal source foods (ASF) among stunted infants and children would only avert 12.6% of cases among the groups under study (64). My unadjusted bivariate analyses of the NIDS data in Chapter 7 found that low dietary diversity increased the risk of severe stunting (OR 1.87) among children aged 5 and below and that each unit increase of dietary diversity reduced the risk of severe stunting (OR 0.90). In the final multivariable model for severe stunting, low dietary diversity increased the risk of severe stunting by 63%. However, the households with food expenditure below the poverty line are likely to represent some of the poorest households that will be deprived in multiple domains.

An overall improvement in food security and better-quality diets for vulnerable South Africans remains a worthwhile and important goal, but such changes take time and may not necessarily translate into a meaningful reduction in outcomes like stunting. The findings of this PhD suggest that the main benefits to improved food security among women would be an improvement in mental health indices, while the improvements for children's growth outcomes may be more difficult to measure.

9.1.7 Coronavirus and food insecurity

The qualitative and quantitative findings of the MomConnect data indicate that hunger and worries about food supply were a significant issue for pregnant women and new mothers. In addition, both hunger and mental distress were higher among pregnant women and new mothers than the general population (65). This group is particularly vulnerable to social and economic shocks like the pandemic and should be prioritised for social protection and other forms of government assistance. Given the informal nature of employment for many South African women, this group was particularly vulnerable to labour disruptions caused by the hard lockdowns and the additional childcare demands caused by schools and daycare centres closing (66). These closures also had adverse implications for the poorest children in South Africa who were suddenly deprived of school meals. The cost of this for South Africa's children cannot be underestimated given that this would be the only meal in the day for millions of children. The pandemic had negative impacts on maternal mental health globally. A systematic review and meta-analysis of maternal mental health before and after the pandemic found that the pandemic significantly increased the risk of anxiety among women during pregnancy and perinatal period. Depression scores were also higher during the pandemic though the difference was not statistically significant to pre-pandemic levels (67). However, numerous studies in both high and low income countries did identify an increased risk of maternal depression as a result of the pandemic (68–71). Furthermore, the social and economic impacts of the pandemic are likely to have been worse among women in LMIC settings. Some studies also observed an increase in gender based violence during the pandemic as a result of stay at home orders, compounding the poor mental health of vulnerable women (71,72).

In NIDS as well as the MomConnect data, food insecurity and hunger were consistently associated with worse mental health among this vulnerable group. Longitudinal research among low-income women in the US has found that food insecurity and maternal depression

share a bidirectional relationship. Thus, women who are food insecure are more likely to become depressed and women who are depressed are more likely to become food insecure (37,73) A recent study of over 4000 mothers in the Fragile Families and Child Wellbeing (FFCW) study used structural equation modelling to examine if one condition predicted the other and measured both food insecurity and depression at two separate time points. The study found that maternal depression at time 1 was associated with 53% increased odds of food insecurity, at time 2, controlling for time 1 food insecurity, concurrent depression and covariates. Food insecurity at time 1 was associated with 36% increased odds of maternal depression at time 2, controlling for time 1 depression, concurrent food insecurity and covariates (37).

9.1.8 Food Inadequacy and Social Vulnerability

The food inadequacy and social vulnerability hypothesis suggest that a mother's social situation and deprivations like food insecurity can perpetuate depression. The mental health hypothesis suggests that depressed mothers may be too fatigued or apathetic to manage meal preparation and food procurement and may lack the agency to join the workforce and secure stable income (37,74). This creates a vicious cycle similar to the one that Kruger has described in her qualitative research among poor South African mothers. The situation described in the US studies is likely to be worse in LMIC where both food insecurity and maternal depression are more prevalent than high-income countries. These findings suggest that holistic interventions that combine food assistance with mental health support may be more effective than interventions that focused on a single domain (37).

9.1.9 Pregnancy intention & parity

In Chapter 6 and Chapter 8 I found that women who had previously given birth (OR 1.64) and new mothers (OR 1.27) were more likely to be depressed than pregnant women. Motherhood can be a joyful and life affirming experience, but it also takes a large physical and emotional toll on mothers. Although it is seldom discussed as an intervention, family planning, appropriate spacing between pregnancies and delaying pregnancy altogether could reduce some of the hardships experienced by mothers in resource poor settings. Unintended and unwanted pregnancies, as well as pregnancies during adolescence, are a risk factor for maternal depression, although my studies did not include data on pregnancy intention (75–77). In the NIDS data, 26% of my sample was comprised of adolescent women (aged 15–19) while over 35% of mothers in the MomConnect study were aged between ages 18 and 24

(MomConnect did not collect data on mothers younger than 18). For younger women in particular, delaying pregnancy and motherhood may be an important factor to reduce maternal depression, secure education and employment and improve maternal and child outcomes alike.

9.2 Developing the conceptual framework

Figure 9.1 is a draft of the conceptual framework from my PhD proposal in 2018. I had listed the various factors associated with both maternal depression and food insecurity and how these might influence childhood health outcomes.

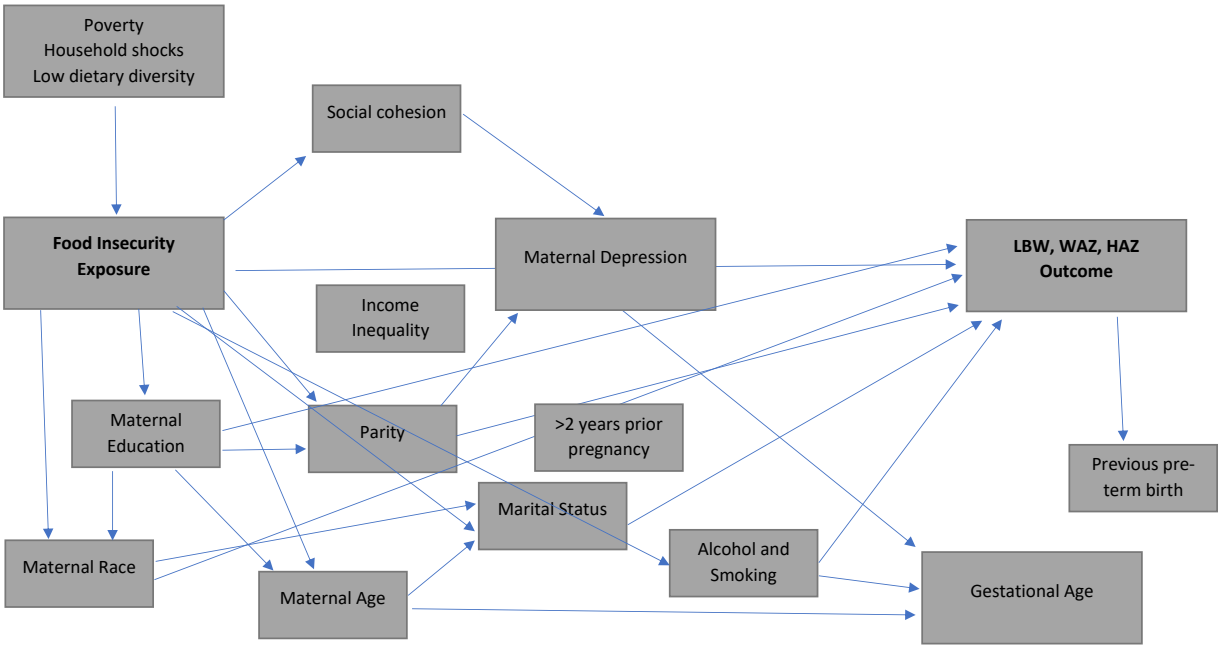


Figure 9.1: Conceptual framework draft

Figure 9.2 is a revised conceptual framework based on the findings of the work that I completed during this PhD study as well as the various factors that are associated with either the exposure (food insecurity and maternal depression) or outcomes (low birthweight, stunting wasting and adult overweight and obesity) of interest. I've illustrated some of the factors that I found significant in my various results chapters as well as latent variables that weren't measured in my study but may still influence exposure or outcome. Given the bidirectional relationship between many of the variables included here, I have left out arrows and simply linked them with a line. The characteristics in the orange blocks (social capital, self-efficacy, IUGR and gestational age) were not measured in this study but are closely

linked to the outcomes of interest. Social capital and self-efficacy are both associated with food security as well as maternal depression while IUGR and gestational age are also associated with food insecurity in some studies as well as LBW and stunting as children age. Interestingly, child hunger in the household was associated with LBW but none of the other food security indicators. Maternal education emerged as an important protective factor and reduced the risk of maternal depression as well as stunting and severe stunting among children as they aged.

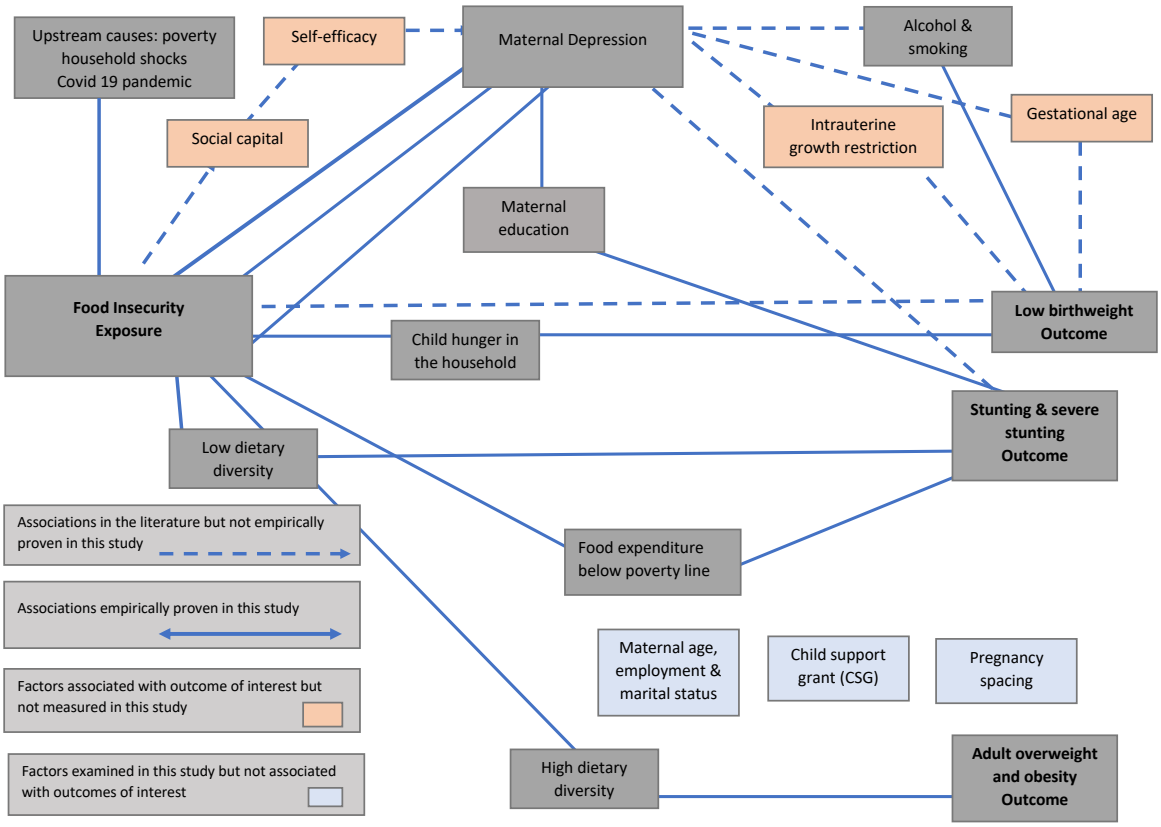


Figure 9.2: Final conceptual framework

This PhD study has revealed the pernicious impact of food and nutrition insecurity on maternal mental health as well as early childhood growth outcomes in South Africa. Insufficient healthy and affordable food is perhaps the single most important social determinant of health inequity globally. My study also highlights the limits of experiential measures of food insecurity in the context of the nutrition transition that is taking place in South Africa and other LMIC. One strength of this study is that the NIDS data had a large sample size and collected food security indicators as well as anthropometry data in Wave 1 which enabled an examination of these associations both cross-sectionally and longitudinally.

9.3 Conclusions and Recommendations

9.3.1 Antenatal and Postnatal Depression

The reality is that most women receiving antenatal care in the public sector will not be screened for depressive symptoms, let alone referred for treatment. Healthcare workers are overburdened and fatigued, and many women may not even identify themselves as depressed or discuss their concerns with a healthcare worker. Task shifting has often been suggested as a potential way to fill the treatment gap for antenatal depression in LMIC settings, but the evidence on such interventions in not promising. A double-blind individual randomised controlled trial conducted in Khayelitsha, Cape Town, compared structured psychological treatment with routine antenatal healthcare and three phone calls each month. Ultimately, the trial did not observe significant differences in depression prevalence between the intervention and control arm (78). In rural Tanzania, a Community health worker (CHW) intervention that focused on health and nutrition and responsive stimulation, but did not specifically target maternal mental health significantly reduced the incidence of depressive symptoms. Another arm of the study that comprised a CHW intervention that also included conditional cash transfers (CCTs) did not significantly reduce depressive symptoms among mothers (79). These somewhat surprising findings indicate that community-based interventions that are focused on broader aspects of maternal and child health and wellbeing may be more effective than targeted interventions for maternal depression. Such interventions may indirectly improve maternal mental health by improving their social support network or increasing their sense of self efficacy, both factors that reduce the risk of depression (79). Furthermore, the large body of evidence on food insecurity and mental health, as well as their bidirectional relationship, suggests that interventions that address maternal hunger and food insecurity may be more effective than those that are purely focused on improving mental health indices (65).Women who are depressed by factors like hunger and food insecurity in their households are unlikely to benefit from a psychological intervention that doesn't provide instrumental support. Ultimately, improving the daily conditions in which so many South Africans live may be the most effective long-term solution to reduce the prevalence of depression among pregnant and postnatal women.

However, given that women in high-income countries also experience antenatal and postnatal depression, some women may be genetically or otherwise predisposed to depression and there will always be a 'baseline' proportion of depressed women, regardless of living

circumstances or food security status. A systematic review on antenatal depression observed that between 8% and 12% of pregnant women in the US experienced depression during their pregnancies (80). The review also noted that depression among low-income minority women in the US tended to be about twice that of high-income women. This is corroborated by observational epidemiological studies from South Africa which have observed depression prevalence estimates between 25% and 29% among pregnant women (8,41,45). Thus, it seems plausible that beyond the certain 'baseline' of women who would experience antenatal or postnatal depression regardless of setting, the additional prevalence of depression observed in South Africa and other LMIC can be attributed to potentially modifiable risk factors such as food insecurity, unemployment, or gender-based violence.

Although gender-based violence is not an exposure that was measured in my study, this is a huge problem in South Africa and is also consistently associated with food insecurity in observational epidemiological studies. A cross sectional study in South Africa observed high rates of IPV, between 7 and 27%, and also found that antenatal maternal depression and IPV were associated with food insecurity (74). There is a substantial evidence base from both cross-sectional and longitudinal studies that has found significant associations and pathways between domestic violence and food insecurity with bi-directional relationships between food insecurity and poor mental health, domestic violence and poor mental health, and risks that increase with the severity of exposure (81). These findings suggest that interdisciplinary approaches may be most effective to address the multiple vulnerabilities of women who experience both food insecurity and domestic violence.

Nutritional interventions for depression

Nutritional psychology is a nascent field and there is growing research interest in preventative interventions that include nutritional components to prevent depression (82). However, the etiology of depression remains complex and the underlying causes include cognitive, environmental as well as physiological causes (82). It has been suggested that nutritional interventions may be effective for reducing or preventing depression in at risk groups, but such studies have shown mixed results. For example, a systematic review and meta-analysis observed that omega-3 intake is inversely associated with depression and this may be partly attributed this to their anti-inflammatory properties (83,84). However, a randomized controlled trial that examined omega-3 supplements in relation to depressive symptoms among HIV positive pregnant women found no significant differences in the

intervention or control group (85). Another study that examined omega-3 intake in relation to depression among adolescents also found no association once the analysis adjusted for lifestyle confounders (86). These findings suggest that nutritional interventions alone may be insufficient to prevent or treat depression, but this should not negate the potential of such interventions. It has been suggested that whole diet approach which focuses on nutrient dense diets low in ultra-processed foods would be more effective than focusing on individual nutrients. This will account for both known and unknown nutrients in the diet and also has the potential to improve mental as well as physical health for a large number of people (87).

9.3.2 Stunting

The DBM (stunting and overweight) among young children in many parts of the world has caused the nutrition community to realise the need for multi-faceted interventions (88). Interventions such as multiple micronutrient supplementation (MMS) during pregnancy can reduce adverse pregnancy outcomes such as anaemia, LBW and neural tube defects (88). Given the strong association with LBW and subsequent stunting, interventions that reduce the risk of intrauterine growth restriction and improve the foetal environment may play an important role in reducing the prevalence of stunting. A RCT that provided nutrient supplementation to women preconception or early pregnancy versus standard of care found that periconceptional supplementation was significantly associated with improved growth outcomes among infants at six months (89). However, high quality data on improving preconception maternal status are scare, and this is an important avenue for future research.

Improving linear growth for children who are already stunted is an enormous challenge. A Cochrane review of interventions of nutritional interventions for preventing stunting among children aged<5 years in urban slums found that there was no evidence of an effect of interventions for improving linear growth among children (90). Furthermore, the existing evidence suggests that even children who do have catch up growth between the ages of two and five years perform almost as poorly in cognitive tests as children who remained stunted (91). This is a sobering finding given the high prevalence of stunting in South Africa and the lifetime disadvantage that it confers upon future generations. The first two years of life are critical for both linear growth and cognitive development and much of the evidence reinforces the need for interventions that can reduce stunting in the first 1000 days of life (91).

In the South African context, there are also abundant misconceptions and a low prevalence rate of exclusive breastfeeding, another nutritional practice with important health implications for babies, particularly in resource poor settings (92,93) A subgroup analysis of a community-based randomised trial promoting exclusive breastfeeding found that at 12 weeks postpartum 20% of HIV-negative women and 40% of HIV-positive women had stopped breastfeeding (92). A cross-sectional study that examined stunting among South African children observed that only 5.9% of infants were exclusively breastfed at six months (94). The most recent South African Demographic and Health Survey (SDHS) reported that just 32% of infants below the age of six months were exclusively breastfed in 2016 (93). Interventions to improve breastfeeding might also be an important avenue to improve the health outcomes of vulnerable South African children, although a recent review of breastfeeding interventions found no direct impact on stunting and wasting but did observe a 24% decrease in diarrhoeal diseases (also a risk factor for stunting) (95).

Complementary feeding programmes do not appear to have significant effects on stunting, wasting, weight gain or height gain, but more interventions are needed to educate mothers about healthy diets and appropriate feeding practices (61). These findings suggest that macro level improvements in living standards and poverty reduction policies that increase employment opportunities and improve access to a wider variety of foods, in conjunction with nutritional education, may gradually improve the high stunting prevalence among South African children. There are also important lessons to be learned from countries like Peru, who have managed to reduce the prevalence of stunting in children under 5 years from 31.3% in 2000 to 13.1% in 2016 (96). Decomposition analysis of GHS data indicated that the most important factors to decrease stunting were increased maternal BMI and maternal height, improved maternal and new-born healthcare, increased parental education and reduced fertility (96,97).

Numerous studies in LMIC have found that increased maternal education is associated with a reduction in stunting and improved nutritional outcomes among children. In Chapter 7, I found in unadjusted bivariate analyses that each additional year of maternal education reduced the risk of severe stunting (OR 0.92), although this was not significant in the final model. An analysis of South African children who received the CSG found no overall improvements in stunting but did observe a significant improvement among children with educated mothers. For children with mothers who had more than eight years of schooling,

early receipt of the CSG had a positive impact, increasing HAZ by 0.19 SDs (98). Thus, grants may be more effective at improving stunting rates when combined with maternal education, as improving children's dietary diversity requires both money as well as knowledge about nutrition.

Another study by Casale et al., that examined the determinants of stunting at age two among a South African cohort, also found that mother's education was no longer significant in the final regression model (99). However, the results show that the largest mediating effect on stunting is through improved SES, with other pathways being antenatal outcomes (birthweight) and maternal parity (99). In Chapter 6, I also found that each additional year of maternal education reduced the risk of depression in the final multivariable model (OR 0.90). These relationships reinforce the importance of education for girls, both to empower mothers and improve their mental health and to improve their children's outcomes. A study among rural Mexican mother-child pairs also found that maternal schooling reduced the negative effects of household wealth on the prevalence of double burden households (100). These findings indicate that interventions like the CSG or other improvements in household income alone are insufficient to improve household nutritional outcomes. When combined with factors like maternal education and improved dietary diversity, such interventions may be more effective.

However, this does not invalidate the urgent need for nutritional programmes and interventions to improve nutrition among young children and adolescents. The national school nutrition programme (NSNP) in South Africa is a government funded programme that provides one nutritious meal to students in poorer primary and secondary schools. The objective of the programme is to improve their ability to learn. Millions of disadvantaged children suffered when schools were closed during the Covid-19 pandemic as for many of them, this was the only food that they ate all day (101)Such interventions are a small attempt to address the deeply rooted inequality in South Africa and the basic right to food. They can improve overall nutritional status and wellbeing but will not necessarily translate into an improvement in children's linear growth.

9.3.3 Food Security

In 2014, Brazil was commended for its efforts to reduce national food security and was removed from the World Food Programs (WFP) hunger map, meaning that less than 5% of its population faced severe food insecurity (102). The FAO noted that over a ten year period,

Brazil managed to reduce its level of hunger by 80% and the country was praised for its 'Zero Hunger' campaign (102). The zero hunger campaign placed the eradication of hunger and extreme poverty at the forefront of its social and economic policies and in a relatively short amount of time was able to improve food access and income generation as well as support food production by small farmers (103). The Brazilian government formed a national council of nutritional and food security to implement the programme and mobilised governmental and non-governmental sectors to work together. The government provided emergency food packages for the most needy households, constructed cisterns for clean water in the poorest communities, partnered with restaurants to offer meals for $1.00 and constructed community kitchens in the favelas (Brazilian slums) (102). They also implemented the Bolsa Familia (Family allowance) direct cash transfer programme to needy families to encourage children to remain in school. These inclusive policies were highly effective in reducing hunger and creating a more equal society. Unfortunately, a subsequent recession and increasingly conservative government policies capped public spending for needy families and food security programmes and dissolved the ministry of agrarian development. Neoliberal policies encouraged increased privatisation and food exports and increased local food prices (103). Changes in public spending as well as the pandemic decreased national food security and sadly Brazil was back on the hunger map by 2021. The success of Brazils zero hunger policy, as well as the unfortunate failure to sustain national food security, highlights the importance of political will and competent leadership to decrease hunger and food insecurity at the national level.

In the South African context, the Agriculture and Agro-processing Master Plan and the Economic Recovery and Reconstruction Plan are aligned with the National Development Plan (NDP) (104). These are social programmes that aim to increase agricultural production, boost competitiveness and job creation and broaden the inclusion of black farmers (105). Increasing support for small scale farmers and integrating them into value chains has also been a focus of the South African government to improve food security at the national level. Thus far, over 100 000 farmers have received vouchers to expand their production. However, progress has been slow for smallholder farmers and many younger people are not interested in farming and do not see it as a viable career. The high prevalence of violence on farms may also be a deterrent to would-be farmers. At the community level, although food gardens have often been suggested as a viable intervention to improve household food security, in practice food gardens are difficult to implement and sustain and have limited success when NGOs and

programme implementers leave (106). Tomita and colleagues also found that those living in food insecurity 'hotspots' were more likely to become depressed and that food insecurity was prevalent in areas with high food-producing potential, such as fertile soil and sufficient rainfall (107). Ultimately, hunger and malnutrition cannot be a purely governmental effort. Communities and individuals need to have the agency and the will to grow their own food and improve their health despite the challenges. This conflict between the state and individual autonomy has been in the back of my mind throughout this PhD study. On the one hand, there must be recognition of the importance of the social determinants of health, and governments should strive to create more enabling environments for health and human flourishing. On the other hand, people still make choices and suggesting that the poor are incapable of improving their circumstances in any way without intervention from the state is not helpful either. It is worth noting the importance of social support and human contact to mitigate the adverse impacts of both depression and food insecurity (108–110). The simple act of staying connected to others, being part of a broader community and reaching out in times of need may be the most realistic and effective intervention in some settings.

9.3.4 Low birthweight

There is increased recognition of the importance of improving periconceptional health as a potential intervention to reduce LBW. The Women First randomised controlled trial compared the impact of maternal nutrition supplementation preconception, at 11 weeks gestation or standard of care (no supplementation). The trial sites were in the DRC, Guatemala, India and Pakistan. Linear growth in both arm 1 and arm 2 were statistically greater than arm 3 for infants in the first six months of life, with children in Arm 1 experiencing the best growth (89). These findings suggest that prenatal factors were more important than postnatal diet in influencing growth during the first six months of children's life.

However, it is also important to note that main causes of LBW differ by geographic region. In Asia, LBW is primarily driven by maternal undernutrition, including mothers who are stunted themselves and deliver SGA infants. In settings with a large proportion of adolescent pregnancies or high levels of infections, preterm birth is the main cause of LBW (111). Single and MMS (combining iron and folic acid) during pregnancy can reduce maternal anaemia and offers a 12% reduction in the risk for having a LBW infant (61).

An overview of systematic reviews found that oral supplementation of Vitamin A, low dose calcium, zinc, multiple micronutrient supplements, nutritional education and preventative antimalarial intervention significantly decreased the risk of LBW (112). A meta-analysis of studies across the income spectrum found that Vitamin D supplementation can reduce the risks of LBW by up to 45% (113). However, these relatively simple and cost effective interventions need to be implemented at scale in the public sector as it is the most socioeconomically disadvantaged mothers who bear the brunt of poor pregnancy and birth outcomes. Women who are pregnant need to attend antenatal care throughout their pregnancies to ensure that they are in optimal health, and to test for anaemia and other deficiencies that may increase their risk of delivering a LBW infant. A randomised controlled trial in Bangladesh also found that a short term nutrition education programme (3 months) substantially reduced LBW and improved pregnancy outcomes among poor women (114) While the situation in Bangladesh is considerably different to South Africa, with a high prevalence of maternal underweight, the intervention demonstrated that women were amenable to changing their eating habits and eating more in the third trimester to improve their pregnancy outcomes (114). South Africa has a high rate of obesity which is also a risk factor for adverse birth and pregnancy outcomes (115). A systematic review that examined counselling and active behavioural interventions to limit gestational weight gain (GWG) found that these interventions were associated with decreased risk of gestational diabetes, emergency caesarean delivery, macrosomia, and large for gestational age (116). Unfortunately, such interventions are not a part of routine care in the public sector and the information that pregnant women receive regarding nutrition and overall health during their pregnancies may be minimal. Mobile platforms like MomConnect may be useful in this regard. This initiative aims to electronically register all pregnancies in the public health system as early as possible and to send targeted health promotion messages to pregnant women to improve both their and their babies' health (https://www.health.gov.za/momconnect/).

9.4 Recommendations for further research

There is emerging interest in whether certain micronutrient deficiencies may also play a role in the development of perinatal depressive symptoms (117). Thus far, the evidence remains inconclusive, but this is an important area for research, particularly in LMIC where women may experience multiple micronutrient deficiencies in the perinatal period. A recent systematic review of 13 different studies examining dietary patterns and antenatal and

postnatal depressive symptoms found that healthy eating patterns were inversely associated with depression, while a deficiency of calcium, iron, and folate were also associated with maternal depression (118). Many of the studies included in the review were conducted in the US or other high-income countries, which limits inferences to LMIC like South Africa. This is an important avenue for future research as targeted supplementation of specific micronutrients like calcium and folate may reduce depressive symptoms among women in these settings. In addition, micronutrient deficiencies are associated with LBW, so trials that examine both maternal depressive symptoms as well as birth outcomes could address both questions regarding maternal mental health as well as LBW and linear growth among children. Studies that examine overall dietary patterns in relation to depression in the South African context are also required in addition to studies that examine specific micronutrients. This may also require the development of context specific dietary data collection tools and/or the adjustment of existing measures as well as validation studies to confirm that these tools accurately reflect South African dietary patterns.

Further research is needed to establish and elucidate the associations between maternal depression and child health outcomes. This would require rigorous longitudinal studies that examine the chronicity of maternal depression, using continuous scores at various timepoints during pregnancy and postnatally, and adjust for a variety of confounding factors, maternal and environmental characteristics. Such studies should also use measurement instruments especially developed for pregnant or postpartum women (e.g. The EPDS) (76).

Stunting remains a serious global public health problem and one that is particularly difficult to solve given its intergenerational component as well as multiple environmental factors. More research is needed to understand what interventions are the most effective to address stunting in LMIC and how to best allocate the funding for social protection and humanitarian policies. A RCT that examines an extension of the CSG into pregnancy could be studied in relation to both maternal and child health outcomes (maternal depression, LBW, length for gestational age, preterm birth and stunting) to inform policymakers in social development. More RCTs are needed to examine the long-term effects of preconception nutritional supplementation on children's birth outcomes and linear growth in the first five years of life.

There is abundant research about stunting among younger children, but less is understood about stunting during adolescence and whether catch up growth is even possible (119). Adolescence is also a critical time for development and stunting has been associated with

delayed puberty as well as poor peer relationships among adolescents (120). In addition, although boys are more likely to be severely stunted in early childhood (as we found in Chapter 7), emerging research suggests that stunting in later childhood and early adolescence has worse health implications for girls (120). This is particularly important in countries where there is a high rate of adolescent pregnancies as these young mothers may continue the cycle of poor growth outcomes among their children. Longitudinal studies are needed to examine if catch up growth can occur in adolescence and how stunting in adolescence impacts cognitive development as well as other health outcomes.

More research is needed to improve the existing measures of dietary diversity as well as increased standardisation of measurement instruments across different studies and geographical regions. The inclusion of a separate category for processed foods would be very useful given the proliferation of these types of foods over the past two decades as well as their implications for obesity and potentially for mental health (17,121). In addition, measurement of dietary diversity could be improved if there were some indications of the quantities of food groups consumed. Dietary diversity data may also have potential for gauging the impacts of shocks like the Coronavirus pandemic, not only because dietary diversity is sensitive to shock, but also because they are cost effective and can be frequently collected (35). Longitudinal studies that examine dietary diversity over time and in relation to child and adult anthropometry across the income spectrum may further elucidate these relationships. Validation studies in LMIC would also be useful for generating a gold standard with regards to cut-offs for household level dietary diversity data.

9.5 References

1. Jiang W, Mo M, Li M, Wang S, Muyiduli X, Shao B, et al. The relationship of dietary diversity score with depression and anxiety among prenatal and post-partum women. J Obstet Gynaecol Res. 2018 Oct;44(10):1929–36.
2. Sparling TM, Waid JL, Wendt AS, Gabrysch S. Depression among women of reproductive age in rural Bangladesh is linked to food security, diets and nutrition. Public Health Nutr. 2020 Mar;23(4):660–73. 10.1017/S1368980019003495
3. Adhikari RP, Williamson R, Sparling TM, Ferguson E, Cunningham K. Parental depression and nutrition: findings from a cross-sectional household survey in Nepal. Public Health Nutr. 2020 Nov;23(16):2983–93. 10.1017/S1368980020000968
4. Emerson JA, Caulfield LE, Kishimata EM, Nzanzu J-P, Doocy S. Mental health symptoms and their relations with dietary diversity and nutritional status among mothers of young children in eastern Democratic Republic of the Congo. BMC Public Health. 2020 Feb;20(1):225. 10.1186/s12889-019-8092-3
5. Koury AJ, Dynia J, Dore R, Logan JAR, Purtell KM, Joy E, et al. Food Insecurity and Depression among Economically Disadvantaged Mothers: Does Maternal Efficacy Matter? Appl Psychol Heal Well-Being. 2020;12(2):432–48. 10.1111/aphw.12191

6. Pourmotabbed A, Moradi S, Babaei A, Ghavami A, Mohammadi H, Jalili C, et al. Food insecurity and mental health: A systematic review and meta-analysis. Public Health Nutr. 2020;23(10):1778–90. 10.1017/S136898001900435X

7. Dewing S, Tomlinson M, Le Roux IM, Chopra M, Tsai AC. Food insecurity and its association with co-occurring postnatal depression, hazardous drinking, and suicidality among women in peri-urban South Africa. J Affect Disord [Internet]. 2013;150(2):460–5. Available from: http://dx.doi.org/10.1016/j.jad.2013.04.040

8. Abrahams Z, Lund C, Field S, Honikman S. Factors associated with household food insecurity and depression in pregnant South African women from a low socio-economic setting: a cross-sectional study. Soc Psychiatry Psychiatr Epidemiol [Internet]. 2018;0(0):0. Available from: http://www.ncbi.nlm.nih.gov/pubmed/29445850%0Ahttp://link.springer.com/10.1007/s00127-018-1497-y

9. Sparling TM, Henschke N, Nesbitt RC, Gabrysch S. The role of diet and nutritional supplementation in perinatal depression: a systematic review. Vol. 13, Maternal & Child Nutrition. 2017. p. 1. DOI: 10.1111/mcn.12235

10. Prado EL, Ullman MT, Muadz H, Alcock KJ, Shankar AH. The effect of maternal multiple micronutrient supplementation on cognition and mood during pregnancy and postpartum in Indonesia: A randomized trial. PLoS One [Internet]. 2012 Mar 12;7(3). Available from: http://0-search.ebscohost.com.innopac.wits.ac.za/login.aspx?direct=true&db=psyh&AN=2012-07934-001&site=ehost-live&scope=site

11. Prado EL, Yakes Jimenez E, Vosti S, Stewart R, Stewart CP, Somé J, et al. Path analyses of risk factors for linear growth faltering in four prospective cohorts of young children in Ghana, Malawi and Burkina Faso. BMJ Glob Heal [Internet]. 2019;4(1). Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85061779800&doi=10.1136%2Fbmjgh-2018-001155&partnerID=40&md5=0b3665ef638cfabb8ec5b442e84d7f29

12. Ahun MN, Aboud FE, Aryeetey R, Colecraft E, Marquis GS. Child development in rural Ghana: Associations between cognitive/language milestones and indicators of nutrition and stimulation of children under two years of age. Can J Public Heal [Internet]. 2017 Jan;108(5–6):e578–85. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85040927379&doi=10.17269%2Fcjph.108.5875&partnerID=40&md5=85fb6ed087d868069fe8ae458c3a6a3a

13. Miller LC, Neupane S, Sparling TM, Shrestha M, Joshi N, Lohani M, et al. Maternal depression is associated with less dietary diversity among rural Nepali children. Matern Child Nutr [Internet]. 2021;17(4). Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85107831785&doi=10.1111%2Fmcn.13221&partnerID=40&md5=d55c50b01bb09c89975413ac555b947c

14. Anato A, Baye K, Tafese Z, Stoecker BJ. Maternal depression is associated with child undernutrition: A cross-sectional study in Ethiopia. Matern Child Nutr. 2020 Jul;16(3):e12934. 10.1111/mcn.12934

15. Prado EL, Abbeddou S, Adu-Afarwuah S, Arimond M, Ashorn P, Ashorn U, et al. Predictors and pathways of language and motor development in four prospective cohorts of young children in Ghana, Malawi, and Burkina Faso. J Child Psychol Psychiatry. 2017 Nov;58(11):1264–75.

16. Luppino FS, de Wit LM, Bouvy PF, Stijnen T, Cuijpers P, Penninx BWJH, et al. Overweight, obesity, and depression: a systematic review and meta-analysis of longitudinal studies. Arch Gen Psychiatry. 2010 Mar;67(3):220–9. 10.1001/archgenpsychiatry.2010.2

17. Gomez-Donoso C, Sanchez-Villegas A, Martinez-Gonzalez MA, Gea A, Mendonca RD, Lahortiga-Ramos F, et al. Ultra-processed food consumption and the incidence of depression in a Mediterranean cohort: the SUN Project. Eur J Nutr. 2020;59:1093–103. DOI: 10.1007/s00394-019-01970-1

18. Sanchez-Villegas A, Toledo E, de IJ, Ruiz-Canela M, Pla-Vidal J, Martinez-Gonzalez MA. Fast-food and commercial baked goods consumption and the risk of depression. Vol. 15, Public Health Nutrition. 2012. p. 424–32. 10.1017/S1368980011001856

19. Karimbeiki R, Pourmasoumi M, Feizi A, Abbasi B, Hadi A, Rafie N, et al. Higher dietary diversity score is associated with obesity: a case–control study. Public Health [Internet]. 2018;157:127–34. Available from: https://www.sciencedirect.com/science/article/pii/S0033350618300386

20. Jayawardena R, Byrne NM, Soares MJ, Katulanda P, Yadav B, Hills AP. High dietary diversity is associated with obesity in Sri Lankan adults: An evaluation of three dietary scores. BMC Public Health. 2013;13(1). 10.1186/1471-2458-13-314

21. Amugsi DA, Dimbuene ZT, Bakibinga P, Kimani-Murage EW, Haregu TN, Mberu B. Dietary diversity, socioeconomic status and maternal body mass index (BMI): quantile regression analysis of nationally representative data from Ghana, Namibia and Sao Tome and Principe. BMJ Open. 2016;6(9). 10.1136/bmjopen-2016-012615

22. Popkin BM, Corvalan C, Grummer-Strawn LM. Dynamics of the double burden of malnutrition and the changing nutrition reality. Lancet [Internet]. 2020;395(10217):65–74. Available from: http://dx.doi.org/10.1016/S0140-6736(19)32497-3

23. Dewey KG, Begum K. Long-term consequences of stunting in early life. Matern Child Nutr [Internet]. 2011 Oct [cited 2013 Nov 19];7 Suppl 3:5–18. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21929633

24. Leroy JL, Frongillo EA. Perspective: What Does Stunting Really Mean? A Critical Review of the Evidence. Adv Nutr. 2019;10(2):196–204. 10.1093/advances/nmy101

25. Popkin BM, Gordon-Larsen P. The nutrition transition: worldwide obesity dynamics and their determinants. Int J Obes Relat Metab Disord [Internet]. 2004;28 Suppl 3(Suppl 3):S2-9. Available from: http://www.researchgate.net/publication/8184173_Popkin_BM_Gordon-Larsen_P._The_nutrition_transition_worldwide_obesity_dynamics_and_their_determinants._Int_J_Obes_Relat_Metab_Disord_28(Suppl)_S2-S9

26. Siega-Riz AM, Laraia B. The implications of maternal overweight and obesity on the course of pregnancy and birth outcomes. Matern Child Health J. 2006;10(SUPPL. 7):153–6. 10.1007/s10995-006-0115-x

27. Spradley FT, Palei AC, Granger JP. Increased risk for the development of preeclampsia in obese pregnancies: Weighing in on the mechanisms. Am J Physiol - Regul Integr Comp Physiol. 2015;309(11):R1326–43. 10.1152/ajpregu.00178.2015

28. Cois A, Day C. Obesity trends and risk factors in the South African adult population. BMC Obes. 2015;2(1):1–10. 10.1186/s40608-015-0072-2

29. FAO. The State of Food Security and Nutrition in the World. Transforming food systems for food security, improved nutrition and affordable healthy diets for all [Internet]. Rome; 2021. Available from: https://doi.org/10.4060/ca9692en

30. Shisana o, Labadarios D, Rehle T, Simbayi L, Zuma K, Dhansay A, Reddy P, Parker W, Hoosain E, Naidoo P, Hogoro C, Mchiza Z S. The South African National Health and Nutrition Examination Survey, 2012 SANHANES-1. CAPiTiLPRESS; 2014. 423 p.

31. Steyn NP, Nel JH, Drummond L, Malczyk S, Senekal M. Has Food Security and Nutritional Status Improved in Children 1–<10 Years in Two Provinces of South Africa between 1999 (National Food Consumption Survey) and 2018 (Provincial Dietary Intake Study (PDIS)). Int J Environ Res Public Health. 2022;19(3):1–21. 10.3390/ijerph19031038

32. Van Den Berg VL, Okeyo AP, Dannhauser A, Nel M. Body weight, eating practices and nutritional knowledge amongst university nursing students, Eastern Cape, South Africa. African J Prim Heal Care Fam Med. 2012;4(1):1–9. 10.4102/phcfm.v4i1.323

33. Molotja, C. M., Maliwichi, L. L., & Jideani AI. Nutrition knowledge and food choices of primary school learners in Limpopo province, South Africa. J Consum Sci. 2020;5(May 2019):98–114. ISSN 0378-5254

34. Leroy JL, Ruel M, Frongillo EA, Harris J, Ballard TJ. Measuring the food access dimension of food security: A critical review and mapping of indicators. Food Nutr Bull. 2015;36(2):167–95. 10.1177/0379572115587274

35. Headey D, Ecker O. Rethinking the measurement of food security: From first principles to best practice. Food Secur. 2013;5(3):327–43. 10.1007/s12571-013-0253-0

36. Tomlinson M, Cooper PJ, Stein A, Swartz L, Molteno C. Post-partum depression and infant growth in a South African peri-urban settlement. Child Care Health Dev. 2006;32(1):81–6. 10.1111/j.1365-2214.2006.00598.x

37. Reesor-Oyer L, Cepni AB, Lee CY, Zhao X, Hernandez DC. Disentangling food insecurity and maternal depression: Which comes first? Public Health Nutr. 2021;24(16):5506–13. 10.1017/S1368980021000434

38. Barker ED, Kirkham N, Ng J, Jensen SKG. Prenatal maternal depression symptoms and nutrition, and child cognitive function. Br J Psychiatry. 2013;203(6):417–21. 10.1192/bjp.bp.113.129486

39. Wemakor A, Iddrisu H. Maternal depression does not affect complementary feeding indicators or stunting status of young children (6-23 months) in Northern Ghana. BMC Res Notes [Internet]. 2018;11(1). Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85049095363&doi=10.1186%2Fs13104-018-3528-x&partnerID=40&md5=86e43b7b1cbdf7c65b30519652df7cc4

40. Avan B, Richter LM, Ramchandani PG, Norris SA, Stein A. Maternal postnatal depression and children ' s growth and behaviour during the early years of life : exploring the interaction between physical and mental health. Arch Dis Child. 2010;690–5. 10.1136/adc.2009.164848

41. van Heyningen T, Myer L, Onah M, Tomlinson M, Field S, Honikman S, et al. Antenatal depression and adversity in urban South Africa. J Affect Disord [Internet]. 2016;203:121–9. Available from: http://dx.doi.org/10.1016/j.jad.2016.05.052

42. Herba CM, Glover V, Ramchandani PG, Rondon MB. Maternal depression and mental health in early childhood: an examination of underlying mechanisms in low-income and middle-income countries. The Lancet Psychiatry [Internet]. 2016;3(10):983–92. Available from: http://dx.doi.org/10.1016/S2215-0366(16)30148-1

43. Garman EC, Schneider M, Lund C. Perinatal depressive symptoms among low-income South African women at risk of depression: Trajectories and predictors. BMC Pregnancy Childbirth. 2019;19(1):1–11. 10.1186/s12884-019-2355-y

44. Slomian J, Honvo G, Emonts P, Reginster J, Bruyère O. Consequences of maternal postpartum depression : A systematic review of maternal and infant outcomes. Women's Health. 2019; 15:1-55. 10.1177/1745506519844044

45. Drysdale RE, Richter LM, Slemming W. Father involvement , maternal depression and child nutritional outcomes in Soweto , South Africa. Matern Child Nutr. 2021;17(February):1–12. 10.1111/mcn.13177

46. Mcnab S, Fisher J, Honikman S, Muvhu L, Levine R, Sungani GC, et al. Comment : silent burden no more : a global call to action to prioritize perinatal mental health. BMC Pregnancy Childbirth [Internet]. 2022;10–3. Available from: https://doi.org/10.1186/s12884-022-04645-8

47. Kruger LM, Lourens M. Motherhood and the "Madness of Hunger": "…Want Almal Vra vir My vir 'n Stukkie Brood" ("…Because Everyone Asks Me for a Little Piece of Bread"). Cult Med Psychiatry. 2016;40(1):124–43. 10.1007/s11013-015-9480-5

48. Sparling TM, Waid JL, Wendt AS, Gabrysch S. Depression among women of reproductive age in rural Bangladesh is linked to food security, diets and nutrition. Public Health Nutr. 2020 Mar;23(4):660–73. 10.1017/S1368980019003495

49. Moradi S, Arghavani H, Issah A, Mohammadi H, Mirzaei K. Review Article Food insecurity and anaemia risk : a systematic review and meta-analysis. Public Health Nutr. 2018;21(16):3067–79. 10.1017/S1368980018001775

50. Mchiza ZJ, Parker W, Hossin MZ, Heshmati A, Labadarios D, Falkstedt D, et al. Social and Psychological Predictors of Body Mass Index among South Africans 15 Years and Older : SANHANES-1. :1–20. doi:10.3390/ijerph16203919

51. Traore SS, Bo Y, Amoah AN, Khatun P, Kou G, Hu Y, et al. A meta-analysis of maternal dietary patterns and preeclampsia. Clin Nutr Open Sci [Internet]. 2021;40:15–29. Available from: https://doi.org/10.1016/j.nutos.2021.08.001

52. Mbhatsani H V., Mabapa NS, Ayuk TB, Mandiwana TC, Mushaphi LF, Mohlala M, et al. Food security and related health risk among adults in the Limpopo Province of South Africa. S Afr J Sci. 2021;117(11–12):1–7. 10.17159/SAJS.2021/8848

53. UNICEF. Low birthweight prevalence, by country and region, 2015 [Internet]. 2019. Available from: https://data.unicef.org/topic/nutrition/low-birthweight/

54. Radimer KL, Olson CM, Greene JC, Campbell CC, Habicht J-P. Understanding hunger and developing indicators to assess it in women and children. J Nutr Educ [Internet]. 1992;24(1, Supplement 1):36S-44S. Available from: https://www.sciencedirect.com/science/article/pii/S0022318212801373

55. Weingarten SE, Dearden KA, Crookston BT, Penny ME, Behrman JR, Humphries DL. Are household expenditures on food groups associated with children's future heights in Ethiopia, India, Peru, and Vietnam? Int J Environ Res Public Health. 2020;17(13):1–23. 10.3390/ijerph17134739

56. Humphries DL, Dearden KA, Crookston BT, Woldehanna T, Penny ME, Behrman JR. Household food group expenditure patterns are associated with child anthropometry at ages 5, 8 and 12 years in Ethiopia, India, Peru and Vietnam. Econ Hum Biol [Internet]. 2017;26:30–41. Available from: https://www.sciencedirect.com/science/article/pii/S1570677X16300788

57. Mhlongo V, Daniels RC. Food expenditure patterns in South Africa : Evidence from the NIDS.Working Paper Number 123. 2013;(123):27. ISBN: 9781920517649

58. Devereux S, Waidler J. Why does malnutrition persist in South Africa despite social grants? Food Security SA Working Paper Series No. 001. 2017.

59. Khosa P, Kaseke E. The Utilisation of the Child Support Grant by caregivers: The case of Ba-Phalaborwa Municipality in Limpopo Province. Soc Work. 2014;50(4):504–15. ISSN 0952-3987

60. Mohamed S. Fighting hunger, one bowl at a time – two days in the unending battle to feed South Africa's starving children. Daily Maverick. 2022;1–15.

61. Keats EC, Das JK, Salam RA, Lassi ZS, Imdad A, Black RE, et al. Effective interventions to address maternal and child malnutrition: an update of the evidence. Lancet Child Adolesc Heal [Internet]. 2021;5(5):367–84. Available from: http://dx.doi.org/10.1016/S2352-4642(20)30274-1

62. Kozuki N, Katz J, Lee ACC, Vogel JP, Silveira MF, Sania A, et al. Short Maternal Stature Increases Risk of Small- for-Gestational-Age and Preterm Births in Low- and Middle-Income Countries : Individual Participant Data Meta-Analysis and Population Attributable Fraction. J Nutr. 2015;145:2452–2450. 10.3945/jn.115.216374.preterm63. Subramanian S V., Karlsson O, Kim R. Revisiting the stunting metric for monitoring and evaluating nutrition policies. Lancet Glob Heal [Internet]. 2022;10(2):e179–80. Available from: http://dx.doi.org/10.1016/S2214-109X(21)00504-0

64. Krasevec J, An X, Kumapley R, Bégin F, Frongillo EA. Diet quality and risk of stunting among infants and young children in low- and middle-income countries. Matern Child Nutr. 2017 Oct;13 Suppl 2(Suppl 2). 10.1111/mcn.12430

65. Hunt X, Stein DJ, Spaull N, Tomlinson M. Hunger as a driver of depressive symptoms: Optimising responses to mental health aspects of the COVID-19 pandemic. South African Med J. 2021;111(7):604–5. 10.7196/SAMJ.2021.v111i7.15754

66. Casale D, Posel D. Gender and the early effects of the Covid-19 crisis in the paid and unpaid economies in South Africa. 2020.

67. Hessami K, Romanelli C, Chiurazzi M, Cozzolino M. COVID-19 pandemic and maternal mental health : a systematic review and meta-analysis. J Matern Neonatal Med [Internet]. 2022;35(20):4014–21. Available from: https://doi.org/10.1080/14767058.2020.1843155

68. Mola CL De, Martins-silva T, Carpena MX, Blumenberg C, Martins RC, Dias IM, et al. Maternal mental health before and during the COVID-19 pandemic in the 2019 Rio Grande birth cohort. Brazilian J Psychiatry. 2021;43(4):402–6. 10.1590/1516-4446-2020-1673

69. Davenport MH, Meyer S, Meah VL, Strynadka MC, Khurana R. Moms Are Not OK: COVID-19 and Maternal Mental Health. Front Glob Women's Heal. 2020;1(June):1–6. 10.3389/fgwh.2020.00001

70. Perzow SED, Hennessey E-MP, Hoffman MC, Grote NK, Davis EP, Hankin BL. Mental health of pregnant and postpartum women in response to the COVID-19 pandemic. J Affect Disord Reports [Internet]. 2021;4:100123. Available from: https://www.sciencedirect.com/science/article/pii/S2666915321000500

71. Hamadani JD, Hasan MI, Baldi AJ, Hossain SJ, Shiraji S, Bhuiyan MSA, et al. Immediate impact of stay-at-home orders to control COVID-19 transmission on socioeconomic conditions, food insecurity, mental health, and intimate partner violence in Bangladeshi women and their families: an interrupted time series. Lancet Glob Heal. 2020 Nov;8(11):e1380–9. 10.1016/S2214-109X(20)30366-1

72. Dlamini NJ. Gender-Based Violence , Twin Pandemic to COVID-19. Crit Sociol. 2021;19. 10.1177/0896920520975465

73. Huddleston-Casas C, Charnigo R, Simmons LA. Food insecurity and maternal depression in rural, low-income families: A longitudinal investigation. Public Health Nutr. 2009 Aug;12(8):1133–40. 10.1017/S1368980008003650

74. Barnett W, Pellowski J, Kuo C, Koen N, Donald KA, Zar HJ, et al. Food-insecure pregnant women in South Africa: A cross-sectional exploration of maternal depression as a mediator of violence and trauma risk factors. BMJ Open. 2019;9(3):1–11. 10.1136/bmjopen-2017-018277

75. Wado YD, Afework MF, Hindin MJ. Effects of maternal pregnancy intention, depressive symptoms and social support on risk of low birth weight: A prospective study from Southwestern Ethiopia. PLoS One. 2014;9(5):1–7. 10.1371/journal.pone.0096304

76. Yin X, Sun N, Jiang N, Xu X, Gan Y, Zhang J, et al. Prevalence and associated factors of antenatal depression: Systematic reviews and meta-analyses. Clin Psychol Rev [Internet]. 2021;83(September 2020):101932. Available from: https://doi.org/10.1016/j.cpr.2020.101932

77. Fisher J, Tran T, Duc Tran T, Dwyer T, Nguyen T, Casey GJ, et al. Prevalence and risk factors for symptoms of common mental disorders in early and late pregnancy in Vietnamese women: A prospective population-based study. J Affect Disord [Internet]. 2013;146(2):213–9. Available from: https://www.sciencedirect.com/science/article/pii/S0165032712006350

78. Lund C, Schneider M, Garman EC, Davies T, Munodawafa M, Honikman S, et al. Task-sharing of psychological treatment for antenatal depression in Khayelitsha, South Africa: Effects on antenatal and postnatal outcomes in an individual randomised controlled trial. Behav Res Ther [Internet]. 2020;130(September 2019):103466. Available from: https://doi.org/10.1016/j.brat.2019.103466

79. Bliznashka L, Yousafzai AK, Asheri G, Masanja H, Sudfeld CR. Effects of a community health worker delivered intervention on maternal depressive symptoms in rural Tanzania. Health Policy Plan. 2021;36(4):473–83. 10.1093/heapol/czaa170

80. Grote, N.K. Bridge, J.A. Gavin, A.R. Melville, J.L. Iyengar, S. Katon WJ. A meta-analysis of depression during pregnancy and the risk of preterm birth, low birth weight, and intrauterine growth restriction. Arch Womens Ment Health [Internet]. 2011;14(10):S26. Available from: http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L70557360%5Cnhttp://dx.doi.org/10.1007/s00737-010-0203-1

81. Laurenzi C, Field S, Honikman S. Food Insecurity, Maternal Mental Health, and Domestic Violence: A Call for a Syndemic Approach to Research and Interventions. Matern Child Health J. 2020 Apr;24(4):401–4. 10.1007/s10995-019-02872-8

82. Owens M, Watkins E, Bot M, Brouwer IA, Roca M, Kohls E, et al. Nutrition and depression : Summary of findings from the EU-funded MooDFOOD depression prevention randomised controlled trial and a critical review of the literature. Nutr Bull. 2020;403–14. 10.1111/nbu.1244783. Grosso G, Micek A, Marventano S, Castellano S, Mistretta A, Pajak A, et al. Dietary n-3 PUFA, fish consumption and depression: A systematic review and meta-analysis of observational studies. Vol. 205, Journal of Affective Disorders. 2016. p. 269–81. DOI: 10.1016.j.jad.2016.08.011

84. Grosso G, Galvano F, Marventano S, Malaguarnera M, Bucolo C, Drago F, et al. Omega-3 Fatty Acids and Depression : Scientific Evidence and Biological Mechanisms. Oxid Med Cell Longev. 2014;2014(Figure 1). 10.1155/2014/313570

85. Opiyo RO, Nyasulu PS, Koigi RK, Obondo A, Ogoyi D, Kogi-Makau W. Effect of fish oil omega-3 fatty acids on reduction of depressive symptoms among HIV-seropositive pregnant women: A randomized, double-blind controlled trial. Ann Gen Psychiatry [Internet]. 2018 Nov 26;17. 10.1186/s12991-018-0220-4

86. Oddy WH, Hickling S, Smith MA, O'Sullivan TA, Robinson M, de Klerk NH, et al. Dietary intake of omega-3 fatty acids and risk of depressive symptoms in adolescents. Depress Anxiety [Internet]. 2011 Jul;28(7):582–8. Available from: 10.1002/da.2082287. Upton N. Developing our understanding of nutrition in depression. Br J Nutr [Internet]. 2021/05/27. 2022;127(7):1010–7. Available from: https://www.cambridge.org/core/article/developing-our-understanding-of-nutrition-in-depression/548B630869E022F57B9ABFE02700D642

88. Heidkamp RA, Piwoz E, Gillespie S, Keats EC, Alimonte MRD, Menon P, et al. Series Maternal and

Child Undernutrition Progress 2 Mobilising evidence , data , and resources to achieve global maternal and child undernutrition targets and the Sustainable Development Goals : an agenda for action. Lancet [Internet]. 2021;6736(21):1–19. Available from: http://dx.doi.org/10.1016/S0140-6736(21)00568-7

89. Krebs NF, Hambidge KM, Westcott JL, Garc AL, Figueroa L, Tsefu AK, et al. Growth from Birth Through Six Months for Infants of Mothers in the "Women First" Preconception Maternal Nutrition Trial. The Journal of Pediatrics. 2020; 10.1016/j.jpeds.2020.09.032

90. Goudet S, Bogin B, Madise N, Griffiths P. Nutritional interventions for preventing stunting in children (birth to 59 months) living in urban slums in low- and middle-income countries (LMIC) (Review).Cochrane Database of Systematic Reviews. 2019. 10.1002/14651858.CD011695.pub2.www.cochranelibrary.com

91. Casale D, Desmond C, Richter LM. Catch-up growth in height and cognitive function: Why definitions matter. Econ Hum Biol. 2020;37. 10.1016/j.ehb.2020.100853

92. Doherty T, Sanders D, Jackson D, Swanevelder S, Lombard C, Zembe W, et al. Early cessation of breastfeeding amongst women in South Africa: an area needing urgent attention to improve child health. BMC Pediatr [Internet]. 2012 Jan;12:105. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3441849&tool=pmcentrez&rendertype=abstract

93. May J, Witten C, Lake L. South African Child Gauge 2020: Food and nutrition security. Cape Town; 2020.

94. Matsungo TM, Kruger HS, Faber M, Rothman M, Smuts CM. The prevalence and factors associated with stunting among infants aged 6 months in a peri-urban South African community.Public Health Nutrition 2017;20(17):3209–18. 10.1017/S1368980017002087

95. Mosites E, Dawson-Hahn E, Walson J, Rowhani-Rahbar A, Neuhouser ML. Piecing together the stunting puzzle: a framework for attributable factors of child stunting. Paediatr Int Child Health. 2017;37(3):158–65. 10.1080/20469047.2016.1230952

96. Huicho L, Vidal-cárdenas E, Akseer N, Brar S, Conway K, Islam M, et al. Drivers of stunting reduction in Peru : a country case study. AM J Clin Nutr. 2020;112:816–29. doi: https://doi.org/10.1093/ajcn/nqaa164.

97. Huicho L, Huayanay-espinoza CA, Herrera-perez E, Segura ER, Guzman JN De, Rivera-ch M, et al. Factors behind the success story of under-five stunting in Peru : a district ecological multilevel analysis. BMC Pediatr [Internet]. 2017;1–9. Available from: http://dx.doi.org/10.1186/s12887-017-0790-3

98. DSD, SASSA, UNICEF. The South African Child Support Grant Impact Assessment: Evidence form a survey of children [Internet]. 2012. Available from: https://www.unicef.org/evaldatabase/files/The_South_African_Child_Support_Grant_Impact_Assessment.pdf

99. Casale D, Espi G, Norris SA. Estimating the pathways through which maternal education affects stunting: Evidence from an urban cohort in South Africa. Public Health Nutr. 2018;21(10):1810–8. 10.1017/S1368980018000125

100. Leroy JL, Habicht J-P, González de Cossío T, Ruel MT. Maternal Education Mitigates the Negative Effects of Higher Income on the Double Burden of Child Stunting and Maternal Overweight in Rural Mexico. J Nutr. 2014;144(5):765–70. 10.3945/jn.113.188474

101. van der Berg S, Zuze L, Bridgman G. The impact of hte Coronavirus and lockdown on children's welfare in South Africa; Evidence from NIDS-CRAM Wave 1. 2020.

102. Alves L. Pandemic puts Brazil back on the world hunger map. The New Humanitarian. 2022;1–11.

103. Sepúlveda A. Brazil : from a global example of food security to back on the Hunger Map. SciencesPo observatoire politique de l'amerique ltine et des caraibes. 2014. p. 1–5.

104. South African National Development Plan 2030 Executive Summary. 2022.

105. Banda M. What is the government doing about food security? The Daily Maverick. 2022;1–11.

106. Du Toit MJ, Rendón O, Cologna V, Cilliers SS, Dallimer M. Why Home Gardens Fail in Enhancing Food Security and Dietary Diversity. Front Ecol Evol. 2022;10(February). 10.3389/fevo.2022.804523

107. Tomita A, Cuadros DF, Mabhaudhi T, Sartorius B, Ncama BP, Dangour AD, et al. Spatial clustering of food insecurity and its association with depression: a geospatial analysis of nationally representative South African data, 2008–2015. Sci Rep [Internet]. 2020;10(1):1–11. Available from: https://doi.org/10.1038/s41598-020-70647-1

108. Tsai AC, Tomlinson M, Comulada WS, Rotheram-Borus MJ. Food insufficiency, depression, and the modifying role of social support: Evidence from a population-based, prospective cohort of pregnant women in peri-urban South Africa. Soc Sci Med [Internet]. 2016;151:69–77. Available from: http://dx.doi.org/10.1016/j.socscimed.2015.12.042

109. Nakamura A, El-Khoury Lesueur F, Sutter-Dallay A-L, Franck J-ève, Thierry X, Melchior M, et al. The role of prenatal social support in social inequalities with regard to maternal postpartum depression according to migrant status. J Affect Disord [Internet]. 2020;272:465–73. Available from: https://www.sciencedirect.com/science/article/pii/S0165032719331726

110. Richards M, Weigel M, Li M, Rosenberg M, Ludema C. Household food insecurity and antepartum depression in the National Children's Study. Ann Epidemiol [Internet]. 2020;44:38-44.e1. Available from: https://www.sciencedirect.com/science/article/pii/S1047279719305599

111. Blencowe H, Krasevec J, de Onis M, Black RE, An X, Stevens GA, et al. National, regional, and worldwide estimates of low birthweight in 2015, with trends from 2000: a systematic analysis. Lancet Glob Heal [Internet]. 2019;7(7):e849–60. Available from: http://dx.doi.org/10.1016/S2214-109X(18)30565-5

112. Lopes S, Ota E, Shakya P, Dagvadorj A, Balogun OO, Peña-rosas JP, et al. Effects of nutrition interventions during pregnancy on low birth weight : an overview of systematic reviews. 2017;1–11. 10.1136/bmjgh-2017-000389

113. Palacios C, Kostiuk LK, Peña-Rosas JP. Vitamin D supplementation for women during pregnancy. Cochrane Database of Systematic Reviews 2019, Issue 7. Art. No.: CD008873. DOI: 10.1002/14651858.CD008873.pub4

114. Jahan K, Roy SK, Mihrshahi S, Sultana N, Khatoon S, Roy H, et al. Short-term nutrition education reduces low birthweight and improves pregnancy outcomes among urban poor women in Bangladesh. Food and Nutr Bull. 2014;35(4):414–21. 10.1177/156482651403500403

115. Melchor I, Burgos J, Campo A, Aiartzaguena A, Gutiérrez J, Melchor JC. Effect of maternal obesity on pregnancy outcomes in women delivering singleton babies : a historical cohort study. J. Perinat. Med. 2019;47(6):625–30. doi:10.1515/jpm-2019-0103

116. Cantor A, Jungbauer R, McDonagh M, Blazina I, Marshall N, Weeks C, et al. Counseling and Behavioral Interventions for Healthy Weight and Weight Gain in Pregnancy Evidence Report and Systematic Review for the US Preventive Services Task Force. JAMA - J Am Med Assoc. 2021;325(20):2094–109. 10.1001/jama.2021.4230

117. Sparling TM, Nesbitt RC, Henschke N, Gabrysch S. Nutrients and perinatal depression: a systematic review. J Nutr Sci. 2017; 10.1017/jns.2017.58

118. Khan R, Waqas A, Bilal A, Mustehsan ZH, Omar J, Rahman A. Association of Maternal depression with diet: A systematic review. Asian J Psychiatr [Internet]. 2020;52(August 2019):102098. Available from: https://doi.org/10.1016/j.ajp.2020.102098

119. Campisi SC, Carducci B, Söder O, Bhutta ZA. The Intricate Relationship between Chronic Undernutrition , Impaired Linear Growth and Delayed Puberty : Is ' catch-up ' growth possible during adolescence ? Office of Research - Innocenti Working Paper. Florence; 2018.

120. Himaz R. Stunting later in childhood and outcomes as a young adult : Evidence from India. World Dev [Internet]. 2018;104:344–57. Available from: https://doi.org/10.1016/j.worlddev.2017.12.019. 10.1016/j.worlddev.2017.12.019

121. Purushotham A, Mittal N, Ashwini BC, Umesh KB, Taubadel S von C-, Vollmer S. A quantile regression analysis of dietary diversity and health outcomes among children and women in the rural-urban interface of India Anjali. Food Policy [Internet]. 2003;107(1):6–8. Available from: https://doi.org/10.1016/j.foodpol.2021.102216

Chapter 10 CONCLUSION

This study has revealed that household food insecurity is a critical social determinant of both maternal and child health. Child hunger in the household is associated with low birthweight while low dietary diversity is associated with stunting among children as they age. Food insecurity significantly increases the risk of maternal depression among periconceptional and antenatal women as well as new mothers. This group is particularly vulnerable to both food insecurity and mental disorders and these can be considered cumulative social determinants of poor health that multiply across the lifespan.

Given the adverse life course implications of early childhood stunting, interventions that can improve periconceptional nutrition and reduce the prevalence of low birthweight in South Africa may also improve the high prevalence of stunting. However, there is a paucity of data on such interventions and more high quality longitudinal studies are required. In addition to improved nutrition, periconceptional and pregnant women also need to be counselled about alcohol and tobacco use, excessive gestational weight gain, hypertension and other risk factors for low birthweight. Interventions that can improve maternal food insecurity may be more effective than targeted psychological interventions to improve maternal wellbeing and mental health. An extension of the child support grant into pregnancy may improve antenatal nutrition and subsequent birth and pregnancy outcomes but further research is needed to determine if this will be feasible or effective.

Dietary diversity in particular is an important indicator of overall dietary health and nutrition and should be routinely collected during the course of national surveys. Experiential indicators of food insecurity such as hunger should still be collected but additional measures are needed to capture dietary quality.

However, increased dietary diversity was also associated with an increased risk of overweight and obesity among adults. Public health interventions such as increased taxes on processed foods and sugary beverages may help reduce the increased consumption of unhealthy foods and beverages in low and middle income countries like South Africa. In addition, public health messaging around good nutrition and healthy eating and complimentary feeding practices for young children is virtually non-existent. Targeted

public health campaigns that discuss the adverse effects of poor diets and overweight and obesity are needed. Existing measures of dietary diversity could be improved by the inclusion of a separate category for processed foods as well as further validation studies of household dietary diversity instruments in a variety of settings.

At the macro scale, government policies that can improve economic growth and employment opportunities can enable more people to purchase sufficient healthy and nutritious food for themselves and their families. The Covid 19 pandemic has deepened existing health and social inequalities in South Africa and increased food insecurity and mental distress among vulnerable populations. It is important that the National Development plan support smallholder agriculture and encourage younger people to become involved in farming to secure the future of the food system in South Africa.

The events of the past two years have highlighted the multiple vulnerabilities of the global and local food system to climate change, pandemics and civil and political unrest. Thus, governments must prepare for these eventualities and have contingency plans in place and it is the role of researchers and academics to inform some of these policies. Improving South Africa's food security and nutritional status is a task that will require political will and commitment as well as multi sectoral action from government, academia, civil society and individuals. The Covid 19 pandemic has caused the world to take stock of the existing weakness in the food system and the inequalities that underlie access to nutritious food. This presents an important opportunity for South Africa to renew the focus on eradicating hunger and malnutrition and work towards building a more sustainable and equitable food system for all.

Bibliography

1. Aboagye RG, Seidu A, Ahinkorah BO, Arthur-holmes F, Cadri A, Dadzie LK, et al. Dietary Diversity and Undernutrition in Children Aged 6-23 Months in Sub-Saharan Africa. 2021;1–22. https://doi.org/10.3390/nu13103431
2. Abrahams Z, Lund C, Field S, Honikman S. Factors associated with household food insecurity and depression in pregnant South African women from a low socio-economic setting: a cross-sectional study. Soc Psychiatry Psychiatr Epidemiol [Internet]. 2018;0(0):0. Available from: https://doi.org/10.1007/s00127-018-1497-
3. Accortt EE, Cheadle ACD, Dunkel Schetter C. Prenatal Depression and Adverse Birth Outcomes: An Updated Systematic Review. Vol. 19, Maternal and Child Health Journal. 2015. 1306–1337 doi:10.1007/s10995-014-1637-2
4. Adhikari RP, Williamson R, Sparling TM, Ferguson E, Cunningham K. Parental depression and nutrition: findings from a cross-sectional household survey in Nepal. Public Health Nutr. 2020 Nov;23(16):2983–93. 10.1017/S1368980020000968
5. Ahun MN, Aboud FE, Aryeetey R, Colecraft E, Marquis GS. Child development in rural Ghana: Associations between cognitive/language milestones and indicators of nutrition and stimulation of children under two years of age. Can J Public Heal [Internet]. 2017;108(5–6):e578–85. Available from: 10.17269/cjph.108.5875
6. Akena D, Joska J, Obuku EA, Amos T, Musisi S, Stein DJ. Comparing the accuracy of brief versus long depression screening instruments which have been validated in low and middle income countries: A systematic review. BMC Psychiatry. 2012;12(2007). 10.1186/1471-244X-12-187
7. Alegría M, Nemoyer A, Bagué IF, Wang Y, Alvarez K. Social Determinants of Mental Health : Where We Are and Where We Need to Go. Curr Psychiatry Rep. 2018;20(95). Available from: https://doi.org/10.1007/s11920-018-0969-9
8. Ali GC, Ryan G, De Silva MJ. Validated screening tools for common mental disorders in low and middle income countries: A systematic review. PLoS One. 2016;11(6):1–14. DOI:10.1371/journal.pone.0156939
9. Almudena S-V, Miguel R-C, Alfredo G, Francisca L, A M-GM. The association between the Mediterranean lifestyle and depression [Internet]. Vol. 4, Clinical Psychological Science. 2016. p. 1085–93. Available from: http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=psyc13&NEWS=N&AN=2016-55681-013
10. Alves L. Pandemic puts Brazil back on the world hunger map. The New Humanitarian. 2022;1–11. https://www.thenewhumanitarian.org/news-feature/2021/7/19/pandemic-puts-brazil-back-on-the-world-hunger-map
11. Amugsi DA, Dimbuene ZT, Bakibinga P, Kimani-Murage EW, Haregu TN, Mberu B. Dietary diversity, socioeconomic status and maternal body mass index (BMI): quantile regression analysis of nationally representative data from Ghana, Namibia and Sao Tome and Principe. BMJ Open. 2016;6(9). 10.1136/bmjopen-2016-012615
12. Anato A, Baye K, Tafese Z, Stoecker BJ. Maternal depression is associated with child undernutrition: A cross-sectional study in Ethiopia. Matern Child Nutr. 2020 Jul;16(3):e12934. DOI: 10.1111/mcn.12934
13. Arenas DJ, Thomas A, Wang J, Delisser HM. A systematic review and meta-analysis of depression, anxiety, and sleep disorders in US adults with food

insecurity. J Gen Intern Med [Internet]. 2019 [cited 2022 Aug 24];34(12):2874-82. DOI:10.1007/s11606-019-05202-4
14. Arredondo A, Torres C, Orozco E, Pacheco S, Huang F, Zambrano E, et al. Socio-economic indicators, dietary patterns, and physical activity as determinants of maternal obesity in middle-income countries: Evidences from a cohort study in Mexico. Int J Health Plann Manage. 2019;34(1):e713–25. DOI: 10.1002/hpm.2684
15. Avan B, Richter LM, Ramchandani PG, Norris SA, Stein A. Maternal postnatal depression and children's growth and behaviour during the early years of life : exploring the interaction between physical and mental health. Arch Dis Child. 2010;690–5. 10.1136/adc.2009.164848
16. Ayano G, Tesfaw G, Shumet S. Prevalence and determinants of antenatal depression in Ethiopia: A systematic review and meta-analysis. PLoS One. 2019;14(2):e0211764. DOI: 10.1111/mcn.12934
17. Banda M. What is the government doing about food security? The Daily Maverick. 2022;1–11. https://www.dailymaverick.co.za/article/2022-02-14-what-is-the-government-doing-about-food-security/ 1/11
18. Barker ED, Kirkham N, Ng J, Jensen SKG. Prenatal maternal depression symptoms and nutrition, and child cognitive function. Br J Psychiatry. 2013;203(6):417–21. 0.1192/bjp.bp.113.129486
19. Barnett W, Pellowski J, Kuo C, Koen N, Donald KA, Zar HJ, et al. Food-insecure pregnant women in South Africa: A cross-sectional exploration of maternal depression as a mediator of violence and trauma risk factors. BMJ Open. 2019;9(3):1–11. 10.1136/bmjopen-2017-018277
20. Baron EC, Davies T, Lund C. Validation of the 10-item Centre for Epidemiological Studies Depression Scale (CES-D-10) in Zulu, Xhosa and Afrikaans populations in South Africa. BMC Psychiatry [Internet]. 2017;17(1):1–14. Available from: http://dx.doi.org/10.1186/s12888-016-1178-x
21. Bauserman M, Nowak K, Nolen TL, Patterson J, Lokangaka A, Tshefu A, et al. The relationship between birth intervals and adverse maternal and neonatal outcomes in six low and lower-middle income countries. Reprod Health [Internet]. 2020;17(Suppl 2):1–10. Available from: http://dx.doi.org/10.1186/s12978-020-01008-4
22. Beltrán S, Pharel M, Montgomery CT, López-Hinojosa IJ, Arenas DJ, DeLisser HM. Food insecurity and hypertension: A systematic review and meta-analysis. PLoS One. 2020;15(11 November):1–17. 10.1371/journal.pone.0241628
23. Bhana A, Rathod SD, Selohilwe O, Kathree T, Petersen I. The validity of the Patient Health Questionnaire for screening depression in chronic care patients in primary health care in South Africa. BMC Psychiatry. 2015;15(1):1–9. 10.1186/s12888-015-0503-0
24. Black RE, Allen LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M, et al. Maternal and child undernutrition: global and regional exposures and health consequences. Lancet. 2008;371(9608):243–60. 10.1016/S0140-6736(07)61690-0
25. Blencowe H, Krasevec J, de Onis M, Black RE, An X, Stevens GA, et al. National, regional, and worldwide estimates of low birthweight in 2015, with trends from 2000: a systematic analysis. Lancet Glob Heal [Internet]. 2019;7(7):e849–60. Available from: http://dx.doi.org/10.1016/S2214-109X(18)30565-5
26. Bliznashka L, Yousafzai AK, Asheri G, Masanja H, Sudfeld CR. Effects of a community health worker delivered intervention on maternal depressive symptoms

in rural Tanzania. Health Policy Plan. 2021;36(4):473–83. 10.1093/heapol/czaa170
27. Bramham K, Parnell B, Nelson-Piercy C, Seed PT, Poston L, Chappell LC. Chronic hypertension and pregnancy outcomes: Systematic review and meta-analysis. BMJ [Internet]. 2014;348(April):1–20. Available from: http://dx.doi.org/doi:10.1136/bmj.g2301
28. Broussard NH. What explains gender differences in food insecurity? Food Policy [Internet]. 2019;83(January 2018):180–94. Available from: https://doi.org/10.1016/j.foodpol.2019.01.003
29. Budree S, Stein DJ, Brittain K, Goddard E, Koen N, Barnett W, et al. Maternal and infant factors had a significant impact on birthweight and longitudinal growth in a South African birth cohort. Acta Paediatr Int J Paediatr. 2017;106(11):1793–801. 10.1111/apa.14015
30. Buffa G, Dahan S, Sinclair I, St-Pierre M, Roofigari N, Mutran D, et al. Prenatal stress and child development: A scoping review of research in low- and middle-income countries. PLoS One. 2018;13(12):1–24. 10.1371/journal.pone.0207235
31. Burger R, Nkonki L, Rensburg R, Smith A, van Schalkwyk C. Examining the unintended health consequences of the COVID-19 pandemic in South Africa. 2015.
32. Cafiero C, Melgar-Quiñonez HR, Ballard TJ, Kepple AW. Validity and reliability of food security measures. Ann N Y Acad Sci. 2014;1331(1):230–48.
33. Cafiero C, Viviani S, Nord M. Food security measurement in a global context: The food insecurity experience scale. Meas J Int Meas Confed [Internet]. 2018;116(November):146–52. Available from: http://dx.doi.org/10.1016/j.measurement.2017.10.065
34. Campisi SC, Carducci B, Söder O, Bhutta ZA. The Intricate Relationship between Chronic Undernutrition , Impaired Linear Growth and Delayed Puberty : Is ‘ catch-up ’ growth possible during adolescence ? 2018. 10.1111/nyas.12594
35. Cantor A, Jungbauer R, McDonagh M, Blazina I, Marshall N, Weeks C, et al. Counseling and behavioral interventions for healthy weight and weight gain in pregnancy: Evidence report and systematic review for the US Preventive Services Task Force. JAMA [Internet]. 2021 [cited 2022 Aug 26];325(20):2094-109. DOI:10.1001/jama.2021.4230
36. Carmichael SL, Yang W, Herring A, Abrams B, Shaw GM. Maternal food insecurity is associated with increased risk of certain birth defects. J Nutr [Internet]. 2007;137(9):2087–92. Available from: 137/9/2087 [pii]
37. Casale D, Desmond C, Richter LM. Catch-up growth in height and cognitive function: Why definitions matter. Econ Hum Biol. 2020;37. 10.1016/j.ehb.2020.100853
38. Casale D, Espi G, Norris SA. Estimating the pathways through which maternal education affects stunting: Evidence from an urban cohort in South Africa. Public Health Nutr. 2018;21(10):1810–8.
39. Casale D, Espi G. The determinants of stunting at age two: a holistic model for South Africa using the birth to twenty cohort study [Internet]. Vol. 1, Food security SA Research Series. Johannesburg; 2017. Available from: https://foodsecurity.ac.za/wp-content/uploads/2018/12/FINAL.CoE-Research-Report-_Daniela-Casale-and-Gabriel-Espi.Aug2017_DC29.12.18.pdf%0Awww.foodsecurity.ac.za
40. Casale D, Posel D. Gender and the early effects of the Covid-19 crisis in the paid and unpaid economies in South Africa. 2020.

41. Center for Epidemiologic Studies Depression Scale Revised (CESD-R- 10). 2008. p. 0–2.
42. Chandrasekhar S, Aguayo VM, Krishna V, Nair R. Household food insecurity and children's dietary diversity and nutrition in India. Evidence from the comprehensive nutrition survey in Maharashtra. Matern Child Nutr. 2017;13(October 2016):1–8. 10.1111/mcn.12447
43. Chang HY, Keyes KM, Lee K, Choi IA, Joo S, Kim KW, et al. Prenatal maternal depression is associated with low birth weight through shorter gestational age in term infants in Korea. Early Hum Dev. 2014;90(1):15–20. 10.1016/j.earlhumdev.2013.11.006.Prenatal
44. Chowdhury M, Dibley MJ, Alam A, Huda TM, Raynes-Greenow C. Household Food Security and Birth Size of Infants: Analysis of the Bangladesh Demographic and Health Survey 2011. Curr Dev Nutr [Internet]. 2018;2(3):1–8. Available from: https://academic.oup.com/cdn/article/doi/10.1093/cdn/nzy003/4851100
45. Christian P, Lee SE, Angel MD, Adair LS, Arifeen SE, Ashorn P, et al. Risk of childhood undernutrition related to small-for-gestational age and preterm birth in low- and middle-income countries. Int J Epidemiol. 2013;42(5):1340–55. 10.1093/ije/dyt109
46. Coates J, Frongillo EA, Rogers BL, Webb P, Wilde PE, Houser R, et al. What Are We Assessing When We Measure Food Security? A Compendium and Review of Current Metrics. Adv Nutr [Internet]. 2013;4(February):481–505. Available from: http://www.elgaronline.com/view/9780857939371.xml
47. Coates J, Frongillo EA, Rogers BL, Webb P, Wilde PE, Houser R, et al. Exploring public views of global food security. Adv Nutr [Internet]. 2013;4(February):812. Available from: http://www.elgaronline.com/view/9780857939371.xml
48. Coates J, Frongillo EA, Rogers BL, Webb P, Wilde PE, Houser R. Commonalities in the experience of household food insecurity across cultures: What are measures missing? J Nutr. 2006;136(5):1438–48. 10.1093/jn/136.5.1438s
49. Cois A, Day C. Obesity trends and risk factors in the South African adult population. adult population. BMC Obes. 2015;2(1):1–10. 10.1186/s40608-015-0072-2
50. Cois A, Ehrlich R. Analysing the socioeconomic determinants of hypertension in South Africa: A structural equation modelling approach. BMC Public Health. 2014;14(1). 10.1186/1471-2458-14-414
51. Crush J, Caeser M, Haysom G. Hungry Cities Partnership: The State of Household Food Insecurity in Cape Town, South Africa. Vol. 2. 2018. 10.3366/E147494750800022X
52. Dadi AF, Miller ER, Mwanri L. Antenatal depression and its association with adverse birth outcomes in low and middleincome countries: A systematic review and meta-analysis. PLoS One [Internet]. 2020;15(1):1–23. Available from: http://dx.doi.org/10.1371/journal.pone.0227323
53. Dadi AF, Wolde HF, Baraki AG, Akalu TY. Epidemiology of antenatal depression in Africa: A systematic review and meta-analysis. BMC Pregnancy Childbirth. 2020;20(1):1–13. 10.3366/E147494750800022X
54. Daley AJ, Foster L, Long G, Palmer C, Robinson O, Walmsley H, et al. The effectiveness of exercise for the prevention and treatment of antenatal depression: systematic review with meta-analysis. BJOG [Internet]. 2015 Jan 1 [cited 2022 Aug 25];122(1):57-62. Available from: https://doi.org/10.1111/1471-0528.12909de Onis M, Branca F. Childhood stunting: A global perspective. Matern Child Nutr.

2016;12:12–26.
55. De Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organ. 2007;85(9):660–7. 10.2471/BLT.07.043497
56. Devereux S, Waidler J. Why does malnutrition persist in South Africa despite social grants? Food Security SA Working Paper Series No. 001. 2017.
57. Dewey KG, Begum K. Long-term consequences of stunting in early life. Matern Child Nutr [Internet]. 2011 Oct [cited 2013 Nov 19];7 Suppl 3:5–18. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21929633
58. Dewing S, Tomlinson M, Le Roux IM, Chopra M, Tsai AC. Food insecurity and its association with co-occurring postnatal depression, hazardous drinking, and suicidality among women in peri-urban South Africa. J Affect Disord [Internet]. 2013;150(2):460–5. Available from: http://dx.doi.org/10.1016/j.jad.2013.04.040
59. Dibaba Y, Fantahun M, Hindin MJ. The association of unwanted pregnancy and social support with depressive symptoms in pregnancy: evidence from rural Southwestern Ethiopia. BMC Pregnancy Childbirth. 2013 Jun;13:135. 10.1186/1471-2393-13-135
60. Dlamini NJ. Gender-Based Violence , Twin Pandemic to COVID-19. Crit Sociol. 2021;19. 10.1177/0896920520975465
61. Doherty T, Sanders D, Jackson D, Swanevelder S, Lombard C, Zembe W, et al. Early cessation of breastfeeding amongst women in South Africa: an area needing urgent attention to improve child health. BMC Pediatr [Internet]. 2012 Jan;12:105. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3441849&tool=pmcentrez&rendertype=abstract
62. Dowlatchahi M. Pakistan and FAO Partnering to eliminate hunger and malnutrition through agricultural development [Internet]. Vol. 1947. 2018. Available from: http://www.fao.org/3/ax985e/AX985E.pdf
63. DSD, SASSA, UNICEF. The South African Child Support Grant Impact Assessment: Evidence form a survey of children [Internet]. 2012. Available from: https://www.unicef.org/evaldatabase/files/The_South_African_Child_Support_Grant_Impact_Assessment.pdf
64. Du Toit MJ, Rendón O, Cologna V, Cilliers SS, Dallimer M. Why Home Gardens Fail in Enhancing Food Security and Dietary Diversity. Front Ecol Evol. 2022;10(February). 10.3389/fevo.2022.804523
65. Eaton L, Pitpitan E, Kalichman S, Sikkema K, Skinner D, Watt M, et al. Food Insecurity and Alcohol Use Among Pregnant Women at Alcohol Serving Establishments in South Africa. 2008;86(12):3279–88. DOI: 10.1007/s11103-011-9767-z.Plastid
66. Emerson JA, Caulfield LE, Kishimata EM, Nzanzu J-P, Doocy S. Mental health symptoms and their relations with dietary diversity and nutritional status among mothers of young children in eastern Democratic Republic of the Congo. BMC Public Health. 2020 Feb;20(1):225. 10.1186/s12889-019-8092-3
67. Emerson JA, Caulfield LE, Musafiri Kishimata E, Nzanzu J-P, Doocy S. Maternal mental health symptoms are positively associated with child dietary diversity and meal frequency but not nutritional status in Eastern Democratic Republic of Congo. Public Health Nutr [Internet]. 2020;23(10):1810–9. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-

85083382565&doi=10.1017%2FS1368980019004087&partnerID=40&md5=fead6a8428f028949607ce012b7d9a03
68. Evensen M. Food insecurity and mental health: New answers and remaining questions. J Epidemiol Community Health. 2021;0(0):2021. 10.1136/jech-2021-216938
69. Fan W, Qian Y. Long-term health and socioeconomic consequences of early-life exposure to the 1959-1961 Chinese Famine. Soc Sci Res [Internet]. 2015;49:53–69. Available from: http://dx.doi.org/10.1016/j.ssresearch.2014.07.007
70. FAO, IFAD and WFP. 2015. The State of Food Insecurity in the World 2015. Meeting the 2015 international hunger targets: taking stock of uneven progress. Rome, FAO. ISBN 978-92-5-107316-2
71. FAO. Food Security and Nutrition in the World. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing. 2018. 202 p.
72. FAO. The State of Food Security and Nutrition in the World. Transforming food systems for food security, improved nutrition and affordable healthy diets for all [Internet]. Rome; 2021. Available from: https://doi.org/10.4060/ca9692en
73. FAO. Voice of Hungry [Internet]. Vol. 2016. 2016. 60 p. Available from: http://www.fao.org/3/a-i4830e.pdf
74. Faber M, Laubscher R, Berti C. Poor dietary diversity and low nutrient density of the complementary diet for 6- to 24-month-old children in urban and rural KwaZulu-Natal, South Africa. Matern Child Nutr. 2016 Jul;12(3):528–45.
75. Faber M, Schwabe C, Drimie S. Dietary diversity in relation to other household food security indicators. Int J Food Safety, Nutr Public Heal. 2009;2(1):1.
76. Felker-Kantor E, Wood CH. Female-headed households and food insecurity in Brazil. Food Secur. 2012;4(4):607–17. 10.1007/s12571-012-0215-y
77. Fisher J, de Mello MC, Patel V, Rahman A, Tran T, Holton S, et al. Prevalence and determinants of common perinatal mental disorders in women in low-and lower-middle-income countries: A systematic review. Bull World Health Organ. 2012;90(2):139–49. 10.2471/BLT.11.091850
78. Fisher J, Tran T, Duc Tran T, Dwyer T, Nguyen T, Casey GJ, et al. Prevalence and risk factors for symptoms of common mental disorders in early and late pregnancy in Vietnamese women: A prospective population-based study. J Affect Disord [Internet]. 2013;146(2):213–9. Available from: https://www.sciencedirect.com/science/article/pii/S0165032712006350
79. Fisher J, Tran T, Duc Tran T, Dwyer T, Nguyen T, Casey GJ, et al. Prevalence and risk factors for symptoms of common mental disorders in early and late pregnancy in Vietnamese women: A prospective population-based study. J Affect Disord [Internet]. 2013;146(2):213–9. Available from: https://www.sciencedirect.com/science/article/pii/S0165032712006350
80. Frank J, Abel T, Campost rini S, Cook S, Lin VK, Mcqueen D V. The Social Determinants of Health : Time to Re-Think ? doi:10.3390/ijerph17165856
81. G.S. Jonatan, N. Hasanah SK. Association Between Food Insecurity Status Towards Low Birth Weight Among 0-11 Month-Old Infants in Sambas District, West Kalimantan. Adv Sci Lett. 2018;24:6393–7. ISBN: 9788578110796
82. Garman EC, Schneider M, Lund C. Perinatal depressive symptoms among low-income South African women at risk of depression: Trajectories and predictors. BMC Pregnancy Childbirth. 2019;19(1):1–11. 10.1186/s12884-019-2355-y
83. Gassara G, Chen J. Household food insecurity, dietary diversity, and stunting in sub-

saharan africa: A systematic review. Nutrients. 2021;13(12). 10.3390/nu13124401
84. Gelaye B, Rondon M, Araya R, Williams M. Epidemiology of maternal depression, risk factors, and child outcomes in low-income and middle-income countries. Lancet Psychiatr. 2016;3(10):1562–72. 10.1016/S2215-0366(16)30284-X.Epidemiology
85. Getaneh T, Negesse A, Dessie G, Desta M. The impact of pregnancy induced hypertension on low birth weight in Ethiopia: systematic review and meta-analysis. Ital J Pediatr. 2020;46(1):1–11. 10.1186/s13052-020-00926-0
86. Ghimire U, Papabathini SS, Kawuki J, Obore N, Musa TH. Depression during pregnancy and the risk of low birth weight, preterm birth and intrauterine growth restriction- an updated meta-analysis. Early Hum Dev [Internet]. 2021;152(October 2020):105243. Available from: https://doi.org/10.1016/j.earlhumdev.2020.105243
87. Gina Kennedy, Terri Ballard MD. Guidelines for measuring household and individual dietary diversity. FAO. 2010. 1–60 p. ISBN 978-92-5-106749-9
88. Giri RK, Khatri RB, Mishra SR, Khanal V, Sharma VD, Gartoula RP. Prevalence and factors associated with depressive symptoms among post-partum mothers in Nepal. BMC Res Notes. 2015;8(1):1–7. 10.1186/s13104-015-1074-3
89. Gladstone ME, Salim N, Ogillo K, Shamba D, Gore-Langton GR, Day LT, et al. Birthweight measurement processes and perceived value: qualitative research in one EN-BIRTH study hospital in Tanzania. BMC Pregnancy Childbirth [Internet]. 2021;21(Suppl 1):1–11. Available from: http://dx.doi.org/10.1186/s12884-020-03356-2
90. Gomez-Donoso C, Sanchez-Villegas A, Martinez-Gonzalez MA, Gea A, Mendonca RD, Lahortiga-Ramos F, et al. Ultra-processed food consumption and the incidence of depression in a Mediterranean cohort: the SUN Project. Vol. 59, European Journal of Nutrition. 2020. p. 1093–103.
91. Gomez-Donoso C, Sanchez-Villegas A, Martinez-Gonzalez MA, Gea A, Mendonca RD, Lahortiga-Ramos F, et al. Ultra-processed food consumption and the incidence of depression in a Mediterranean cohort: the SUN Project. Vol. 59, European Journal of Nutrition. 2020. p. 1093–103. DOI: 10.1007/s00394-019-01970-1
92. Goudet S, Bogin B, Madise N, Griffiths P. Nutritional interventions for preventing stunting in children (birth to 59 months) living in urban slums in low- and middle-income countries (LMIC) (Review). 2019. 10.1002/14651858.CD011695.pub2.www.cochranelibrary.com
93. Christian A. Gregory, Alisha Coleman-Jensen. Food Insecurity, Chronic Disease, and Health Among Working-Age Adults, ERR-235, U.S. Department of Agriculture, Economic Research Service, July 2017.
94. Grosso G, Micek A, Marventano S, Castellano S, Mistretta A, Pajak A, et al. Dietary n-3 PUFA, fish consumption and depression: A systematic review and meta-analysis of observational studies. Vol. 205, Journal of Affective Disorders. 2016. p. 269–81. DOI: 10.1016.j.jad.2016.08.011
95. Grosso G, Galvano F, Marventano S, Malaguarnera M, Bucolo C, Drago F, et al. Omega-3 Fatty Acids and Depression : Scientific Evidence and Biological Mechanisms. Oxid Med Cell Longev. 2014;2014(Figure 1). 10.1155/2014/313570
96. Grote, N.K. Bridge, J.A. Gavin, A.R. Melville, J.L. Iyengar, S. Katon WJ. A meta-analysis of depression during pregnancy and the risk of preterm birth, low birth weight, and intrauterine growth restriction. Arch Womens Ment Health [Internet]. 2011;14(10):S26. Available from: http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L7

0557360%5Cnhttp://dx.doi.org/10.1007/s00737-010-0203-1
97. Hadley C, Tegegn A, Tessema F, Cowan JA, Asefa M, Galea S. Food insecurity, stressful life events and symptoms of anxietry and depression in east Africa: Evidence from the Gilgel Gibe growth and development study. J Epidemiol Community Health. 2008;62(11):980–6. 10.1136/jech.2007.068460
98. Hamadani JD, Hasan MI, Baldi AJ, Hossain SJ, Shiraji S, Bhuiyan MSA, et al. Immediate impact of stay-at-home orders to control COVID-19 transmission on socioeconomic conditions, food insecurity, mental health, and intimate partner violence in Bangladeshi women and their families: an interrupted time series. Lancet Glob Heal. 2020 Nov;8(11):e1380–9. 10.1016/S2214-109X(20)30366-1
99. Hall, K., Sambu, w., Berry l., Giese, S., and almeleh, c. (2017). South african early childhood review 2017. cape town: children's institute, university of cape town and ilifa labantwana
100. Headey D, Ecker O. Rethinking the measurement of food security: From first principles to best practice. Food Secur. 2013;5(3):327–43. 10.1007/s12571-013-0253-0
Headey D. Improving the Measurement of Food Security. 2012;(November).
101. Heidkamp RA, Piwoz E, Gillespie S, Keats EC, Alimonte MRD, Menon P, et al. Series Maternal and Child Undernutrition Progress 2 Mobilising evidence , data , and resources to achieve global maternal and child undernutrition targets and the Sustainable Development Goals : an agenda for action. Lancet [Internet]. 2021;6736(21):1–19. Available from: http://dx.doi.org/10.1016/S0140-6736(21)00568-7
102. Hendriks SL. The challenges facing empirical estimation of household food (in)security in South Africa. Dev South Afr. 2005;22(1):103–23. 10.1080/03768350500044651
103. Hendriks SL, van der Merwe C, Ngidi MS, Manyamba C, Mbele M, McIntyre AM, et al. What are we measuring? Comparison of household food security indicators in the Eastern Cape Province, South Africa. Ecol Food Nutr [Internet]. 2016;55(2):141–62. Available from: http://dx.doi.org/10.1080/03670244.2015.1094063
104. Herba CM, Glover V, Ramchandani PG, Rondon MB. Maternal depression and mental health in early childhood: an examination of underlying mechanisms in low-income and middle-income countries. The Lancet Psychiatry [Internet]. 2016;3(10):983–92. Available from: http://dx.doi.org/10.1016/S2215-0366(16)30148-1
105. Hessami K, Romanelli C, Chiurazzi M, Cozzolino M. COVID-19 pandemic and maternal mental health : a systematic review and meta-analysis. J Matern Neonatal Med [Internet]. 2022;35(20):4014–21. Available from: https://doi.org/10.1080/14767058.2020.1843155
106. Himaz R. Stunting later in childhood and outcomes as a young adult : Evidence from India. World Dev [Internet]. 2018;104:344–57. Available from: https://doi.org/10.1016/j.worlddev.2017.12.019
107. HLPE. Food Security and Nutrition: Building a Global Narrative towards 2030. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. [Internet]. High Level Panel of Experts. Rome; 2020. Available from: http://www.fao.org/3/ca9731en/ca9731en.pdf
108. Hromi-Fiedler A, Bermúdez-Millán A, Segura-Pérez S, Pérez-Escamilla R.

Household food insecurity is associated with depressive symptoms among low-income pregnant Latinas. Matern Child Nutr. 2011 Oct;7(4):421–30. 10.1111/j.1740-8709.2010.00266.x
109. Huddleston-Casas C, Charnigo R, Simmons LA. Food insecurity and maternal depression in rural, low-income families: a longitudinal investigation. Public Health Nutr. 2009 Aug;12(8):1133–40. 10.1017/S1368980008003650
110. Humphries DL, Dearden KA, Crookston BT, Woldehanna T, Penny ME, Behrman JR. Household food group expenditure patterns are associated with child anthropometry at ages 5, 8 and 12 years in Ethiopia, India, Peru and Vietnam. Econ Hum Biol [Internet]. 2017;26:30–41. Available from: https://www.sciencedirect.com/science/article/pii/S1570677X16300788
111. Hunt X, Stein DJ, Spaull N, Tomlinson M. Hunger as a driver of depressive symptoms: Optimising responses to mental health aspects of the COVID-19 pandemic. South African Med J. 2021;111(7):604–5. 10.7196/SAMJ.2021.v111i7.15754
112. Hunter W, Patel L, Sugiyama NB. How family and child cash transfers can empower women: Comparative lessons from Brazil and South Africa. Glob Soc Policy. 2021;21(2):258–77. 10.1177/1468018120981421
113. Husain N, Munshi T, Jafri F, Husain M, Parveen A, Saeed Q, et al. Antenatal depression is not associated with low birth weight: A study from urban Pakistan. Front Psychiatry. 2014;5(NOV):1–5. 10.3389/fpsyt.2014.00175
114. Ingram J. Nutrition security is more than food security [Internet]. Vol. 1, Nature Food. Springer US; 2020. p. 2. Available from: http://dx.doi.org/10.1038/s43016-019-0002-4
115. Iqbal S, Ali I. Maternal food insecurity in low-income countries: Revisiting its causes and consequences for maternal and neonatal health. J Agric Food Res [Internet]. 2021;3(November 2020):100091. Available from: https://doi.org/10.1016/j.jafr.2020.100091
116. Irving SM, Njai RS, Siegel PZ. Food insecurity and self-reported hypertension among hispanic, black, and white adults in 12 states, behavioral risk factor surveillance system, 2009. Prev Chronic Dis. 2014;11(9):1–6. 10.5888/pcd11.140190
117. Ivers LC, Cullen K a. Food insecurity : special considerations for women 1 – 4. Am J Clin Nutr. 2011;94:1740–4. 10.3945/ajcn.111.012617.1
118. Jahan K, Roy SK, Mihrshahi S, Sultana N, Khatoon S, Roy H, et al. Short-term nutrition education reduces low birthweight and improves pregnancy outcomes among urban poor women in Bangladesh. Food Nutr Bull [Internet]. 2014 [cited 2022 Aug 26];35(4):414-21. DOI:10.1177/156482651403500403
119. Jang H, Serra C. Nutrition, Epigenetics, and Diseases. Clin Nutr Res. 2014;3:1–8. http://dx.doi.org/10.7762/cnr.2014.3.1.1
120. Jayawardena R, Byrne NM, Soares MJ, Katulanda P, Yadav B, Hills AP. High dietary diversity is associated with obesity in Sri Lankan adults: An evaluation of three dietary scores. BMC Public Health. 2013;13(1). 10.1186/1471-2458-13-314
121. Jeena PM, Asharam K, Mitku AA, Naidoo P, Naidoo RN. Maternal demographic and antenatal factors, low birth weight and preterm birth: findings from the mother and child in the environment (MACE) birth cohort, Durban, South Africa. BMC Pregnancy Childbirth. 2020;20(1):1–11. 10.1186/s12884-020-03328-6
122. Jiang W, Mo M, Li M, Wang S, Muyiduli X, Shao B, et al. The relationship of

dietary diversity score with depression and anxiety among prenatal and post-partum women. J Obstet Gynaecol Res. 2018 Oct;44(10):1929–36. 10.1111/jog.13728
123. Jones AD. Food Insecurity and Mental Health Status: A Global Analysis of 149 Countries. Am J Prev Med [Internet]. 2017;53(2):264–73. Available from: http://dx.doi.org/10.1016/j.amepre.2017.04.008
124. Jung NM, de Bairros FS, Pattussi MP, Pauli S, Neutzling MB. Gender differences in the prevalence of household food insecurity: a systematic review and meta-analysis. Public Health Nutr [Internet]. 2017;20(5):902–16. Available from: http://www.ncbi.nlm.nih.gov/pubmed/27829486
125. Karimbeiki R, Pourmasoumi M, Feizi A, Abbasi B, Hadi A, Rafie N, et al. Higher dietary diversity score is associated with obesity: a case–control study. Public Health [Internet]. 2018;157:127–34. Available from: https://www.sciencedirect.com/science/article/pii/S0033350618300386
126. Kaibi FKM, Steyn NP, Ochola SA, Plessis L Du. The relationship between agricultural biodiversity , dietary diversity , household food security , and stunting of children in rural Kenya. 2016;243–54. 10.1002/fsn3.387
127. Kana MA, Correia S, Peleteiro B, Severo M, Barros H. Impact of the global fi nancial crisis on low birth weight in Portugal : a time-trend analysis. 2017;(October 2008):1–11. 10.1136/bmjgh-2016-000147
128. Keats EC, Das JK, Salam RA, Lassi ZS, Imdad A, Black RE, et al. Effective interventions to address maternal and child malnutrition: an update of the evidence. Lancet Child Adolesc Heal [Internet]. 2021;5(5):367–84. Available from: http://dx.doi.org/10.1016/S2352-4642(20)30274-1
129. Kersey M, Geppert J, Cutts DB. Hunger in young children of Mexican immigrant families. Public Health Nutr. 2007 Apr;10(4):390–5. 10.1017/S1368980007334071
130. Khan R, Waqas A, Bilal A, Mustehsan ZH, Omar J, Rahman A. Association of Maternal depression with diet: A systematic review. Asian J Psychiatr [Internet]. 2020;52(August 2019):102098. Available from: https://doi.org/10.1016/j.ajp.2020.102098
131. Khosa P, Kaseke E. The Utilisation of the Child Support Grant by caregivers: The case of Ba-Phalaborwa Municipality in Limpopo Province. Soc Work. 2014;50(4):504–15. ISSN 0952-3987
132. Koury AJ, Dynia J, Dore R, Logan JAR, Purtell KM, Joy E, et al. Food Insecurity and Depression among Economically Disadvantaged Mothers: Does Maternal Efficacy Matter? Appl Psychol Heal Well-Being. 2020;12(2):432–48. 10.1111/aphw.12191
133. Kozuki N, Katz J, Lee ACC, Vogel JP, Silveira MF, Sania A, et al. Short Maternal Stature Increases Risk of Small- for-Gestational-Age and Preterm Births in Low- and Middle-Income Countries : Individual Participant Data Meta-Analysis and Population Attributable Fraction. J Nutr. 2015;145:2452–2450. 10.3945/jn.115.216374.preterm
134. Krasevec J, An X, Kumapley R, Bégin F, Frongillo EA. Diet quality and risk of stunting among infants and young children in low- and middle-income countries. Matern Child 10.1111/mcn.12430
135. Krebs NF, Hambidge KM, Westcott JL, Garc AL, Figueroa L, Tsefu AK, et al. Growth from Birth Through Six Months for Infants of Mothers in the “Women First” Preconception Maternal Nutrition Trial. 2020; 10.1016/j.jpeds.2020.09.032
136. Kruger LM, Lourens M. Motherhood and the “Madness of Hunger”: “…Want Almal

Vra vir My vir ‘n Stukkie Brood” (“…Because Everyone Asks Me for a Little Piece of Bread”). Cult Med Psychiatry. 2016;40(1):124–43. 10.1007/s11013-015-9480-5
137. Labadarios D, McHiza ZJ-R, Steyn NP, Gericke G, Maunder EMW, Davids YD, et al. Food security in South Africa: a review of national surveys. Bull World Health Organ [Internet]. 2011 Dec 1 [cited 2013 May 30];89(12):891–9. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3260897&tool=pmcentrez&rendertype=abstract
138. Labadarios D, Steyn N, Maunder E, MacIntryre U, Gericke G, Swart R, et al. The National Food Consumption Survey (NFCS): South Africa, 1999. Public Health Nutr. 2005;8(5):533–43. 10.1079/phn2005816
139. Laborde D, Martin W, Swinnen J, Vos R. COVID-19 risks to global food security. Science (80-). 2020;369(6503):500–2. 10.1126/science.abc4765
140. Laraia B, Vinikoor-Imler LC, Siega-Riz AM. Food insecurity during pregnancy leads to stress, disordered eating, and greater postpartum weight among overweight women. Obesity. 2015;23(6):1303–11. 10.1002/oby.21075
141. Laraia BA, Siega-Riz AM, Gundersen C, Dole N. Psychosocial factors and socioeconomic indicators are associated with household food insecurity among pregnant women. J Nutr [Internet]. 2006;136(1):177–82. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16365079
142. Laraia BA, Siega-Riz AM, Gundersen C. Household Food Insecurity Is Associated with Self-Reported Pregravid Weight Status, Gestational Weight Gain, and Pregnancy Complications. J Am Diet Assoc [Internet]. 2010;110(5):692–701. Available from: http://dx.doi.org/10.1016/j.jada.2010.02.014
143. Lassi ZS, Kedzior SGE, Tariq W, Jadoon Y, Das JK. Effects of Preconception Care and Periconception Birth Outcomes in Low- and Middle-Income. Nutrients. 2020;12(606). doi:10.3390/nu12030606
144. Laurenzi C, Field S, Honikman S. Food Insecurity, Maternal Mental Health, and Domestic Violence: A Call for a Syndemic Approach to Research and Interventions. Matern Child Health J. 2020 Apr;24(4):401–4. 10.1007/s10995-019-02872-8
145. LeFevre AE, Dane P, Copley CJ, Pienaar C, Parsons AN, Engelhard M, et al. Unpacking the performance of a mobile health information messaging program for mothers (MomConnect) in South Africa: Evidence on program reach and messaging exposure. BMJ Glob Heal. 2018;3:1–12. 10.1136/bmjgh-2017-000583
146. Lehohla P. Food security and agriculture 2002 – 2011: In-depth analysis of the General Household Survey data [Internet]. Vol. IV. Pretoria, South AFrica: Statistics South Africa, Private Bag X44, Pretoria 0001; 2012. Available from: http://www.statssa.gov.za/Publications2/Report-03-18-03/Report-03-18-032011.pdf
147. Leibbrandt M, Woolard I, De Villiers L. Methodology : Report on NIDS Wave 1. 2009.
148. Leroy JL, Frongillo EA. Perspective: What Does Stunting Really Mean? A Critical Review of the Evidence. Adv Nutr. 2019;10(2):196–204. 10.1093/advances/nmy101
149. Leroy JL, Habicht J-P, González de Cossío T, Ruel MT. Maternal Education Mitigates the Negative Effects of Higher Income on the Double Burden of Child Stunting and Maternal Overweight in Rural Mexico. J Nutr. 2014;144(5):765–70. 10.3945/jn.113.188474
150. Leroy JL, Ruel M, Frongillo EA, Harris J, Ballard TJ. Measuring the food access dimension of food security: A critical review and mapping of indicators. Food Nutr Bull. 2015;36(2):167–95. 10.1177/0379572115587274

151. Leroy JL, Ruel M, Habicht JP, Frongillo EA. Linear growth deficit continues to accumulate beyond the first 1000 days in low- and middle-income Countries: Global evidence from 51 national surveys. J Nutr. 2014;144(9):1460–6. 10.3945/jn.114.191981
152. Leung CW, Epel ES, Willett WC, Rimm EB, Laraia BA. Household Food Insecurity Is Positively Associated with Depression among Low-Income Supplemental Nutrition Assistance Program Participants and Income-Eligible Nonparticipants. J Nutr. 2015;145(3):622–7. 10.3945/jn.114.199414
153. Lewandowska M. Maternal Obesity and Risk of Low Birth Weight, Fetal Growth Restriction, and Macrosomia: Multiple Analyses. Nutrients. 2021;13(1213). https://doi.org/10.3390/nu13041213
154. Lima SAM, El Dib RP, Rodrigues MRK, Ferraz GAR, Molina AC, Neto CAP, et al. Is the risk of low birth weight or preterm labor greater when maternal stress is experienced during pregnancy? A systematic review and meta-analysis of cohort studies. PLoS One. 2018;13(7):1–15. 10.1371/journal.pone.0200594
155. Lopes S, Ota E, Shakya P, Dagvadorj A, Balogun OO, Peña-rosas JP, et al. Effects of nutrition interventions during pregnancy on low birth weight: an overview of systematic reviews. BMJ Glob Health [Internet]. 2017 [cited 2022 Aug 26]; 2:e000389. Available from: http://dx.doi.org/10.1136/bmjgh-2017-000389
156. Lund C, Schneider M, Garman EC, Davies T, Munodawafa M, Honikman S, et al. Task-sharing of psychological treatment for antenatal depression in Khayelitsha, South Africa: Effects on antenatal and postnatal outcomes in an individual randomised controlled trial. Behav Res Ther [Internet]. 2020;130(September 2019):103466. Available from: https://doi.org/10.1016/j.brat.2019.103466
157. Luppino FS, de Wit LM, Bouvy PF, Stijnen T, Cuijpers P, Penninx BWJH, et al. Overweight, obesity, and depression: a systematic review and meta-analysis of longitudinal studies. Arch Gen Psychiatry. 2010 Mar;67(3):220–9. 10.1001/archgenpsychiatry.2010.2
158. M. Christopher AMLS. Depression During Pregnancy and Adverse Birth Outcomes Among Predominantly Puerto Rican Women. Physiol Behav. 2016;176(1):100–106. 10.1007/s10995-016-2195-6.Depression
159. M'Kaibi FK, Steyn NP, Ochola SA, Du Plessis L. The relationship between agricultural biodiversity, dietary diversity, household food security, and stunting of children in rural Kenya. Food Sci Nutr. 2017;5(2):243–54. 10.1002/fsn3.387
160. MacGinty RP, Kariuki SM, Barnett W, Wedderburn CJ, Hardy A, Hoffman N, et al. Associations of antenatal maternal psychological distress with infant birth and development outcomes: Results from a South African birth cohort. Compr Psychiatry [Internet]. 2020;96:152128. Available from: https://doi.org/10.1016/j.comppsych.2019.152128
161. Madeghe BA, Kogi-Makau W, Ngala S, Kumar M. Nutritional Deficiencies and Maternal Depression: Associations and Interventions in Lower and Middle-Income Countries: a Systematic Review of Literature. Glob Soc Welf. 2021; 10.1007/s40609-020-00199-9
162. Madlala S. The dietary diversity, household food security status and presence of depression in relation to pregnancy pattern of weight gain and infant birth weight. University of KwaZulu-Natal; 2017.
163. Magaña-Lemus D, Ishdorj A, Rosson CP, Lara-Álvarez J. Determinants of household food insecurity in Mexico. Agric Food Econ [Internet]. 2016;4(1).

Available from: http://dx.doi.org/10.1186/s40100-016-0054-9
164. Maharaj V, Tomita A, Thela L, Mhlongo M, Burns JK. Food Insecurity and Risk of Depression Among Refugees and Immigrants in South Africa. J Immigr Minor Heal. 2017;19(3):631–7.
165. Makelarski JA, Abramsohn E, Benjamin JH, Du S, Lindau ST. Diagnostic Accuracy of Two Food Insecurity Screeners Recommended for Use in Health Care Settings. 2017;107(11):1812–7.
166. Makoka D, Masibo PK. Is there a threshold level of maternal education sufficient to reduce child undernutrition? Evidence from Malawi, Tanzania and Zimbabwe. BMC Pediatr [Internet]. 2015;15(1):1–10. Available from: http://dx.doi.org/10.1186/s12887-015-0406-8
167. Mallick D, Rafi M. Are Female-Headed Households More Food Insecure? Evidence from Bangladesh. World Dev [Internet]. 2010;38(4):593–605. Available from: http://dx.doi.org/10.1016/j.worlddev.2009.11.004
168. Manikkam L, Burns JK. Antenatal depression and its risk factors: An urban prevalence study in KwaZulu-Natal. South African Med J. 2012;102(12):940–4. 10.7196/SAMJ.6009
169. Marmot M, Friel S, Bell R, Houweling TA, Taylor S, Commission on Social Determinants of Health. Closing the gap in a generation: health equity through action on the social determinants of health. Lancet [Internet]. 2008 [cited 2022 Aug 25];372(9650):1661-9. DOI:10.1016/S0140-6736(08)61690-6
170. Marmot M, Allen J. Social determinants of health. Am J Public Health [Internet]. 2014 [cited 2022 Aug 25];104(Suppl 4):S517-9. DOI:10.2105/AJPH.2014.302200
171. Matsungo TM, Kruger HS, Faber M, Rothman M, Smuts CM. The prevalence and factors associated with stunting among infants aged 6 months in a peri-urban South African community. 2017;20(17):3209–18. 10.1017/S1368980017002087
172. Maxwell, Daniel, Jennifer Coates, and Bapu Vaitla (2013). How Do Different Indicators of Household Food Security Compare? Empirical Evidence from Tigray. Feinstein International Center, Tufts University: Medford, USA.Maxwell S. Food Security: A Post-modern Perspective. Brighton, England; 1994. Report No.: ISSN 1353-6141.
173. May J, Witten C & Lake L (eds) (2020) South African Child Gauge 2020. Cape Town: Children's Institute, University of Cape Town.ISBN: 978-0-620-91494-9
174. Maynard M, Andrade L, Packull-McCormick S, Perlman CM, Leos-Toro C, Kirkpatrick SI. Food insecurity and mental health among females in high-income countries. Int J Environ Res Public Health [Internet]. 2018 Jul [cited 2022 Aug 24];15(7):1424. DOI:10.3390/ijerph15071424
175. Mayosi BM, Lawn JE, Van Niekerk A, Bradshaw D, Abdool Karim SS, Coovadia HM. Health in South Africa: Changes and challenges since 2009. Lancet [Internet]. 2012;380(9858):2029–43. Available from: http://dx.doi.org/10.1016/S0140-6736(12)61814-
176. Mbhatsani H V., Mabapa NS, Ayuk TB, Mandiwana TC, Mushaphi LF, Mohlala M, et al. Food security and related health risk among adults in the Limpopo Province of South Africa. S Afr J Sci. 2021;117(11–12):1–7. 10.17159/SAJS.2021/8848
177. Mboweni BO. A child support grant for pregnant women would help prevent stunting in our future generations. Daily Maverick. 2022;1–11.

178. Mchiza ZJ, Parker W, Hossin MZ, Heshmati A, Labadarios D, Falkstedt D, et al. Social and Psychological Predictors of Body Mass Index among South Africans 15 Years and Older : SANHANES-1. :1–20. doi:10.3390/ijerph16203919

179. Mclaren S, Steenkamp L, Feeley A. Food insecurity , social welfare and low birth weight : Implications for childhood malnutrition in an urban Eastern Cape Province township. 2018;12(3):0–4. 10.17159/SAJS.2021/8848

180. Melchor I, Burgos J, Campo A, Aiartzaguena A, Gutiérrez J, Melchor JC. Effect of maternal obesity on pregnancy outcomes in women delivering singleton babies : a historical cohort study. 2019;47(6):625–30. ISBN 3494600600

181. Mhlongo V, Daniels RC. Food expenditure patterns in South Africa : Evidence from the NIDS.Working Paper Number 123. 2013;(123):27. ISBN: 9781920517649

182. Miller LC, Neupane S, Joshi N, Shrestha M, Neupane S, Lohani M, et al. Diet quality over time is associated with better development in rural Nepali children. Matern Child Nutr. 2020 Jul;16(3):e12964.

183. Miller LC, Neupane S, Sparling TM, Shrestha M, Joshi N, Lohani M, et al. Maternal depression is associated with less dietary diversity among rural Nepali children. Matern Child Nutr [Internet]. 2021; Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85107831785&doi=10.1111%2Fmcn.13221&partnerID=40&md5=d55c50b01bb09c89975413ac555b947c

184. Misselhorn A, Hendriks SL. A systematic review of sub-national food insecurity research in South Africa: Missed opportunities for policy insights. Vol. 12, PLoS ONE. 2017. 1–32 p. 10.1371/journal.pone.0182399

185. Modjadji P, Molokwane D. Dietary Diversity and Nutritional Status of Preschool Children in North West Province , South Africa : 2020;1–14. ISBN 2712521366

186. Mohamed S. Fighting hunger, one bowl at a time – two days in the unending battle to feed South Africa's starving children. Daily Maverick. 2022;1–15.

187. Mohammadi-Nasrabadi F, Omidvar N, Khoshfetrat MR, Kolahdooz F. Household food insecurity in the Islamic Republic of Iran: A systematic review and meta-analysis. East Mediterr Heal J. 2014;20(11):698–706.

188. Molendijk M, Molero P, Sanchez-Pedreno O, F, Does V der, W, et al. Diet quality and depression risk: A systematic review and dose-response meta-analysis of prospective studies. Vol. 226, Journal of Affective Disorders. 2018. p. 346–54.

189. Mola CL De, Martins-silva T, Carpena MX, Blumenberg C, Martins RC, Dias IM, et al. Maternal mental health before and during the COVID-19 pandemic in the 2019 Rio Grande birth cohort. Brazilian J Psychiatry. 2021;43(4):402–6. 10.1590/1516-4446-2020-1673

190. Molotja, C. M., Maliwichi, L. L., & Jideani AI. Nutrition knowledge and food choices of primary school learners in Limpopo province, South Africa. J Consum Sci. 2020;5(May 2019):98–114.

191. Moradi S, Arghavani H, Issah A, Mohammadi H, Mirzaei K. Review Article Food insecurity and anaemia risk : a systematic review and meta-analysis. Public Health Nutr. 2018;21(16):3067–79. 10.1017/S1368980018001775 \

192. Mosites E, Dawson-Hahn E, Walson J, Rowhani-Rahbar A, Neuhouser ML. Piecing

together the stunting puzzle: a framework for attributable factors of child stunting. Paediatr Int Child Health. 2017;37(3):158–65.
193. Munodawafa M, Mall S, Lund C, Schneider M. Process-evaluations-of-task-sharing-interventions-for-perinatal-depression-in-low-and-middle-income-countries-LMIC-A-systematic-review-and-qualitative-metasynthesisBMC-Health-Services-Research.pdf. 2018;1–10.
194. Mwaka1 NPSMLNNM, Affiliations: Nutrition knowledge , attitudes and practices o f primary school children in Tshwane. African J Prim Heal Care Fam Med. 2019;1–7.
195. Nakamura A, El-Khoury Lesueur F, Sutter-Dallay A-L, Franck J-ève, Thierry X, Melchior M, et al. The role of prenatal social support in social inequalities with regard to maternal postpartum depression according to migrant status. J Affect Disord [Internet]. 2020;272:465–73. Available from: https://www.sciencedirect.com/science/article/pii/S0165032719331726
196. Naqvi S, Naqvi F, Saleem S, Thorsten VR, Figueroa L, Mazariegos M, et al. Health care in pregnancy during the COVID- - 19 pandemic and pregnancy outcomes in six low- - and- - income countries : Evidence from a prospective , observational registry of the Global Network for Women ' s and Children ' s Health. 2022;2019(March):1298–307.
197. Nasreen HE, Kabir ZN, Forsell Y, Edhborg M. Low birth weight in offspring of women with depressive and anxiety symptoms during pregnancy: Results from a population based study in Bangladesh. BMC Public Health. 2010;10.
198. Noonan K, Corman H, Reichman NE. Effects of maternal depression on family food insecurity. Econ Hum Biol. 2016 Sep;22:201–15.
199. Nord M. Introduction to Item Response Theory applied to Food Security Measurement: Basic Concepts , Parameters and Statistics. 2014.
200. Oddy WH, Hickling S, Smith MA, O'Sullivan TA, Robinson M, de Klerk NH, et al. Dietary intake of omega-3 fatty acids and risk of depressive symptoms in adolescents. Depress Anxiety [Internet]. 2011 Jul;28(7):582–8. Available from: 10.1002/da.20822
201. Opiyo RO, Nyasulu PS, Koigi RK, Obondo A, Ogoyi D, Kogi-Makau W. Effect of fish oil omega-3 fatty acids on reduction of depressive symptoms among HIV-seropositive pregnant women: A randomized, double-blind controlled trial. Ann Gen Psychiatry [Internet]. 2018 Nov 26;17. 10.1186/s12991-018-0220-4
202. Otekunrin OA, Otekunrin OA, Ayinde IA, Sanusi RA, Onabanjo OO, Ariyo O. Dietary diversity , environment and health - related factors of under - five children : evidence from cassava commercialization households in rural. Environ Sci Pollut Res [Internet]. 2022;19432–46. Available from: https://doi.org/10.1007/s11356-021-17221-y
203. Palacios C, Kostiuk LK, Peña-Rosas JP. Vitamin D supplementation for women during pregnancy. Cochrane Database of Systematic Reviews 2019, Issue 7. Art. No.: CD008873. DOI: 10.1002/14651858.CD008873.pub
204. Patel V, DeSouza N, Rodrigues M. Postnatal depression and infant growth and development in low income countries: A cohort study from Goa, India. Arch Dis Child. 2003;88(1):34–7.
205. Pellowski JA, Bengtson AM, Barnett W, DiClemente K, Koen N, Zar HJ, et al. Perinatal depression among mothers in a South African birth cohort study: Trajectories from pregnancy to 18 months postpartum. J Affect Disord [Internet].

2019;259:279–87.
Available from:
https://www.sciencedirect.com/science/article/pii/S0165032718332439
206. Penne T, Goedemé T. Can low-income households afford a healthy diet? Insufficient income as a driver of food insecurity in Europe. Food Policy. 2021;99(October 2020).
207. Pereira AL, Handa S, Holmqvist G. Prevalence and Correlates of Food Insecurity among Children across the Globe. Innocenti Work Pap. 2017;(June):1–37.
208. Popkin BM, Corvalan C, Grummer-Strawn LM. Dynamics of the double burden of malnutrition and the changing nutrition reality. Lancet [Internet]. 2020;395(10217):65–74. Available from: http://dx.doi.org/10.1016/S0140-6736(19)32497-3
209. Popkin BM, Gordon-Larsen P. The nutrition transition: worldwide obesity dynamics and their determinants. Int J Obes Relat Metab Disord [Internet]. 2004;28 Suppl 3(Suppl 3):S2-9.
210. Popkin BM. Relationship between shifts in food system dynamics and acceleration of the global nutrition transition. Nutr Rev. 2017;75(2):73–82.
211. Popova S, Lange S, Probst C, Gmel G, Rehm J. Estimation of national, regional, and global prevalence of alcohol use during pregnancy and fetal alcohol syndrome: a systematic review and meta-analysis. Lancet Glob Heal. 2017;5(3):e290–9.
212. Pourmotabbed A, Moradi S, Babaei A, Ghavami A, Mohammadi H, Jalili C, et al. Food insecurity and mental health: A systematic review and meta-analysis. Public Health Nutr. 2020;23(10):1778–90.
213. Prado EL, Abbeddou S, Adu-Afarwuah S, Arimond M, Ashorn P, Ashorn U, et al. Predictors and pathways of language and motor development in four prospective cohorts of young children in Ghana, Malawi, and Burkina Faso. J Child Psychol Psychiatry. 2017 Nov;58(11):1264–75.
214. Prado EL, Yakes Jimenez E, Vosti S, Stewart R, Stewart CP, Somé J, et al. Path analyses of risk factors for linear growth faltering in four prospective cohorts of young children in Ghana, Malawi and Burkina Faso. BMJ Glob Heal [Internet]. 2019;4(1). Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85061779800&doi=10.1136%2Fbmjgh-2018-001155&partnerID=40&md5=0b3665ef638cfabb8ec5b442e84d7f29
215. Prendergast AJ, Humphrey JH. The stunting syndrome in developing countries. Paediatr Int Child Health. 2014;34(4):250–65.
216. Prom MC, Denduluri A, Philpotts LL, Rondon MB, Borba CPC, Gelaye B, et al. A Systematic Review of Interventions That Integrate Perinatal Mental Health Care Into Routine Maternal Care in Low- and Middle-Income Countries. Front Psychiatry. 2022;13(March).
217. Purushotham A, Mittal N, Ashwini BC, Umesh KB, Taubadel S von C-, Vollmer S. A quantile regression analysis of dietary diversity and health outcomes among children and women in the rural-urban interface of India Anjali. Food Policy [Internet]. 2003;107(1):6–8. Available from: https://doi.org/10.1016/j.foodpol.2021.102216
218. Quirk SE, Williams LJ, O'Neil A, Pasco JA, Jacka FN, Housden S, et al. The association between diet quality, dietary patterns and depression in adults: A systematic review. BMC Psychiatry [Internet]. 2013 Jun 27;13. Available from: http://0-

search.ebscohost.com.innopac.wits.ac.za/login.aspx?direct=true&db=psyh&AN=2013-26178-001&site=ehost-live&scope=site
219. Quisumbing AR, Sproule K, Martinez EM, Malapit H. Do tradeoffs among dimensions of women's empowerment and nutrition outcomes exist? Evidence from six countries in Africa and Asia. Food Policy [Internet]. 2021 [cited 2022 Aug 23];100:102001. DOI:10.1016/j.foodpol.2020.102001
220. Quisumbing AR, Brown LR, Feldstein HS, Haddad L, Peña C. Women: The Key to Food Security. Food Nutr Bull. 1996;17(1):1–2. 10.1177/156482659601700116
221. Radimer KL, Olson CM, Greene JC, Campbell CC, Habicht J-P. Understanding hunger and developing indicators to assess it in women and children. J Nutr Educ [Internet]. 1992;24(1, Supplement 1):36S-44S. Available from: https://www.sciencedirect.com/science/article/pii/S0022318212801373
222. Rah JH, Akhter N, Semba RD, de Pee S, Bloem MW, Campbell a a, et al. Low dietary diversity is a predictor of child stunting in rural Bangladesh. Eur J Clin Nutr [Internet]. 2010 Dec [cited 2014 Dec 10];64(12):1393–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20842167
223. Redinger S, Norris SA, Pearson RM, Richter L, Rochat T. First trimester antenatal depression and anxiety: Prevalence and associated factors in an urban population in Soweto, South Africa. J Dev Orig Health Dis. 2018;9(1):30–40. 10.1017/S204017441700071X
224. Reeder N, Tapanee P, Persell A, Tolar-Peterson T. Food insecurity, depression, and race: Correlations observed among college students at a university in the Southeastern United States. Int J Environ Res Public Health. 2020;17(21):1–11. 10.3390/ijerph17218268
225. Reesor-Oyer L, Cepni AB, Lee CY, Zhao X, Hernandez DC. Disentangling food insecurity and maternal depression: Which comes first? Public Health Nutr. 2021;24(16):5506–13. 10.1017/S1368980021000434
226. Rehm J, Shield KD. Global Burden of Disease and the Impact of Mental and Addictive Disorders. Curr Psychiatry Rep. 2019;21(2). 10.1007/s11920-019-0997-0
227. Republic of South Africa. National Development Plan 2030: Our future – Make it work: Executive Summary [Internet]. 2022 [cited 2022 Aug 26]. Available from: https://www.gov.za/sites/default/files/Executive%20Summary-NDP%202030%20-%20Our%20future%20-%20make%20it%20work.pdf
228. Richards M, Weigel M, Li M, Rosenberg M, Ludema C. Household food insecurity and antepartum depression in the National Children's Study. Ann Epidemiol [Internet]. 2020;44:38-44.e1. Available from: https://www.sciencedirect.com/science/article/pii/S1047279719305599
229. Richardson K, Barkham M. Recovery from depression: a systematic review of perceptions and associated factors. J Ment Heal [Internet]. 2020 Jan 2;29(1):103–15. Available from: https://doi.org/10.1080/09638237.2017.1370629
230. Richterman A, Raymonville M, Hossain A, Millien C, Joseph JP, Jerome G, et al. Food insecurity as a risk factor for preterm birth: a prospective facility-based cohort study in rural Haiti. BMJ Glob Heal. 2020 Jul;5(7). 10.1136/bmjgh-2020-002341
231. Roseboom TJ, Painter RC, Van Abeelen AFM, Veenendaal MVE, De Rooij SR. Hungry in the womb: What are the consequences? Lessons from the Dutch famine. Maturitas [Internet]. 2011;70(2):141–5. Available from: http://dx.doi.org/10.1016/j.maturitas.2011.06.017
232. Ruel MT. Operationalizing Dietary Diversity: A Review of Measurement Issues and

Research Priorities. Am Soc Nutr Sci. 2003;133:3927S–3931S. ISSN 00223166
233. Ryan J, Leibbrandt M. Multidimensional Food Insecurity Measurement. SALDRU Working Paper No. 160. [Internet]. 2015. Available from: http://localhost:8080/handle/11090/793
234. Saeed A, Naqvi M, Javed A. Effects of Maternal food Insecurity on Birth Weight of Neonates: A Prospective Cohort. Ann King Edward Med Univ. 2018;23(4). 10.21649/journal.akemu/2017/23.4.524.530
235. Said-Mohamed R, Micklesfield LK, Pettifor JM, Norris SA. Has the prevalence of stunting in South African children changed in 40 years? A systematic review. BMC Public Health. 2015;15(1):1–10. 10.1186/s12889-015-1844-9
236. Sawyer CC. Child Mortality Estimation: Estimating Sex Differences in Childhood Mortality since the 1970s. PLoS Med. 2012;9(8). 10.1371/journal.pmed.1001287
237. Sayed N, Burger R, Harper A, Swart EC. Lockdown-associated hunger may be affecting breastfeeding: Findings from a large sms survey in South Africa. Int J Environ Res Public Health. 2022;19(1). 10.3390/ijerph19010351
238. Schmeer KK, Piperata BA, Herrera Rodríguez A, Salazar Torres VM, Centeno Cárdenas FJ. Maternal resources and household food security: evidence from Nicaragua. Public Health Nutr [Internet]. 2015;18(16):2915–24. Available from: http://0-search.ebscohost.com.innopac.wits.ac.za/login.aspx?direct=true&db=lhh&AN=20153365881&site=ehost-live&scope=site
239. Scott V, Schaay N, Schneider H, Sanders D. Addressing social determinants of health in South Africa: the journey continues. In: SAHR 20th Edition. 2017. p. 77–88.
240. Sen A. Poverty and famines: An essay on entitlement and deprivation [Internet]. Oxford University Press; 1981 [cited 2022 Aug 24]. Available from: https://www.prismaweb.org/nl/wp-content/uploads/2017/06/Poverty-and-famines%E2%94%82Amartya-Sen%E2%94%821981.pdf
241. Sepúlveda A. Brazil : from a global example of food security to back on the Hunger Map. SciencesPo observatoire politique de l'amerique ltine et des caraibes. 2014. p. 1–5.
242. Shafiei F, Salari-Moghaddam A, Larijani B, Esmaillzadeh A. Adherence to the Mediterranean diet and risk of depression: a systematic review and updated meta-analysis of observational studies. Vol. 77, Nutrition Reviews. 2019. p. 230–9. doi: 10.1093/nutrit/nuz012.
243. Shisana o, Labadarios D, Rehle T, Simbayi L, Zuma K, Dhansay A, Reddy P, Parker W, Hoosain E, Naidoo P, Hogoro C, Mchiza Z, Steyn NP, Dwane N, Makoae M, Maluleke T, Ramlagan S, zungu N, Evans MG, Jacobs L FM& S-1 T. The South African National health and Nutrition Examination Survey SANHANES-1. Cape Town; 2013. ISBN 9780796924766
244. Siega-Riz AM, Laraia B. The implications of maternal overweight and obesity on the course of pregnancy and birth outcomes. Matern Child Health J. 2006;10(SUPPL. 7):153–6. 10.1007/s10995-006-0115-x
245. Singh DR, Sunuwar DR, Adhikari S, Singh S, Karki K. Determining factors for the prevalence of depressive symptoms among postpartum mothers in lowland region in southern Nepal. PLoS One [Internet]. 2021;16(1 January):1–16. Available from: http://dx.doi.org/10.1371/journal.pone.0245199
246. Slomian J, Honvo G, Emonts P, Reginster J, Bruyère O. Consequences of maternal

postpartum depression : A systematic review of maternal and infant outcomes. Women's Health. 2019; 15:1-55. 10.1177/1745506519844044
247. Smith LC, Ramakrishnan U, Ndiaye A, Haddad L, Martorell R, Mayufis RG, et al. The Importance of Women's Status for Child Nutrition in Developing Countries. Washington DC; 2003.
248. Smith LC, Subandoro A. Measuring Food Security Using Household Expenditure Surveys. Measuring Food Security Using Household Expenditure Surveys. International Food Policy Research Institute; 2007.
249. Smith MD, Kassa W, Winters P. Assessing food insecurity in Latin America and the Caribbean using FAO's Food Insecurity Experience Scale. Food Policy [Internet]. 2017;71:48–61. Available from: http://dx.doi.org/10.1016/j.foodpol.2017.07.005
250. Sparling TM, Henschke N, Nesbitt RC, Gabrysch S. The role of diet and nutritional supplementation in perinatal depression: a systematic review. Vol. 13, Maternal & Child Nutrition. 2017. p. 1. DOI: 10.1111/mcn.12235
251. Sparling TM, Nesbitt RC, Henschke N, Gabrysch S. Nutrients and perinatal depression: a systematic review. J Nutr Sci. 2017; 10.1017/jns.2017.58
252. Sparling TM, Waid JL, Wendt AS, Gabrysch S. Depression among women of reproductive age in rural Bangladesh is linked to food security, diets and nutrition. Public Health Nutr. 2020 Mar;23(4):660–73. 10.1017/S1368980019003495
253. Spaull N, Oyenubi A, Kerr A, Maghan-Brown B, Ardington C, Christian C, et al.NIDS-CRAM Wave 2 Synthesis report. September 2020.
254. Spaull N, Tomlinson M. Feeding a Family on $ 300 a Month. Business Live.
255. Spradley FT, Palei AC, Granger JP. Increased risk for the development of preeclampsia in obese pregnancies: Weighing in on the mechanisms. Am J Physiol - Regul Integr Comp Physiol. 2015;309(11):R1326–43. 10.1152/ajpregu.00178.2015
256. Sraboni E, Quisumbing A. Women's empowerment in agriculture and dietary quality across the life course: Evidence from Bangladesh. Food Policy [Internet]. 2018;81:21–36. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85055750948&doi=10.1016%2Fj.foodpol.2018.09.001&partnerID=40&md5=6e741f7db744327809970eda0f1e9199
257. Stats SA. Towards measuring food security in South Africa: An examination of hunger and food inadequacy [Internet]. Pretoria: Statistics South Africa, Private Bag X44, Pretoria 0001; 2019. 26 p. Available from: www.statssa.gov.za
258. Steyn N, Nel J, Nantel G, Kennedy G, Labadarios D. Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy? Public Health Nutr. 2006;9(5):644–50. 10.1079/phn2005912
259. Steyn NP, Nel JH, Drummond L, Malczyk S, Senekal M. Has Food Security and Nutritional Status Improved in Children 1–<10 Years in Two Provinces of South Africa between 1999 (National Food Consumption Survey) and 2018 (Provincial Dietary Intake Study (PDIS)). Int J Environ Res Public Health. 2022;19(3):1–21. 10.3390/ijerph19031038
260. Steyn NP, Nel JH, Nantel G, Kennedy G, Labadarios D. Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy? Public Health Nutr. 2006;9(5):644–50. 10.1079/phn2005912
261. Subramanian S V., Karlsson O, Kim R. Revisiting the stunting metric for monitoring and evaluating nutrition policies. Lancet Glob Heal [Internet]. 2022;10(2):e179–80. Available from: http://dx.doi.org/10.1016/S2214-109X(21)00504-0

262. Shung-King M, Lake L, Sanders D & Hendricks M (eds) (2019) South African Child Gauge 2019. Cape Town: Children's Institute, University of Cape Town. ISBN: 978-0-620-85838-0
263. Surkan PJ, Kennedy CE, Hurley KM, Black MM. Maternal depression and early childhood growth in developing countries: systematic review and meta-analysis. Bull World Health Organ. 2011;89(8):607–15.
264. Tadesse G, Abate GT, Zewdie T. Biases in self-reported food insecurity measurement: A list experiment approach. Food Policy [Internet]. 2020;92(May 2019):101862. Available from: https://doi.org/10.1016/j.foodpol.2020.101862
265. Tang MN, Ettinger de Cuba S, Coleman SM, Heeren T, Sandel M, Chilton M, et al. Maternal Place of Birth, Socioeconomic Characteristics, and Child Health in US-Born Latinx Children in Boston. Acad Pediatr. 2020 Mar;20(2):225–33. 10.1016/j.acap.2019.09.005
266. Teran JM, Varea C, Juarez S, Bernis C, Bogin B. Social disparities in low birth weight among Spanish mothers during the economic crisis (2007-2015). Nutr Hosp. 2018;129–41. 10.1016/j.acap.2019.09.005
267. Thurstans S, Opondo C, Seal A, Wells J, Khara T, Dolan C, et al. Boys are more likely to be undernourished than girls: A systematic review and meta-analysis of sex differences in undernutrition. BMJ Glob Heal. 2020;5(12):1–17. 10.1136/bmjgh-2020-004030
268. Tomita A, Cuadros DF, Mabhaudhi T, Sartorius B, Ncama BP, Dangour AD, et al. Spatial clustering of food insecurity and its association with depression: a geospatial analysis of nationally representative South African data, 2008–2015. Sci Rep [Internet]. 2020;10(1):1–11. Available from: https://doi.org/10.1038/s41598-020-70647-1
269. Tomita A, Labys CA, Burns JK. Depressive Symptoms Prior to Pregnancy and Infant Low Birth Weight in South Africa. Matern Child Health J. 2015;19(10):2179–86.
270. Tomita A, Burns JK. A multilevel analysis of association between neighborhood social capital and depression : Evidence from the first South African National Income Dynamics Study. J Affect Disord [Internet]. 2013;144(1–2):101–5. Available from: http://dx.doi.org/10.1016/j.jad.2012.05.066
271. Tomita A, Ramlall S, Naidu T, Mthembu SS, Padayatchi N, Burns JK. Major depression and household food insecurity among individuals with multidrug-resistant tuberculosis (MDR-TB) in South Africa. Soc Psychiatry Psychiatr Epidemiol [Internet]. 2019;54(3):387–93. Available from: http://dx.doi.org/10.1007/s00127-019-01669-y
272. Tomlinson M, Cooper PJ, Stein A, Swartz L, Molteno C. Post-partum depression and infant growth in a South African peri-urban settlement. Child Care Health Dev. 2006;32(1):81–6. 10.1111/j.1365-2214.2006.00598.x
273. Tomlinson M, Rotheram-Borus MJ, Scheffler A, le Roux I. Antenatal depressed mood and child cognitive and physical growth at 18-months in South Africa: a cluster randomised controlled trial of home visiting by community health workers. Epidemiol Psychiatr Sci. 2018 Dec;27(6):601–10. 10.1017/S2045796017000257
274. Tomlinson M, Rotheram-borus MJ, Harwood J, Roux IM, Connor MO, Worthman C. Community health workers can improve child growth of antenatally-depressed , South African mothers : a cluster randomized controlled trial. 2015;1–9. 10.1186/s12888-015-0606-7

275. Traore SS, Bo Y, Amoah AN, Khatun P, Kou G, Hu Y, et al. A meta-analysis of maternal dietary patterns and preeclampsia. Clin Nutr Open Sci [Internet]. 2021;40:15–29. Available from: https://doi.org/10.1016/j.nutos.2021.08.001
276. Tsai AC, Tomlinson M, Comulada WS, Rotheram-Borus MJ. Food insufficiency, depression, and the modifying role of social support: Evidence from a population-based, prospective cohort of pregnant women in peri-urban South Africa. Soc Sci Med [Internet]. 2016;151:69–77. Available from: http://dx.doi.org/10.1016/j.socscimed.2015.12.042
277. Tsai AC, Tomlinson M, Dewing S, Ingrid M, Harwood JM, Chopra M, et al. Antenatal depression case-finding by community health workers in South Africa : feasibility of a mobile phone application. Arch Womens Ment Health. 2015;17(5):423–31. 10.1007/s00737-014-0426-7.Antenatal
278. UNICEF. Low birthweight prevalence, by country and region, 2015 [Internet]. 2019. Available from: https://data.unicef.org/topic/nutrition/low-birthweight/
279. Upton N. Developing our understanding of nutrition in depression. Br J Nutr [Internet]. 2021/05/27. 2022;127(7):1010–7. Available from: https://www.cambridge.org/core/article/developing-our-understanding-of-nutrition-in-depression/548B630869E022F57B9ABFE02700D642
280. USAID Nutrition Activities. Beyond Stunting Complementary Indicators for Monitoring and Evaluating USAID Nutrition Activities. 2021;(March). Available from: https://www.advancingnutrition.org/resources/beyond-stunting-complementary-indicators-monitoring-and-evaluating-usaid-nutrition
281. van Bruwaene L, Goga A, Green RJ. What are we doing to the children of South Africa under the guise of COVID-19 lockdown ? South African Med J. 2020;15–6. 10.1007/s00737-014-0426-7.Antenatal
282. Van Den Berg VL, Okeyo AP, Dannhauser A, Nel M. Body weight, eating practices and nutritional knowledge amongst university nursing students, Eastern Cape, South Africa. African J Prim Heal Care Fam Med. 2012;4(1):1–9. 10.4102/phcfm.v4i1.323
283. van der Berg S, Patel L, Bridgman G. Hunger in South Africa: Results from Wave 4 of NIDS-CRAM. 2021.
284. van der Berg S, Zuze L, Bridgman G. The impact of the Coronavirus and lockdown on children's welfare in South Africa; Evidence from NIDS-CRAM Wave 1. 2020.
285. van Heyningen T, Myer L, Onah M, Tomlinson M, Field S, Honikman S, et al. Antenatal depression and adversity in urban South Africa. J Affect Disord [Internet]. 2016;203:121–9. Available from: http://dx.doi.org/10.1016/j.jad.2016.05.052
286. Venter F, Walsh C, Slabber M, Bester C. Body size perception of African women (25-44 years) in Manguang. J Fam Ecol Consum Sci /Tydskrif vir Gesinsekologie en Verbruikerswetenskappe. 2009;37(1). 10.4314/jfecs.v37i1.48942
287. Wado YD, Afework MF, Hindin MJ. Effects of maternal pregnancy intention, depressive symptoms and social support on risk of low birth weight: A prospective study from Southwestern Ethiopia. PLoS One. 2014;9(5):1–7. 10.1371/journal.pone.0096304
288. Walker SP, Wachs TD, Meeks Gardner J, Lozoff B, Wasserman GA, Pollitt E, et al. Child development: risk factors for adverse outcomes in developing countries. Lancet. 2016;369(9556):145–57. 10.1016/S0140-6736(07)60076-2
289. Weaver LJ, Hadley C. Moving beyond hunger and nutrition: A systematic review of the evidence linking food insecurity and mental health in developing countries. Ecol Food Nutr. 2009;48(4):263–84. 10.1080/03670240903001167

290. Webb P, Coates J, Frongillo EA, Loreg Rogers B, Swindale A, Bilinsky P. Advances in Developing Country Food Insecurity Measurement Measuring Household Food Insecurity : Why It ' s So Important and Yet So. Adv Dev Ctry Food Insecurity Meas. 2006;136(2):1404S-1408S. 10.1093/jn/136.5.1404S
291. Weingarten SE, Dearden KA, Crookston BT, Penny ME, Behrman JR, Humphries DL. Are household expenditures on food groups associated with children's future heights in Ethiopia, India, Peru, and Vietnam? Int J Environ Res Public Health. 2020;17(13):1–23. 10.3390/ijerph17134739
292. Wemakor A, Mensah KA. Association between maternal depression and child stunting in Northern Ghana: A cross-sectional study. BMC Public Health [Internet]. 2016;16(1):1–7. Available from: http://dx.doi.org/10.1186/s12889-016-3558-z
293. WHO. COVID-19 pandemic leads to major backsliding on childhood vaccinations , new WHO , UNICEF data shows [Internet]. 2021. Available from: https://www.unicef.org/press-releases/covid-19-pandemic-leads-major-backsliding-childhood-vaccinations-new-who-unicef-data
294. WHO. WHO Child Growth Standards. Vol. 7, World Health Organization. Geneva; 2008. Geneva; 2008.
295. World Health Organization. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. World Health Organ Tech Rep Ser.
296. Willey BA, Cameron N, Norris SA, Pettifor JM, Griffiths PL. Socio-economic predictors of stunting in preschool children - A population-based study from Johannesburg and Soweto. South African Med J. 2009;99(6):450–6. 10.1371/journal.pone.0010722
297. Wills G, Patel L, van der Berg S, Mpeta B. Household resource flows and food poverty during South Africa's lockdown: Short-term policy implications for three channels of social protection. 2020;(Wave 1):46. Available from: https://cramsurvey.org/wp-content/uploads/2020/07/Wills-household-resource-flows-and-food-poverty-during-South-Africa's-lockdown-2.pdf
298. Woody CA, Ferrari AJ, Siskind DJ, Whiteford HA, Harris MG. A systematic review and meta-regression of the prevalence and incidence of perinatal depression. J Affect Disord [Internet]. 2017;219(April 2017):86–92. Available from: http://dx.doi.org/10.1016/j.jad.2017.05.003
299. World Health Organization (WHO). Obesity and overweight. Vol. 13. 2020.
300. Wu Q, Harwood RL, Feng X. Family socioeconomic status and maternal depressive symptoms: Mediation through household food insecurity across five years. Soc Sci Med. 2018 Oct;215:1–6. 10.1016/j.socscimed.2018.08.043
301. Yin X, Sun N, Jiang N, Xu X, Gan Y, Zhang J, et al. Prevalence and associated factors of antenatal depression: Systematic reviews and meta-analyses. Clin Psychol Rev [Internet]. 2021;83(September 2020):101932. Available from: https://doi.org/10.1016/j.cpr.2020.101932
302. Young MF, Nguyen PH, Casanova IG, Addo OY, Tran LM, Nguyen S, et al. Role of maternal preconception nutrition on offspring growth and risk of stunting across the first 1000 days in Vietnam : A prospective cohort study. 2018;1–13. https://doi.org/10.1371/journal.pone.0203201
303. Zar HJ, Pellowski JA, Cohen S, Barnett W, Vanker A, Koen N, et al. Maternal health and birth outcomes in a South African birth cohort study. PLoS One. 2019;14(11):e0222399. 10.1371/journal.pone.0222399

Appendices

Appendix 1: Ethics clearance certificates

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG	HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

Office of the Deputy Vice-Chancellor (Research & Post Graduate Affairs)

TO: Ms A Harper
Division of Epidemiology and Biostatistics
School of Public Health
Medical School
University

E-mail: abigailjroso@gmail.com

CC: Supervisor: Dr S Mall <Sumaya.Mall@wits.ac.za>
and <HREC-Medical.ResearchOffice@wits.ac.za>

FROM: Iain Burns
Human Research Ethics Committee (Medical)
Tel: 011 717 1252

E-mail: Iain.Burns@wits.ac.za

DATE: 2019/10/14

REF: *R14/49*

PROTOCOL NO: **M1909101** *(This is your ethics application study reference number. Please quote this reference number in all correspondence relating to this study)*

PROJECT TITLE: *The relationship between food insecurity, maternal depression during pregnancy and child health outcomes in South Africa*

Please find attached the Clearance Certificate for the above project. I hope it goes well and that an article in a recognized publication comes out of it. This will reflect well on your professional standing and contribute to the Government funding of the University.

MSWorks2000/Iain0007/Clearscan.wps

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R14/49 Ms A Harper

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M1909101

NAME: (Principal Investigator)	Ms A Harper
DEPARTMENT:	Division of Epidemiology and Biostatistics School of Public Health Medical School University
PROJECT TITLE:	The relationship between food insecurity, maternal depression during pregnancy and child health outcomes in South Africa
DATE CONSIDERED:	Ad hoc
DECISION:	Aproved unconditionally
CONDITIONS:	
SUPERVISOR:	Dr S Mall
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2019/10/14

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the 3rd Floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report.** When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **September** and will therefore reports and re-certification will be due early in the month of **September** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature Date

PLEASE QUOTE THE CLEARANCE CERTIFICATE NUMBER IN ALL ENQUIRIES

Appendix 2: NIDS Adult Questionnaire Excerpts

Section F1: Individual income from non-employment sources

INTERVIEWER READ OUT: In this section we are going to talk about any money or any form of assistance that you may receive **which does not involve employment of some kind**.

As I read a list of the different ways in which people can receive money or assistance, please indicate whether [...] did, in fact, receive such assistance or not in the last month.

		1. Did you receive income or assistance from [..] in the last month ?				**Computer Check: If Answer Not=1 skip to next Question.**	**Validation Rule**	2.How much did you receive last month in Rands? **Interviewer: If don't know write "-9". If refused write "-8"**
		Yes	No	Refused	Don't Know			
F1.1 *incgovpen*	State (South African government) old age pension	1	2	-8	-9	**: If Answer Not=1 skip to F1.2**		*incgovpen_v*
F1.2 *incppen*	Private pension or foreign pension	1	2	-8	-9	**: If Answer Not=1 skip to F1.3**		*incppen_v*
F1.3 *incret*	Private retirement annuity	1	2	-8	-9	**: If Answer Not=1 skip to F1.4**		*incret_v*
F1.4 *incretp*	Retirement gratuity or retirement package	1	2	-8	-9	**: If Answer Not=1 skip to F1.5**	Confirm if (A14-B1)<60	*incretp_v*
F1.5 *incuif*	Unemployment insurance (UIF)	1	2	-8	-9	**: If Answer Not=1 skip to F1.6**		*incuif_v*
F1.6 *incwc*	Workmen's compensation	1	2	-8	-9	**: If Answer Not=1 skip to F1.7**		*incwc_v*
F1.7 *incdis*	Disability grant	1	2	-8	-9	**: If Answer Not=1 skip to F1.8**		*incdis_v*
F1.8 *incwar*	War veterans pension	1	2	-8	-9	**: If Answer Not=1 skip to F1.9**		*incwar_v*
F1.9 *incchld*	Child support grant	1	2	-8	-9	**: If Answer Not=1 skip to F1.10**		*incchld_v*
F1.10 *incfos*	Foster care grant	1	2	-8	-9	**: If Answer Not=1 skip to F1.11**		*incfos_v*
F1.11 *incoare*	Care dependency grant	1	2	-8	-9	**: If Answer Not=1 skip to F1.12**		*incoare_v*

				Validation rule	Skips
H7 *edter*	Have you successfully completed any diplomas, certificates or degrees outside of school?	Yes	1		
		No	2	Confirm if w1_tertiyesno=1	CH10
		Refused	-8		CH10
		Don't know	-9		CH10
H8 *edterlev*	What is the highest level of education you have successfully completed? Do not include any courses that you did not successfully complete. **Interviewer: Select from drop-down list. Codes 00 to 15 and 25 are not applicable.**	Highest level of education		valid range: code 00-15 and 25 not applicable	
		If other, specify here *edterlev_o*			
		Refused	-8		
		Don't know	-9		
H9 *edterins*	At what institution did you successfully complete the diploma, certificate or degree? **Interviewer: If don't know write "-9". If refused write "-8"**	Tertiary institution			
CH10	**Computer CHECK! Is this respondent aged between 15 and 30?(i.e. Is (A14-B1)<30?)**	Yes	1		
		No	2		H32
H10 *ed08att*	Did you attend any school or classes or correspondence courses of any kind at any time in 2008? Include university, technical colleges or any courses as well as school.	Yes	1	Confirm if w1_currentenrolyn = 2	
		No	2	Confirm if w1_currentenrolyn = 1	H13
		Refused	-8		H13
		Don't Know	-9		H13
H11 *ed08res*	What was the result of this schooling in 2008?	Withdrew before completing the year	1		
		Failed the grade or programme	2		H13
		Passed the grade or programme	3		H13
		Continuing in programme, no grade given	4		H13
		Refused	-8		H13
		Don't Know	-9		H13
H12 *ed08wdex*	What was the main reason that you withdrew before completing the educational year? **Interviewer: only one answer allowed.**	Could not afford to stay at school	1		
		Wanted to look for a job	2		
		Was pregnant/had a baby	3		
		Was needed at home	4		
		Was ill/sick	5		
		Grades were very poor/ was not allowed to continue	6		
		suspended/expelled	7		
		Other (specify)	8		
		Refused	-8		
		Don't Know	-9		

		Don't Know	-9		
J23 *hllfsmk*	Do you smoke cigarettes?	Yes	1		J26
		No	2		
		Refused	-8		
		Don't Know	-9		
J24 *hllfsmkreg*	Did you ever smoke cigarettes regularly?	Yes	1		
		No	2		J28
		Refused	-8		J28
		Don't Know	-9		J28
J25 *hllfsmklst*	How old were you when you last smoked cigarettes regularly? **Interviewer: If don't know write "-9". If refused write "-8"**	Age			
J26 *hllfsmkfrs*	How old were you when you first smoked cigarettes regularly? **Interviewer: If don't know write "-9". If refused write "-8"**	Age			
J27 *hllfsmkqnt*	On average, how many cigarettes per day did you/ do you smoke? **Interviewer: If don't know write "-9". If refused write "-8"**	Number of cigarettes			

				Validation Rule	Skips
J28 hlfalc	How often do you drink alcohol?	I have never drank alcohol	1		J30
		I no longer drink alcohol	2		J30
		I drink very rarely	3		
		Less than once a week	4		
		On 1 or 2 days a week	5		
		On 3 or 4 days a week	6		
		On 5 or 6 days a week	7		
		Every day	8		
		Refused	-8		
		Don't Know	-9		
J29 hlfalcqnt	On a day that you have an alcoholic drink, how many standard drinks do you usually have? *A standard drink is a small glass of wine; a 330 ml can of regular beer, a tot of spirits, or a mixed drink.*	13 or more standard drinks	1		
		9 to 12 standard drinks	2		
		7 to 8 standard drinks	3		
		5 to 6 standard drinks	4		
		3 or 4 standard drinks	5		
		1 or 2 standard drinks	6		
		Refused	-8		
		Don't Know	-9		
J30 hlfhivtst	I do not want to know the result, but have you ever had an HIV test?	Yes	1		
		No	2		
		Don't Know	-8		
		Refused	-9		
J31 hlmedaid	~~Are you covered by medical aid?~~	~~Yes~~	~~1~~		
		~~No~~	~~2~~		~~K1~~
		~~Refused~~	~~-8~~		~~K1~~
		~~Don't Know~~	~~-9~~		~~K1~~
~~**J32** hlmedpid~~	~~Which person in the household pays for medical aid for you?~~ ~~**Interviewer: If self, write 00.**~~ ~~**If person not in household, write 77**~~ ~~**Interviewer: If don't know write "-9". If refused write "-8"**~~	Name			

Section K: Emotional health

INTERVIEWER READ OUT: We would like to know how your general well-being has been over the past week.

I am going to read a list of some of the ways you may have felt or behaved during the last week. Using the screen, please indicate how often you have felt this way during the **past week.**

Interviewer: Circle one number on each line

	During the past week...	Rarely or none of the time (less than 1 day)	Some or little of the time (1-2 days)	Occasionally or a moderate amount of time (3-4 days)	All of the time (5-7 days)	Refused
K1	I was bothered by things that usually don't bother me *emobth*	1	2	3	4	-8
K2	I had trouble keeping my mind on what I was doing *emomnd*	1	2	3	4	-8
K3	I felt depressed *emodep*	1	2	3	4	-8
K4	I felt that everything I did was an effort *emoeff*	1	2	3	4	-8
K5	I felt hopeful about the future *emohope*	1	2	3	4	-8
K6	I felt fearful *emofear*	1	2	3	4	-8
K7	My sleep was restless *emoslp*	1	2	3	4	-8
K8	I was happy *emohap*	1	2	3	4	-8
K9	I felt lonely *emolone*	1	2	3	4	-8
K10	I could not "get going" *emogo*	1	2	3	4	-8

Section N: Measurements

INTERVIEWER READ OUT: Now we would like to take your height, weight, waist and blood pressure measurements.

				Validation Rule	Skip
N1.1 *height_1*	Respondent's Height – Measure 1 **If Don't Know write "-9"** **If Refused write "-8"**			___ ___ ___ • ___ centimetres	
	Computer CHECK! Is the height measurement less than 130.0cm?	**Yes → Re-do height measure, and correct N1.1 if appropriate**			**1**
		No			**2**
N1.2 *height_2*	Respondent's Height – Measure 2			___ ___ ___ • ___ centimetres	
CN1.3	**Computer CHECK! Is -1 < (N1.1-N1.2) < 1 (Is the difference between N1.1 and N1.2 less than 1cm?)**	**Yes**	**1**		**N2.1**
		No	**2**		
N1.3 *height_3*	Respondent's Height – Measure 3			___ ___ ___ • ___ centimetres	
N2.1 *weight_1*	Respondent's Weight – Measure 1			___ ___ ___ • ___ kilograms	
	Computer CHECK! Does the scale display a figure of more than 150?	**Yes → Reset the scale to kilograms, and correct N2.1**			**1**
		No			**2**
N2.2 *weight_2*	Respondent's Weight – Measure 2			___ ___ ___ • ___ kilograms	
CN2.3	**Computer CHECK! Is -1 <(N2.1-N2.2) < 1 (Is the difference between N2.1 and N2.2 less than 1 kg?)**	**Yes**	**1**		**N3.1**
		No	**2**		
N2.3 *weight_3*	Respondent's Weight – Measure 3			___ ___ ___ • ___ kilograms	
N3.1 *waist_1*	Respondent's Waist – Measure 1			___ ___ ___ • ___ centimetres	
N3.2 *waist_2*	Respondent's Waist – Measure 2			___ ___ ___ • ___ centimetres	
CN3.3	**Computer CHECK! Is -2 < (N3.1-N3.2) < 2 (Is the difference between N3.1 and N3.2 less than 2cm?)**	**Yes**	**1**		**N4.1**
		No	**2**		
N3.3 *waist_3*	Respondent's Waist – Measure 3			___ ___ ___ • ___ centimetres	

N4.1	**Blood pressure – Reading 1**	**N4.2**	**Blood pressure – Reading 2**
1. SYSTOLIC *bpsys_1*	___ ___ ___	1. SYSTOLIC *bpsys_2*	___ ___ ___
2. DIASTOLIC *bpdia_1*	___ ___ ___	2. DIASTOLIC *bpdia_2*	___ ___ ___
3. PULSE *bppls_1*	___ ___ ___	3. PULSE *bppls_2*	___ ___ ___

N5	**INTERVIEWER CHECK! Have you filled out the health information sheet and given it to the respondent?**	Yes	1
		No	2

Appendix 3: NIDS Child Questionnaire Excerpts

Section B: Demographics

INTERVIEWER READ OUT: We would like to ask you some questions about the child's background.				Validation Rule	Skips
B1	What is this child's gender?	Male	1	Validate using w1_gen	
		Female	2		
		Don't Know	-9		
		Refused	-8		
B2 *pop*	What population group does this child belong to?	African	1	Validate using w1_race	
		Coloured	2		
		Asian/Indian	3		
		White	4		
		Other (Specify)	5		
		Don't Know	-9		
		Refused	-8		
B3 *lng*	Which language does the child usually speak at home? If the child is not yet speaking, what language is usually spoken to the child? **If Don't Know write "-9"** **If Refused write "-8"**	Language		Validate using w1_lang	
		If other, specify here *lng_o*			
B4 *slpw*	Over the past 7 nights, how many nights did the child sleep under this roof? **Interviewer: If all, write 7** **If Don't Know write "-9"** **If Refused write "-8"**			Valid range: B4 <= 7	
B5	Over the past month, how many nights did the child sleep under this roof? **Interviewer: If all, write 31** **If Don't Know write "-9"** **If Refused write "-8"**			Valid range: B5 <=31	
B6 *livewoth*	Has this child ever lived in another suburb / town /village?	Yes	1		
		No	2		CC1
		Refused	-8		
		Don't Know	-9		

ection D: Child's health

INTERVIEWER READ OUT: Now we would like to ask you some questions about the child's health.				Validation Rule	Skips
D1	Overall, how is this child's health at this point in time?	Excellent	1		
		Very good	2		
		Good	3		
		Fair	4		
		Poor	5		
		Don't Know	-9		
		Refused	-8		
D2 *bpla*	Was this child born in a hospital, clinic or at home?	Hospital	1	Confirm if w1_placeofbirth!=1	
		Clinic	2	Confirm if w1_placeofbirth!=2	
		Home	3	Confirm if w1_placeofbirth!=3	
		Don't Know	-9		
		Refused	-8		
D3 *bcert*	Does this child have a birth certificate?	Yes	1	Confirm if w1_birthcertyn =2	
		No	2	Confirm if w1_birthcertyn=1	
		Don't Know	-9		
		Refused	-8		
CD4	**Computer Check:** If w1_ dobsourceinfo =1 & w1_ weigsourceinfo = 1 & w1_ headsourceinfo = 1	Yes	1		CD8
		No	2		
D4 *birthcard*	Do you have a clinic (road to health) card for this child? **Interviewer: If yes, ask: May I see it?**	Yes	1		
		No	2		
		Yes, but not available	3		
		Don't Know	-9		
		Refused	-8		
CD6	**Computer Check:** Is w1_ dobsourceinfo =1	Yes	1		CD6
		No	2		
D5 *dob*	What was the child's date of birth? Interviewer: Write date from card if available. **If Don't Know write "-9"** **If Refused write "-8"**	SD __/__ __/__ __ __ __ d d/ m m/ y y y y		confirm using w1_dob_d and w1_dob_m and w1_dob_y	
CD8	**Computer Check:** Is w1_ weigsourceinfo = 1 & is w1_weightbirth valid?	Yes	1		CD7
		No	2		
D6	How much did this child weigh at birth? **Interviewer: Record from card if available.** **If Don't Know write "-9"** **If Refused write "-8"**	_____ _____ _____ _____ grams *bwgbtg* OR _____ • _____ _____ _____ kgs *bwgtkt*		Confirm if D6>7kg or D6 > 7000grams or D6<1.500kg or D6<1500grams	
Interviewer Note: need to make the distinction between grams and kilograms clear					
CD7	**Computer Check:** Is w1_headsourceinfo = 1 and is w1_headcerc valid?	Yes	1		CD8
		No	2		

Section F: Grants

				Validation Rule	Skips
	INTERVIEWER READ OUT: Now we would like to ask some questions about the grants collected on behalf of this child.				
F1 *grcur*	Does anyone currently receive a child support grant, foster care grant or care dependency grant for this child?	Yes	1		
		No	2		F5
		Don't Know	-9		F5
		Refused	-8		F5
F2 *grcurtyp*	What type of grant is this?	Child support grant	1		
		Foster care grant	2		
		Care dependency grant	3		
		Don't Know	-9		
		Refused	-8		
F3	Who is the person that is receiving the grant for this child? **Interviewer: If person not in household, record 77. Select from drop down list** **If Don't Know write "-9"** **If Refused write "-8"**	**F3.1** Name *grcureqpid*			
		F3.2 Relationship to child *grurecrel*		Confirm if relationship code =04/ 05 / 06 / 07 / 13 / 15 / 16 / 17/19/22	
F4 *grcur*	When was this grant first received? **If Don't Know write "-9"** **If Refused write "-8"**	Date	__ __/__ __ __ __ m m/ y y y y		G1
F5 *grpst*	Has anybody **ever** received a Child Support Grant (CSG) on behalf of this child in the past two years?	Yes	1		
		No	2		**F8**
		Don't Know	-9		**F8**
		Refused	-8		**F8**
F6 *grpststrt*	If yes, at which date was the grant first received? **If Don't Know write "-9"** **If Refused write "-8"**	Date	__ __/__ __ __ __ m m/ y y y y	valid range: date < date of wave 2 interview	
F7 *grpststp*	If no longer receiving the grant, when did it stop? **If Don't Know write "-9"** **If Refused write "-8"**	Date	__ __/__ __ __ __ m m/ y y y y	Valid range: date<date of wave 2 interview	G1
F8 *grapp*	Has anyone in this household ever applied for a child support grant on behalf of this child in the last two years? (i.e. since the last survey)	Yes	1		**F10**
		No	2		
		Don't Know	-9		G1
		Refused	-8		G1
F9 *grapperp*	If no, what was the main reason that no-one in this household has applied for a child support grant for this child?	Caregiver has not heard of CSG	01		G1
		Caregiver does not know how to apply for CSG	02		G1
		CSG applied for by someone in another household	03		G1
		Ineligible because the child is too old	04		G1
		Caregiver cannot apply as not the child's mother	05		G1
		Child is not eligible as receives a different grant (foster care/ care dependency)	06		G1
		Child is not eligible as caregiver income too high	07		G1
		Caregiver doesn't have the right documentation (e.g. birth certificate, ID)	08		G1
		Cost of application is too high	09		G1
		Application process is too complicated or too time consuming	10		G1
		In process of applying or getting relevant documentation	11		G1
		Haven't got round to it yet	12		G1
		Cannot be bothered	13		G1
		Other (specify)	14		G1
		Don't Know	-9		G1
		Refused	-8		G1

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Appendix 4: NIDS Household Questionnaire Excerpts

Section G1: Negative events

INTERVIEWER READ OUT: Households sometimes experience good and bad events. First we would like to ask you about any **bad events** your household may have experienced **IN THE LAST 24 MONTHS.**

Event	G1.1 Did a [..] occur in this household in the last 24 months?		G1.2 What month and year did the [..] happen?		G1.3 What was the decrease in income each month?	G1.4 What was the total cost associated with the [..]?
Interviewer: If No to G1.1, go to next.	**Yes**	**No**	**Month**	**Year**	**Rands**	**Rands**
01 - Death of non-resident family member that you depended on for financial assistance *negdthf*	1	2	*negdthfmn*	*negdthfyr*	*negdthfinc*	
02 - Death of a friend that you depended on for financial assistance *negdthfr*	1	2	*negdthfrmn*	*negdthfryr*	*negdthfrinc*	
03 - Death of another friend or relative *negdtho*	1	2	*negdthomn*	*negdthoyr*		*negdthocst*
04 - Serious illness or injury of a household member *negill*	1	2	*negillmn*	*negillyr*		*negillcst*
05 - Widespread death and/or disease of livestock *negstc*	1	2	*negstcmn*	*negstcyr*		*negstccst*
06 - Major crop failure *negcrp*	1	2	*negcrpmn*	*negcrpyr*		*negcrpcst*
07 - Reduction in hours of work of a person that you depended on for financial assistance *negwrk*	1	2	*negwrkmn*	*negwrkyr*	*negwrkinc*	
08 - Job loss of person that you depended on for financial assistance *negjob*	1	2	*negjobmn*	*negjobyr*	*negjobinc*	
09 - Cut-off or decrease of remittances to household *negrem*	1	2	*negremmn*	*negremyr*	*negreminc*	
10 - Cut-off or decrease in government grants *neggrn*	1	2	*neggrnmn*	*neggrnyr*	*neggrninc*	
11 - Theft, fire, or destruction of household property *negpro*	1	2	*negpromn*	*negproyr*		*negprocst*
12 - Any other negative event? Please specify: *nego*	1	2	*negomn*	*negoyr*	*negoinc*	*negocst*

INTERVIEWER READ OUT: Next, we want to ask you some questions about your households' standard of living.
Interviewer: Read out question first and then each response option.

		It was less than adequate for your house-hold's needs	It was just adequate for your house-hold's needs	It was more than adequate for your house-hold's needs	Not applicable
D32.1 *food*	Concerning your household's food consumption over the past month, which of the following is true?	1	2	3	
D32.2 *hou*	Concerning your household's housing, which of the following is true?	1	2	3	
D32.3 *clth*	Concerning your household's clothing, which of the following is true?	1	2	3	
D32.4 *hlth*	Concerning your household's health care cover, which of the following is true?	1	2	3	
D32.5 *sch*	Concerning the schooling of children in the household, which of the following is true?	1	2	3	-5

INTERVIEWER READ OUT: Next, we want to ask you some questions about your relationship with your neighbours and the social interactions that you have with those around you.
Interviewer: Read out question first and then each response option.

		Never happens	Very Rare	Not common	Fairly common	Very common	Don't know
D33.1 *nbhlp*	How common is it that neighbours help each other out?	1	2	3	4	5	-9
D33.2 *nbtog*	How common is it that neighbours do things together?	1	2	3	4	5	-9
D33.3 *nbagg*	How common is it that people in your neighbour-hood are aggressive?	1	2	3	4	5	-9
D33.4 *nbthf*	How common is burglary and theft in your neighbour-hood?	1	2	3	4	5	-9

Section E1: Food spending and consumption

INTERVIEWER READ OUT: Now we would like to ask questions about some specific food that may have been eaten in the **LAST 30 DAYS**. It should **not** include food that has been bought for resale or exchanged for commercial purposes.

E1.1 *fdtot*	What was the total food expenditure of this household in the last 30 days?	Amount	**R**
		Refuse	-8
		Don't know	-9

Interviewer:

- **Read out each item.**
- **First complete Question E1.2 completely. Then answer questions E1.3a to E1.3d. Then continue with the rest of the questions.**
- **For each of the items where the response to question E1.2 is a "yes", ask E1.4 to E1.8, unless the `skip' circumvents the question in its entirety.**
- **For E1.4 to E1.8, write '-8' for Refuse or '-9' for Don't know.**

		Computer: Provide options: -8 = refuse, -9 = don't know			**Skip if E1.3a is not= 1**	**Skip if E1.3b is not= 1**	**Skip if E1.3c is not= 1**	**Skip if E1.3d is not= 1**
		E1.2 Was [..] eaten by this household in the last 30 days?		**E1.4** How much was spent in rands on [..] in the last 30 days?	**E1.5** What was the value in rands of [..] received as *gifts* in the last 30 days?	**E1.6** What was the value in rands of [..] received as *payment* in the last 30 days?	**E1.7** What was the value in rands of [..] eaten from *own production* in the last 30 days?	**E1.8** What was the value in rands of [..] eaten from shop stock in the last 30 days?
Code	**Food Item**	**Yes**	**No**	**Rands**	**Rands**	**Rands**	**Rands**	
01	Mealie meal *fdmm*	1	2	*fdmmspn*	*fdmmgft*	*fdmmpay*	*fdmmprd*	*fdmmss*
02	Samp *fdspm*	1	2	*fdspmspn*	*fdspmgft*	*fdspmpay*	*fdspmprd*	*fdspmss*
03	Flour and bread *fdflr*	1	2	*fdflrspn*	*fdflrgft*	*fdflrpay*		*fdflrss*
04	Rice *fdrice*	1	2	*fdricespn*	*fdricegft*	*fdricepay*		*fdricess*
05	Pasta *fdpas*	1	2	*fdpasspn*	*fdpasgft*	*fdpaspay*		*fdpasss*
06	Biscuits, cakes, rusks *fdbis*	1	2	*fdbisspn*	*fdbisgft*	*fdbispay*		*fdbisss*
07	Red meat (beef, mutton, pork, etc) *fdrm*	1	2	*fdrmspn*	*fdrmgft*	*fdrmpay*	*fdrmprd*	*fdrmss*
08	Canned red meat *fdrmc*	1	2	*fdrmcspn*	*fdrmcgft*	*fdrmcpay*		*fdrmcss*
09	Chicken *fdchi*	1	2	*fdchispn*	*fdchigft*	*fdchipay*	*fdchiprd*	*fdchiss*
10	Fresh fish and shell fish *fdfsh*	1	2	*fdfshspn*	*fdfshgft*	*fdfshpay*	*fdfshprd*	*fdfshss*
11	Tinned fish *fdfshc*	1	2	*fdfshcspn*	*fdfshcgft*	*fdfshcpay*		*fdfshcss*
12	Dried peas, lentils, beans *fdvegd*	1	2	*fdvegdspn*	*fdvegdgft*	*fdvegdpay*	*fdvegdprd*	*fdvegdss*
13	Potatoes *fdpot*	1	2	*fdpotspn*	*fdpotgft*	*fdpotpay*	*fdpotprd*	*fdpotss*

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Section E1: Food spending and consumption (continued)

- **This is a continuation from the previous page.**
- **For E1.4 to E1.8, write '-8' for Refuse or '-9' for Don't know.**

		Computer: Provide options: -8 = refuse, -9 = don't know			**Skip if E1.3a is not= 1**	**Skip if E1.3b is not= 1**	**Skip if E1.3c is not= 1**	**Skip if E1.3d is not= 1**
		E1.2 Was [..] eaten by this household in the last 30 days?		**E1.4** How much was spent in rands on [..] in the last 30 days?	**E1.5** What was the value in rands of [..] received as *gifts* in the last 30 days?	**E1.6** What was the value in rands of [..] received as *payment* in the last 30 days?	**E1.7** What was the value in rands of [..] eaten from *own production* in the last 30 days?	**E1.8** What was the value in rands of [..] eaten from shop stock in the last 30 days?
Code	**Food Item**	**Yes**	**No**	**Rands**	**Rands**	**Rands**	**Rands**	
14	Other vegetables *fdvego*	1	2	*fdvegospn*	*fdvegogft*	*fdvegopay*	*fdvegoprd*	*fdvegoss*
15	Fruits and nuts *fdfru*	1	2	*fdfruspn*	*fdfrugft*	*fdfrupay*	*fdfruprd*	*fdfruss*
16	Oil for cooking *fdoil*	1	2	*fdoilspn*	*fdoilgft*	*fdoilpay*		*fdoilss*
17	Margarine, butter, ghee, other fats *fdmar*	1	2	*fdmarspn*	*fdmargft*	*fdmarpay*	*fdmarprd*	*fdmarss*
18	Peanut butter *fdpb*	1	2	*fdpbspn*	*fdpbgft*	*fdpbpay*	*fdpbprd*	*fdpbss*
19	Milk, cheese, yoghurts and dried milk *fdmlk*	1	2	*fdmlkspn*	*fdmlkgft*	*fdmlkpay*	*fdmlkprd*	*fdmlkss*
20	Eggs *fdegg*	1	2	*fdeggspn*	*fdegggft*	*fdeggpay*	*fdeggprd*	*fdeggss*
21	Sugar, jam, honey, chocolates and sweets *fdsug*	1	2	*fdsugspn*	*fdsuggft*	*fdsugpay*	*fdsugprd*	*fdsugss*
22	Soft drinks and juices *fdsd*	1	2	*fdsdspn*	*fdsdgft*	*fdsdpay*		*fdsdss*
23	Tinned fruit and vegetables *fdfrut*	1	2	*fdfrutspn*	*fdfrutgft*	*fdfrutpay*		*fdfrutss*
24	Breakfast cereal and porridge *fdcer*	1	2	*fdcerspn*	*fdcergft*	*fdcerpay*		*fdcerss*
25	Baby food and baby formula *fdbaby*	1	2	*fdbabyspn*	*fdbabygft*	*fdbabypay*		*fdbabyss*
26	Salt and spices *fdslt*	1	2	*fdsltspn*	*fdsltgft*	*fdsltpay*	*fdsltprd*	*fdsltss*
27	Soya products *fdsoy*	1	2	*fdsoyspn*	*fdsoygft*	*fdsoypay*		*fdsoyss*
28	Coffee and tea *fdcof*	1	2	*fdcofspn*	*fdcofgft*	*fdcofpay*	*fdcofprd*	*fdcofss*
29	Food hampers *fdhmp*	1	2	*fdhmpspn*	*fdhmpgft*	*fdhmppay*		*fdhmpss*
30	Readymade meals brought into the household *fdrdy*	1	2	*fdrdyspn*	*fdrdygft*	*fdrdypay*		*fdrdyss*
31	Meals prepared outside the home (incl. restaurants and take-aways) *fdout*	1	2	*fdoutspn*	*fdoutgft*	*fdoutpay*		*fdoutss*
32	Other food expenditure *fdo*	1	2	*fdospn*	*fdogft*	*fdopay*		*fdoss*

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Appendix 5: Ethics Clearance Certificate Momconnect Study

UNIVERSITEIT STELLENBOSCH UNIVERSITY

CONDITIONAL APPROVAL GRANTED
REC: Social, Behavioural and Education Research (SBER) - Initial Application Form

15 June 2020

Project number: REC-2020-14926

Project title: COVID-19 Rapid mobile survey of maternal and child health (CRAM-MATCH)

Dear Prof Ronelle Burger

Your REC: Social, Behavioural and Education Research (SBER) - Initial Application Form submitted on 12 June 2020 was reviewed by the REC: Humanities and approved with certain conditions.

This conditional approval means that the researcher may proceed with the envisaged research provided that they respond or adhere to the stipulations/conditions.

Ethics approval period:

Protocol approval date (Humanities)	Protocol expiration date (Humanities)
15 June 2020	14 June 2021

REC STIPULATIONS/CONDITIONS:

1. SCIENTIFIC VALIDITY/ METHODOLOGY/ RELEVANCE

The principal investigator (PI) should provide information in the research proposal about how the data will be analysed. [RESPONSE REQUIRED]

2. PROTECTION OF PARTICIPANTS PRIVACY AND CONFIDENTIALITY

In the online application, section 6.7, the PI states "*Any non-disclosure agreements will be electronically signed and stored.*" Kindly clarify the use of the non-disclosure agreements. This is not mentioned in the research proposal. The final signed copies of the NDA documents should please be sent to the REC. [ACTION REQUIRED]

3. INFORMED CONSENT AND ASSENT PROCESSES AND FORMS

3.1) The relevant contact numbers need to be added in the consent form. [ACTION REQUIRED]

3.2) Information about data management in the case a participant decides to withdraw from the study should be included in the electronic informed consent form (as per section 5.14.1 of the online application). [ACTION REQUIRED]

3.3) It is advised that the researchers include contact numbers for counselling/psychological support and perhaps other health support services offered during COVID-19 level 3 restrictions, for participants' information. Such a resource could be outlined more fully on a page at the end of the survey. [ACTION REQUIRED]

4. ADEQUATE MITIGATION OF RISK

4.1) Considering the sensitive nature of the questions which prompt participants to think about personal and challenging experiences, the REC advises that the researchers include contact numbers for counselling/psychological support and other health support services offered during COVID-19 level 3 restrictions, for participants' information. [ACTION REQUIRED]

5. OVERALL RISK LEVEL AND RISK /COST-BENEFIT ASSESSMENT [RESPONSE REQUIRED]

The REC is not in agreement with the applicant that the risk level of this project is low. Most of the questions are sensitive in nature prompting participants to think about personal and challenging aspects of their lives during COVID-19. For example, "*Has an*

adult/child in your household had to go to bed hungry in the last 7 days?" and "*Have you felt scared or panicky for no good reason?*" The REC advises that this study is medium risk. Participants are unlikely to benefit directly from the study, but results may well provide valuable information informing policy development and future interventions. Hence the risk/cost-benefit is considered acceptable. The PI should please respond to the comment about the provision of counselling and resource referral contact numbers.

The project risk classification should please be amended in section 10 of the online application.

6. ADDITIONAL COMMENTS

6.1) The participant gratuity amount (airtime voucher) differs across the research proposal, online application and electronic informed consent form, from R5; R10; R15. Kindly amend and make sure that this information is consistent throughout. [ACTION REQUIRED]

6.2) Online application section 6.1: The researchers should select that they will have access to personal opinions. This section should please be amended. [RESPONSE REQUIRED]

6.3) Online application section 9.1: "*This data gathering process will take place under extreme time constraints. Moreover, as there will be a need to adjust questions for subsequent waves, the instrument/questionnaire will undergo many changes, with inputs also from the government. Thus, it will be necessary to obtain ethical approval on short notice on a number of occasions. This will be dealt with as amendments to this application. It has been agreed that the ethical approval process will be expedited.*" The REC notes that amendments will be made as the project progresses.

HOW TO RESPOND:

Some of these stipulations/conditions may require your response. Where a response is required, you must respond to the REC within **three (3)** months of the date of this letter. Your conditional approval will lapse automatically should your response not be received by the REC within 3 months of the date of this letter.

For instructions on how to respond to these stipulations, please download the FAQ on how to edit your application and follow the steps carefully: HOW TO RESPOND TO REC FEEDBACK

Where revision to supporting documents is required, please ensure that you replace all outdated documents on your application form with the revised versions.

INVESTIGATOR RESPONSIBILITIES

Please take note of the General Investigator Responsibilities attached to this letter. You may commence with your research after complying fully with these guidelines.

If the researcher deviates in any way from the proposal approved by the REC: Humanities, the researcher must notify the REC of these changes.

Please use your SU project number (14926) on any documents or correspondence with the REC concerning your project.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

CONTINUATION OF PROJECTS AFTER REC APPROVAL PERIOD

Please note that a progress report should be submitted to the Research Ethics Committee: Humanities before the approval period has expired if a continuation of ethics approval is required. The Committee will then consider the continuation of the project for a further year (if necessary)

Included Documents:

Document Type	File Name	Date	Version
Informed Consent Form	Whatsapp Consent Numbers to be added	09/04/2020	Numbers to be added
Proof of permission	Praekelt CRAM - Yogan Pillay	09/04/2020	Permission
Proof of Ethics Clearance	Commerce_Ethics_Approval_Letter_Daniels_2020_04_017	17/04/2020	1
Research Protocol/Proposal	Access to maternal and child health CRAM 1 June	01/06/2020	1
Budget	Budget SMS survey Praekelt	01/06/2020	1
Data collection tool	Survey Questions CRAM revised 12 June draft	12/06/2020	1

Appendix 6: Momconnect Questionnaires

	Pre-birth mothers (A)		Post-birth mothers (B)
Consent.	Hi Mama, you have been chosen for a MomConnect study to understand how the Coronavirus affects health. If you answer the questions, you will get R10 airtime. It will not cost you anything. To join the study reply "JOIN". To leave the study at anytime, reply "STOP". For more information, reply "MORE"		Hi Mama, you have been chosen for a MomConnect study to understand how the Coronavirus affects health. If you answer the questions, you will get R10 airtime. It will not cost you anything. To join the study reply "JOIN". To leave the study at anytime, reply "STOP". For more information, reply "MORE"
	If they reply "JOIN" then proceed		If they reply "JOIN" then proceed
	A1		B1
	Thanks for joining! When did you last go to the clinic or hospital? 1-Before March 2-March 3-April 4-May 5-June 6-Don't want to answer		Thanks for joining! When did you last go to the clinic or hospital? 1-Before March 2-March 3-April 4-May 5-June 6-Don't want to answer
	If respondent answers "1-3" for A1, go to A2. If not, go to A3		If respondent answers"1-3" for B1, go to B2. If not, go to B3
	A2		B2
	Why didn't you go to the clinic recently? 1-Waiting time 2-Transport problems 3-Afraid of getting the Coronavirus 4-No need 5-Other 6-Don't want to answer		Why didn't you go to the clinic recently? 1-Waiting time 2-Transport problems 3-Afraid of getting the Coronavirus 4-No need 5-Other 6-Don't want to answer
	A3		B3
	During April, May and June, was there a child in your home who was sick or needed a vaccination? 1-Yes 2-No 3-Don't want to answer		During April, May and June, was there a child in your home who was sick or needed a vaccination? 1-Yes 2-No 3-Don't want to answer
	If respondent answers "Yes" to A3, then ask A4. If not ask A5		If respondent answers "Yes" to B3, then ask B4. If not, ask B6
	A4		B4
	Did the child see a nurse/doctor? 1-Yes 2-No 3-Don't want to answer		Did the child see a nurse/doctor? 1-Yes 2-No 3-Don't want to answer
	If respondent answers "No" to A4, then ask A5, if not ask A6		If respondent answers "No" to B4, then ask B5. If not ask B6
	A5		B5
	Why didn't the child see a nurse/doctor? 1-Afraid of getting the Coronavirus 2-No need 3-Waiting time 4-Transport problems 5-Other 6-Don't want to answer		Why didn't the child see a nurse/doctor? 1-Afraid of getting the Coronavirus 2-No need 3-Waiting time 4-Transport problems 5-Other 6-Don't want to answer
	A6		B6
	If you take ART, during May and June, have you run out of medication? 1-Yes 2-No 3-Don't need ART 4-Don't want to answer		If you take ART, during May and June, have you run out of medication? 1-Yes 2-No 3-Don't need ART 4-Don't want to answer
	If respondent answers "Yes" to A6, then ask A7, if not. If not ask A8		If the respondent answers "Yes" to B6, then ask B7. If not ask B8
	A7		B7
	Why did you run out of ART? 1-Afraid of getting the Coronavirus 2-No ART available 3-Waiting time 4-Transport problems 5-Don't want to answer		Why did you run out of ART? 1-Afraid of getting the Coronavirus 2-No ART available 3-Waiting time 4-Transport problems 5-Don't want to answer

MATCH Wave 2: to be adminsitered to the SAME mothers as Wave 1

Pre-birth mothers (A)	Post-birth mothers (B)
Hi Mama, thanks for completing the last survey on MomConnect, we'd like to ask you a few more questions. If you answer the questions, you will get another R10 airtime.	Hi Mama, thanks for completing the last survey on MomConnect, we'd like to ask you a few more questions. If you answer the questions, you will get another R10 airtime.
It will not cost you anything. To join the study reply "JOIN". To leave the study at anytime, reply "STOP". For more information, reply "MORE"	It will not cost you anything. To join the study reply "JOIN". To leave the study at anytime, reply "STOP". For more information, reply "MORE"
If they reply "JOIN" then proceed	If they reply "JOIN" then proceed
A1	**B1**
Did you use a pregnancy test to see if you were pregnant? 1-Yes 2- No 9- I don't want to answer	Yesterday did you breastfeed your baby? 1- Yes 2- No 9- Don't want to answer
If yes then ask...A2	**B2**
Where did you use the pregnancy test? 1- At home 2- At the clinic or hospital 3- Somewhere else 9 I don't want to answer	Yesterday did you feed your baby formula or porridge such as mealum? 1- Yes 2- No 9- Don't want to answer
If no then ask A3	**If Yes to B1 and No to B2 then ask B3:**
Why did you not use a pregnancy test? 1- I already knew I was pregnant 2- I couldn't afford one 3- It's difficult to get one 4- Other 8-Don't want to answer	In the last 7 days did you feed your baby... 1- ONLY breastmilk 2- ONLY baby formula/mealum 3- Breastmilk AND baby formula/mealum 8 Don't want to answer
A4	**B4**
Do you have any other children? 0- No, this is my first 1- Yes, 1 child 2- Yes, 2 children 3- Yes, 3 children 4- Yes, 4 or more children 8- Don't want to answer	Do you have any other children? 0- No only my baby 1- Yes, 1 child 2- Yes, 2 children 3- Yes, 3 children 4- Yes, 4 or more children 8- Don't want to answer
A5	**B5**
In the last 7 nights did YOU ever go to bed hungry? 1- Yes 2- No 3- Don't know 9- Don't want to answer	In the last 7 nights did YOU ever go to bed hungry? 1- Yes 2- No 3- Don't know 9- Don't want to answer
If Yes to A5 then ask A6	**If Yes to B5 then ask B6**
A6	**B6**
How many nights did YOU go to bed hungry? 0- Never 1- 1 2- 2 3- 3 4- 4 5- 5 6- 6 7- 7 8- Don't know 9- Don't want to answer	How many nights did YOU go to bed hungry? 0- Never 1- 1 2- 2 3- 3 4- 4 5- 5 6- 6 7- 7 8- Don't know 9- Don't want to answer

A7	B7
In the last 7 nights did A CHILD go to bed hungry in your household? 1- Yes 2- No 3- Don't know 8- No children 9- Don't want to answer	In the last 7 nights did A CHILD go to bed hungry in your household? 1- Yes 2- No 3- Don't know 8- No children 9- Don't want to answer
If YES to A7 the ask A8	**If YES to B7 the ask B8**
A8	**B8**
How many nights did the child go to bed hungry? 0- Never 1- 1 2- 2 3- 3 4- 4 5- 5 6- 6 7- 7 8- Don't know 9- Don't want to answer	How many nights did the child go to bed hungry? 0- Never 1- 1 2- 2 3- 3 4- 4 5- 5 6- 6 7- 7 8- Don't know 9- Don't want to answer
A9	**B9**
Have you eaten any meat in the last 30 days? 1-Yes 2-No I can't afford meat 3-No, I didn't want meat 5-Don't Know, 6- Don't want to answer	Have you eaten any meat in the last 30 days? 1-Yes 2-No I can't afford meat 3-No, I didn't want meat 5-Don't Know, 6- Don't want to answer
A10	**B10**
Since you found out you were pregnant how many times have you visited a clinic? 0- Never 1- 1 time 2- 2 times 3- 3 times 4- 4 times 5- 5 times 6- 6 or more 8- Don't know 9- Don't want to answer	Since your baby was born, have you ever taken your baby to the clinic? 1-Yes 2-No 8- Don't know 9- Don't want to answer
A11	**If YES to B10 then ask B11**
Do you think you are likely to get the coronavirus? 1- Yes 2-No 8-Don't know 9-Don't want to answer	How many times have you taken your baby to the clinic since they were born? 0- 0 1- 1 2- 2 3- 3 4- 4 5- 5 6- 6 or more times 8- Don't know 9- Don't want to answer
A12	**B12**
In June did you have any kind of job or sell things or earn any income, no matter how small? 1- Yes 2- No 9-Don't want to answer	When did your child last receive a vaccination/umjovo? 1-Before March 2-March 3-April 4-May 5-June 6-July 8-Don't know 9-Don't want to answer

A13	B13
What is your highest level of education? 1- Completed primary school 2- Some high school 3- I've passed matric 4- Tertiary qualification 9-Don't want to answer	What is your highest level of education? 1- Completed primary school 2- Some high school 3- I've passed matric 4- Tertiary qualification 9-Don't want to answer
A14 Open-ended question	**B14 Open-ended question**
This is the last question, what is the one thing you are MOST worried about at the moment? Please type your answer...	This is the last question, what is the one thing you are MOST worried about at the moment? Please type your answer...
END	END
Thank you! If you need help in these difficult times, contact Lifeline 0861 322 322 or National Mental Health Information Line at 0800 567 567.	Thank you! If you need help in these difficult times, contact Lifeline 0861 322 322 or National Mental Health Information Line at 0800 567 567.

Appendix 7: MCH Manuscript

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Household Food Insecurity and Demographic Factors, Low Birth Weight and Stunting in Early Childhood: Findings from a Longitudinal Study in South Africa

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Abstract

Background Low birthweight (LBW) as well as early childhood stunting are risk factors for increased childhood morbidity in low-and middle-income countries (LMIC). The Covid 19 pandemic has exacerbated food insecurity and unemployment globally, prompting concerns for maternal and child health.

Objectives We used data from the great recession of 2008 to examine the relationship between household food security and other risk factors with LBW and stunting using a longitudinal sample of South African women and their offspring.

Methods Food security indicators, alcohol use, blood pressure and other characteristics were examined in relation to LBW (≤2500 g), stunting (height for age ≤ 2SD) and severe stunting (height for age ≤ 3SD). Regression modelling with clustering at maternal ID level were employed to adjust for maternal characteristics and women who gave birth more than once during the reference period.

Results Birthweight data were available for 1173 children and height for age 1216 children. The prevalence of LBW was 14.7% while stunting and severe stunting was 17.8% and 14.5%. Child hunger in the household, maternal hypertension and alcohol use were associated with low birthweight. Food expenditure below the Stats SA poverty line and low dietary diversity was associated with stunting and severe stunting respectively. Maternal height and low birthweight were associated with both stunting and severe stunting.

Conclusions for Practice Interventions that can improve household food security and nutritional status during the periconceptional and antenatal period may reduce the prevalence of low birthweight and subsequent stunting in low- and middle-income countries.

Keywords Periconceptional nutritional status · Low birthweight · Stunting · Food insecurity · Dietary diversity · Food expenditure · LMIC

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Significance

What is Already Known on this Subject? Household food insecurity is associated with stunting in cross-sectional studies but less is known about the impact of periconceptional and antenatal food insecurity in relation to low birthweight.

What this Study adds? Utilizing longitudinal data, this study found that women who reported a child in the household going hungry were significantly more likely to deliver a low birthweight infant. Low food expenditure and low dietary diversity in the periconceptional period were also associated with stunting and severe stunting among children 5 years later. Interventions to improve periconceptional food security may reduce LBW and subsequent stunting.

Introduction

Pregnancy and the postpartum period are vulnerable times for women in both high and low and middle income (LMIC) countries. In LMIC many pregnant women live in poverty and may experience a number of stressors including intimate partner violence, economic hardship and food insecurity (Fisher et al., 2012; van Heyningen et al., 2016). The Covid 19 pandemic and the subsequent economic fallout has increased rates of food insecurity and unemployment globally but the long-term implications for maternal and child health are still unfolding. A recent study of pregnancy and birth outcomes in LMIC during the pandemic noted a decrease in antenatal care but no increase in low birthweight (Naqvi et al., 2022). Data from the great recession in 2008 may provide some insights into how social and economic shocks impact maternal and child health. Studies from Portugal and Spain both observed a significant increase in low birthweight during the years of the recession (Kana et al., 2017; Teran et al., 2018).

In the South African context, studies of two longitudinal cohorts have observed associations with LBW in mothers who smoke or drink alcohol as well as those with overweight or obese BMI (Budree et al., 2017; Jeena et al., 2020). An unpublished thesis study among pregnant women in an urban area of South Africa found no association with household food insecurity and low birthweight while another birth cohort study in South Africa found that food insecurity was associated with lower infant gestational age (Zar et al., 2019). In South Africa and other countries undergoing a nutrition transition, the association between food insecurity and birth outcomes is further complicated by high levels of maternal overweight and obesity, a separate risk factor for pregnancy and birth complications (Melchor et al., 2019).

These findings, albeit inconsistent, suggest that preconception and antenatal food insecurity may be related to adverse child health outcomes. A review of the literature suggests that there are few longitudinal data on preconception food insecurity and low birthweight in South Africa. This study aimed to fill the gap by examining the relationship between maternal demographic and antenatal characteristics including household food insecurity indicators during the periconceptional and antenatal period with birthweight and stunting in the first 5 years of life using data from a longitudinal population-based survey.

Methods

The South African National Income Dynamics Study (SA-NIDS) is a nationally representative government funded panel survey of over 28,000 individuals in 7300 households across South Africa. The study aims to track post-apartheid inequality and poverty over time. NIDS utilized a stratified two-stage cluster sample design to randomly select 400 of Statistics South Africa's 3000 primary sampling units (PSUs) for inclusion in the surveys (Leibbrandt et al., 2009).

The components of the secondary analysis on which this paper is based are described below:

Sample

The current paper utilized data from Wave 1 and 3 of NIDS. Maternal data were collected in wave 1 (2008) as subsequent waves of NIDS did not collect information on food security. The data from women who became pregnant between Wave 1 and 2 of the study were linked with the data of their children from Wave 3 conducted in 2012. Brief intervals between pregnancies and delivery are a risk factor for low birthweight so we chose to include women who gave birth more than once during the reference period (Bauserman et al., 2020; Blencowe et al., 2019) We linked data of 1208 women with 1391 children born between 2008 and 2011. During data collection, most women (78%) were periconceptional while 21% were in the antenatal stage. The mean time to birth from data collection in 2008 was 21 months (Fig. 1).

Inclusion and Exclusion Criteria

We limited our analysis to singleton births of women between 15 and 44 because younger adolescents and older mothers are both at increased risk of obstetric complications and LBW (Blencowe et al., 2019). Data on children were limited to those born between 2008 and 2011 to ensure proximity to the time of exposure. We excluded children who had already been born at the time of data collection in Wave 1 (2008) and multiple births. At the time of data

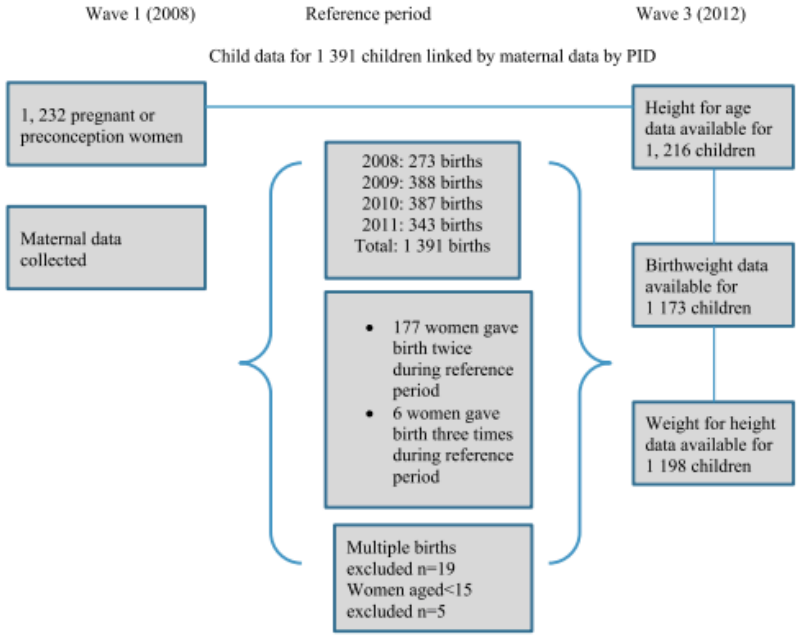

Fig. 1 Sample flowchart

collection in Wave 3, children were aged between 4 months and 55 months with a mean age of 30 months.

Ethical Statement

The SA-NIDS was approved by the Ethics Committee of the Commerce Faculty, University of Cape Town, and the de-identified datasets are publicly available. Ethics approval for this secondary analysis was obtained from the University of the Witwatersrand Research Ethics Committee (protocol number M1909101).

Measures

Food Insecurity

The definition of food security is evolving over time and the past 2 decades have seen a shift from indicators like anthropometry to more subjective measures of food security such as hunger (Coates et al., 2013). Although this study did not include a validated measure of food security, it did examine several household level indicators that literature suggests exist on a spectrum of food security. We will hereinafter refer to these as food security indicators for brevity. The five indicators are: adult and child hunger in the household, household food sufficiency, dietary diversity and monthly per capita food expenditure below the Stats SA food poverty line of R274. In 2021, this inflation adjusted amount was equivalent to R 624 or roughly 43.3 USD.

Hunger and Nutrition Indicators

Adult and Child Hunger

Questions on household hunger were asked separately for adults and children. In the past 12 month did an adult/child in the household go hungry? Responses were never, seldom, sometimes, often or always.

Household Food Sufficiency

In the past 12 months please describe the household food consumption in relation to household's needs. It was less than adequate, it was just adequate, it was more than adequate.

Dietary Diversity

A household dietary diversity score (HDDS) based on 30-day recall was calculated using the Food and Agriculture Organization (FAO) guidelines (Kennedy & Ballard, 2010). The HDDS is comprised of 32 individual food types and 12 different food groups. We used a mean split to classify households as having low dietary diversity (score < 9) or high dietary diversity (score > 8). We examined dietary

diversity as both a continuous variable and binary variable (Kennedy & Ballard, 2010).

Food Expenditure

Per capita food expenditure was calculated by dividing total household monthly food expenditure by the number of household members. Income and expenditure data were imputed by the NIDS team. We used the Statistics South Africa food poverty line cut off of R 274 per capita for 2008 (equivalent to 42.16 USD using Stats SA most recent food poverty line for 2021).

Covariates for the Birthweight Model

In addition to the primary exposures of food security indicators, we included maternal demographic factors associated with LBW in the literature. These included maternal age, parity, maternal height, BMI categories, years of education, alcohol and tobacco use, depression status, employment and blood pressure (Blencowe et al., 2019). At the household level we included geotype.

Alcohol Use

Respondents were asked how often they consumed alcohol. Due to the low number of responses among women who reported drinking alcohol in any quantity, we created a binary indicator by combining women who reported that they never drank or no longer drink into a single category that we classified as not consuming alcohol. Women who reported drinking in any quantity were classified as consuming alcohol, regardless of their pregnancy status.

Tobacco Use

Respondents were asked if they smoked cigarettes and we used this binary indicator to classify women as smokers or non-smokers, regardless of their pregnancy status.

Depression

Depressive symptoms were measured using the CES-D (Center for Epidemiologic Studies Depression Scale). We used a cut-off of 12 to define depression in this sample (Baron et al., 2017).

Employment

Women were categorized as employed or unemployed. Women who were classified as not economically active or seeking employment were also classified as unemployed.

Education

Maternal education was examined as a continuous variable with each unit representing 1 year of education. Maternal education in this sample ranged between 9 and 18 years with a mean of 9.86 years.

Covariates for the Stunting Model

In addition to the food security indicators we examined maternal height, years of education, low birthweight, household size, geotype, child's age in months, child's sex and whether child received a child support grant (CSG). This is a government funded monthly disbursement of R 480 ZAR (equivalent to 28.8 USD in 2022) to the primary caregivers of children and is intended to purchase food, school supplies and other essentials.

Primary Outcomes

The primary outcome is a binary measure of LBW ($\leq$ 2500 g). We included births that were recorded as 2500 g because although birthweight data are normally distributed, heaping birthweight measurement at 2500 g is common practice in the public sector in LMIC to avoid the need for further interventions among LBW infants. In addition, this rounding of birthweight data also occurs due to digit bias for numbers that end in 0 or 5 (Blencowe et al., 2019; Gladstone et al., 2021). The secondary outcome is childhood stunting (height for age $\leq$2SD) and severe stunting (height for age $\leq$3SD) in the first 5 years of life calculated using the WHO child growth standards (WHO, 2008).

Statistical Analyses

Several steps were undertaken to complete the analyses. These accounted for both individual and household level data. Logistic regression modelling was used to examine the relationship between low birthweight or stunting and maternal risk actors. The standard errors in the logistic regression models were estimated using the clustered robust method to account for the clustering due to multiple births. Initial bivariate analyses were conducted to explore covariates associated with LBW, stunting and severe stunting. All variables in the bivariate analyses were added to the model and the variables that were no longer significant were removed from the final model. Time to birth from the time of data collection was adjusted for in the final birthweight model. We conducted separate analyses among women who gave birth more than once during the reference period to examine if pregnancy spacing was associated with low birthweight but we found no relationship and all women were thus included in the final model.

We used logistic regression for the final LBW model and multivariable regression for the final stunting model in children aged 4–55 months. All analyses were conducted using Stata (version 15).

Results

Sample Characteristics

We linked the data from 1208 mothers with the data from their children (N = 1391) who were born between Wave 1 and 2 (2008–2011). Of this sample, 84.5% (1173) children had birthweight data, 87.4% (1216) had height for age data and 86.1% (1198) had weight for height data. Both birthweight and height for age scores were available for 71.7% (998) children. Maternal characteristics are presented in Table 1.

Most women in the sample were of Black African ethnicity and resided in urban areas. The multiple social and economic vulnerabilities of our sample are visible in the high proportion of adolescents (30%) and unemployment (73.5%) among these women. In addition, most respondents were unmarried (74.1%) and did not live with a partner. Almost half of respondents were overweight or obese (47.4%) and 59.5% had previously given birth.

Table 2 presents the various food security indicators for households with birthweight data. Among these, the most reported food security indicator was per capita food expenditure below the Stats SA poverty with 81.2% of households falling into this category. Mean food expenditure was R215 per capita, considerably below the poverty line. The next most common indicator was insufficient household food

Table 1 Maternal and child socio-demographic characteristics of the sample with birthweight data

Maternal variable (wave 1)	Categories	Overall % (n)
Race* (N = 1016)	Black	82.2 (835)
	Mixed race	15.3 (156)
	Indian and White	1.5 (25)
Age Intervals (N = 1016)	15–19	30 (302)
	20–29	46.2 (470)
	30–39	22.2 (225)
	40+	1.7 (17)
Geotype (N = 1016)	Traditional*	42.3 (430)
	Urban	49.7 (505)
	Farm	8 (81)
Employment Status (N = 948)	Unemployed/not economically active	73.5 (697)
	Employed	26.5 (251)
Marital Status (N = 962)	Married/living with partner	24.6 (236)
	Divorced or widowed	1.2 (13)
	Never married	74.1 (713)
Maternal BMI (N = 1016)	Underweight	9.5 (96)
	Normal	43.2 (439)
	Overweight	27.1 (275)
	Obese	20.3 (206)
Ever given birth (N = 965)	Yes	59.5 (574)
	No	40.5 (391)
Depressed (N = 1016)	Yes	16.1 (164)
	No	83.9 (852)
Child Variable (wave 3)		
Gender (N = 1173)	Male	47.3 (618)
	Female	52.7 (618)
Child grant recipient (N = 1213)	Yes	77.3 (907)
	No	22.7 (266)

*We use these categories developed by the South African Apartheid System. Our intention is not to reinforce the differences between races but rather awareness that there are disparities in health reflected by race

Traditional geotype denotes communally-owned land under the jurisdiction of traditional leaders. Settlements within these areas are villages

Table 2 Food security indicators for the sample with birthweight data

Indicator	% (n)
Child hunger in the past year	
Never	68.7 (745)
Seldom	8.6 (93)
Sometimes	18.6 (202)
Often	3.6 (39)
Always	0.5 (5)
Adult hunger in the past year	% (n)
Never	65.6 (767)
Seldom	8.4 (98)
Sometimes	21.5 (251)
Often	4.1 (48)
Always	0.4 (5)
Household food adequacy	% (n)
Less than adequate	44 (513)
It was just adequate	43 (501)
It was more than adequate	13 (152)
Food expenditure	% (n)
Below poverty line	81.2 (953)
Above poverty line	18.8 (220)
Dietary diversity	Mean, SD
Continuous score 1–12	9.1 (2.2)
	% (n)
Low dietary diversity < 9	35.7 (418)

adequacy in the past 12 months which was reported in 44% of households. The mean dietary diversity score was 9.1 with a standard deviation of 2.2 and 35.7% of households had low dietary diversity (a score of less than 9).

Table 3 presents the anthropometric characteristics of children measured in Wave 3. Height-for-age scores were available for 1216 children and weight-for-height scores were available for 1198 children. The prevalence of stunting and severe stunting was 17.8% and 14.4% respectively with 216 children classified as stunted (height for age score < −2 SD) and 176 as severely stunted (height for age score < − 3 SD). A total of 18.4% of children classified as overweight or obese (weight for height Z score > 2 SD) while 6% of children were wasted (weight for height Z score < −2 SD). The most severe growth restriction as well as the highest proportion of overweight and obesity occurred in the 4–24-month age range and subsequently declined. Among children in the 4–24-month category, 15.1% were stunted and 24.7% were severely stunted. More than a quarter (26%) of children in this age group were also overweight or obese (Table 3).

Birthweight information was available for 1173 children. Mean birthweight was 3102 g with a SD of 531 g. The prevalence of LBW in the sample was 14.7% (a total of 172 babies). In bivariate analyses, overweight BMI, maternal hypertension, child hunger in the household and tobacco use were significantly associated with low birthweight. Variables that remained significant in the final multivariate regression model were households that reported a child 'sometimes' going hungry, stage 1 maternal blood pressure, and women who reported drinking alcohol in any quantity (Table 4).

Bivariate Analyses

In bivariate analyses, food expenditure below the poverty line doubled the risk of stunting (RRR = 1.97) while low dietary diversity increased the risk of severe stunting (RRR 1.87) (Table 5). Male children were more likely to be severely stunted than female children although there were no gender differences among stunted children. Somewhat surprisingly, child hunger in the household was not associated with stunting. Low birthweight was associated with stunting but not severe stunting. Children who received a child support grant were significantly more likely to be

Table 3 Child anthropometry by age category

Indicator	Child age category			
	4–24 months % (n)	25–48 months % (n)	49–55 months % (n)	Total % (n)
Height for age				
Normal height	60.2 (231)	71.6 (537)	68.3 (56)	67.8 (824)
Stunted	15.1 (58)	19.2 (144)	17.1 (14)	17.8 (216)
Severely stunted	24.7 (95)	9.2 (69)	14.6 (12)	14.4 (176)
Total	100 (384)	100 (750)	100 (82)	100 (1216)
Weight for height				
Normal weight	66.9 (263)	79.5 (582)	83.6 (61)	75.6 (906)
Wasted or severely wasted	7.1 (28)	5.5 (40)	5.5 (4)	6 (72)
Overweight or obese	26 (102)	15 (110)	10.9 (8)	18.4 (220)
Total	100 (393)	100 (732)	100 (73)	100 (1198)

Table 4 Unadjusted and adjusted measures of the effect of maternal characteristics on low birthweight logistic regression model

Bivariate regression model	% (n)	Unadjusted OR, Confidence Intervals	p value
Overweight BMI	27.1 (275)	0.52 (0.29–0.90)	0.021
Stage 1 maternal blood pressure	18.1 (252)	1.60 (1.06–2.40)	0.025
Child hunger in household	18.8 (243)	1.59 (1.06–2.38)	0.029
Adult hunger in household	21.5 (251)	1.29 (0.87–1.91)	0.199
Household food less than adequate	44 (513)	1.50 (0.85–2.65)	0.162
Smokes tobacco	7.6 (84)	1.76 (1.03–2.98)	0.042
Drinks alcohol	10.8 (143)	1.57 (0.96–2.56)	0.070
Rural Geotype	42.3 (430)	1.00 (0.71–1.41)	0.995
Depressed mother	16.1 (164)	0.89 (0.56–1.42)	0.628
Employed mother	25.7 (336)	0.95 (0.64–1.39)	0.775
Maternal age	NA	1.02 (0.99–1.04)	0.228
Maternal education in years	NA	0.99 (0.93–1.05)	0.740
Maternal height	NA	0.99 (0.97–1.01)	0.295
Parity	NA	0.98 (0.86–1.10)	0.687
Multivariate regression model	% (n)	Adjusted OR, Confidence Intervals	p Value
Drinks alcohol	10.8 (143)	1.78 (1.08–2.94)	0.023
Stage 1 maternal blood pressure	18.1 (252)	1.61 (1.02–2.51)	0.038
Child hunger in household	18.8 (243)	1.53 (1.01–2.35)	0.049

Table 5 Unadjusted bivariate analyses of the effect of independent variables on stunting and severe stunting in children aged 4–55 months with relative risk ratios

Stunting	Unadjusted relative risk ratio, Confidence Intervals	p Value
Food poverty line (R274)	1.97 (1.24–3.11)	0.004
Dietary diversity score (continuous)	0.97 (0.91–1.04)	0.362
Low dietary diversity (score < 9)	1.07 (0.77–1.47)	0.647
Child hunger in household	1.09 (0.73–1.62)	0.814
Maternal height in cm	0.94 (0.92–0.96)	0.000
Maternal education	0.97 (0.92–1.02)	0.277
Male child	1.21 (0.90–1.62)	0.217
Receives child grant	1.67 (1.11–2.50)	0.013
Low birthweight	1.85 (1.21–2.84)	0.005
Childs age in months	0.94 (0.92–0.96)	0.000
Maternal education	0.97 (0.92–1.02)	0.277
Household size	1.02 (0.97–1.06)	0.469
Severe stunting	Unadjusted relative risk ratio, Confidence Intervals	p Value
Food poverty line (R274)	1.73 (1.06–2.81)	0.028
Dietary diversity score (continuous)	0.90 (0.84–0.97)	0.003
Low dietary diversity (score < 9)	1.87 (1.30–2.55)	P < 0.000
Child hunger in household	1.19 (0.76–1.85)	0.445
Maternal height in cm	0.96 (0.93–0.99)	0.009
Maternal education	0.93 (0.87–0.98)	0.013
Male child	1.54 (1.11–2.12)	0.009
Receives child grant	1.13 (0.76–1.68)	0.534
Low birthweight	1.52 (0.94–2.44)	0.085
Childs age in months	0.97 (0.96–0.98)	0.000
Maternal education	0.93 (0.87–0.98)	0.013
Household size	1.00 (0.96–1.06)	0.862

stunted than children who received no grant. This suggests that the children in this sample who do receive a grant are more disadvantaged and experience a generally deficient growth environment (Table 5).

Multivariate Regression Model

Variables associated with stunting and severe stunting were combined in a final multivariable regression model (Table 6). In the final model, maternal height and low birthweight were the only variables associated with both stunting and severe stunting with increased maternal height offering a protective effect. The food security indicators that remained significant in the final model were household food expenditure below the poverty line which increased the risk of stunting and low household dietary diversity which increased the risk of severe stunting. Boys were more likely to be severely stunted than girls and the risk of severe stunting decreased with each month of children's age.

Discussion

This study has revealed important findings about household food insecurity during the preconception and antenatal periods and its association with child health outcomes in the first 5 years of life. We found that women who reported a child in the household sometimes going hungry were significantly more likely to give birth to a low birthweight infant during the reference period. Furthermore, LBW was a significant risk factor for stunting as children aged. These findings highlight the importance of adequate maternal nutrition during the first 1000 days to mitigate the prevalence of low birthweight and subsequent stunting in LMIC.

The prevalence of LBW in the sample was 14.7% and is closely aligned with recent cohort studies of birthweight in South Africa (Budree et al., 2017; Jeena et al., 2020). We found that child hunger in the household was significantly associated with low birthweight but adult hunger was not. Food insecurity is a managed process and longitudinal data suggests that adults will often forego meals themselves to shield their children from hunger (Radimer et al., 1992). Thus, women that reported children going hungry may represent the most disadvantaged and nutritionally deprived households. We also found that the prevalence of low birthweight in this sample was highest during the recession in 2008 (16.4%) and subsequently declined each year to 12.9% by 2011. These differences were not statistically significant, but this may be due to the relatively low sample size. Given that an increase in low birthweight was observed in high income countries it seems plausible that South Africa would also have experienced an increase in LBW as a result of the recession (Kana et al., 2017; Teran et al., 2018).

Although maternal alcohol use was not significantly associated with LBW in bivariate analysis ($p = 0.07$), once it was added to the final model and we adjusted for the time lag between data collection and birth, women who reported drinking alcohol in any quantity were significantly more likely to deliver a low birthweight infant. In this study, 10.8% of women reported drinking alcohol, a result that is comparable to a cohort study in the Western Cape that observed antenatal alcohol use among 18% of women (Budree et al., 2017). Although our study included both periconceptional and pregnant women, South Africa has one of the highest rates of Fetal Alcohol Syndrome (FAS) globally which suggests that alcohol use continues into the antenatal period for some women. Food insecurity may also increase the risk of drinking among women who face multiple social

Table 6 Multivariate models of adjusted measures of the effect of independent variables on stunting and severe stunting in children aged 4–55 months with relative risk ratios

	Adjusted relative risk ratio, Confidence Intervals multinomial regression model	p value
Stunting		
Low dietary diversity	0.74 (0.50–1.11)	0.145
Food poverty line (R274)	2.31 (1.27–4.22)	0.006
Low birthweight	1.71 (1.05–2.78)	0.030
Maternal height	0.95 (0.92–0.97)	p < 0.000
Childs age in months	1.00 (0.99–1.02)	0.762
Male child	1.17 (0.81–1.68)	0.398
Severe stunting		
Low dietary diversity	1.57 (1.05–2.34)	0.027
Food poverty line (R274)	1.21 (0.69–2.12)	0.498
Low birthweight	1.76 (1.06–2.93)	0.028
Maternal height	0.96 (0.94–0.99)	0.008
Childs age in months	0.97 (0.96–0.99)	0.002
Male child	1.57 (1.08–2.29)	0.018

and economic adversities. A study among urban mothers in South Africa found that food insecurity was strongly associated with postnatal depression as well as hazardous drinking. These findings reinforce the importance of food security for psychological well-being as well being a potential risk factor for hazardous drinking, thereby compounding the risk of low birthweight (Dewing et al., 2013).

Our final model also found that maternal hypertension was significantly associated with LBW, an association that has been observed in a systematic review (Getaneh et al., 2020). Hypertension has been linked to food security, obesity and increased BMI as well as poor quality diets, higher salt intake and chronic stress (Cois & Ehrlich, 2014). Thus, hypertension may lie on the causal pathway between food insecurity and low birthweight.

Our study found a similar stunting prevalence to other South African cohorts that examined linear growth in children age 24–60 months and noted prevalence estimates between 26% and 34% (Budree et al., 2017; Casale et al., 2018). The link between LBW and stunting has been well described in previous literature with an analysis of cohort data from LMIC estimating 2.5–3.5 higher odds of stunting among LBW infants (Christian et al., 2013). In our final multivariable stunting model we found that LBW increased the risk of stunting (RRR 1.71) and severe stunting (RRR 1.76). These findings suggest that some aspects of childhood undernutrition and subsequent linear growth have origins in the foetal period and highlight the importance of maternal nutrition both preconceptionally and antenatally (Black et al., 2008; Blencowe et al., 2019; Christian et al., 2013). Increased maternal height also offered a protective effect against stunting and severe stunting in the final model. This is well documented as stunting is a recurrent process and mothers who were themselves stunted are more likely to have stunted offspring (de Onis & Branca, 2016).

Food expenditure below the poverty line was associated with stunting in the final mode. Such data are a useful proxy for food security although these results are less precise than some other measures of food insecurity (Coates et al., 2013). In the final model, low dietary diversity was associated with severe stunting. This has emerged as a risk factor for stunting in studies from LMIC is often associated with child anthropometry across geographical regions (Headey & Ecker, 2013). Somewhat surprisingly, child and adult hunger were not associated with stunting in this sample. This is of as interest as most large surveys currently employ access and hunger-based measures to measure food security at the national scale.

Although food security is not static and subject to change, the use of longitudinal data is one of the strengths of this study and these findings indicate that chronic household food insecurity during the periconceptional and antenatal period likely extends into the early years of childhood and is associated with both low birthweight and restricted linear growth. These findings are reinforced by a study in Bangladesh with a 5 year recall period which found that household food security tended to be relatively stable and preconception food insecurity continued into the antenatal period (Chowdhury et al., 2018). Maternal malnutrition (both underweight and obesity) is associated with adverse child growth outcomes including low birthweight, macrosomia, fetal growth as well as child HAZ at 2 years of age (Melchor et al., 2019; Young et al., 2018).

We also found that the prevalence of severe stunting decreased as children grew older, this is not surprising as previous studies suggest that stunting tends to peak around 24 months and subsequently decrease (Prendergast & Humphrey, 2014). In addition, boys were more likely to be severely stunted than girls. This finding has been observed in a a systematic review of sex related differences in undernutrition (Thurstans et al., 2020). The reasons for this may be both social as well as biological. Girls may spend more time at home and have more regular access to food than boys and boys may be weaned earlier than girls (Thurstans et al., 2020). Biologically, boy infants are also more susceptible to infections and birth complications in early childhood which can predispose them to stunting as they age (Sawyer, 2012).

The emphasis on child growth and development in the first thousand days is based not only on the magnitude of growth restriction that occurs in this time period but on the adverse consequences throughout the life course including reduced cognitive function and an increased risk of chronic disease in adulthood (de Onis & Branca, 2016). In this sample, 25% of children aged 24 months and under were severely stunted and many will never reach their full growth potential as a result (Casale et al., 2020). Thus, interventions that improve periconceptional maternal nutritional status are particularly important in settings where stunting is prevalent. A multi country preconceptional maternal nutritional trial found that the provision of nutritional supplements pre conception and in the early stages of gestation significantly improved infant growth outcomes in the first six months of life (Krebs et al., 2020).

Limitations

Data on gestational age were not available and pretermbirth (a leading cause of LBW) could not be included in our analyses (Blencowe et al., 2019; Christian et al., 2013). In the absence of a validated measure for food insecurity this study examined the relationship between various food security indicators and child health outcomes. These indicators were collected at the household level and the questionnaire was answered by oldest woman in the

household. This is standard for household level surveys and given that data was not collected at the individual level we don't feel that this would have introduced substantial bias.

Conclusion

Reducing the high prevalence of low birthweight and stunting in South Africa and other LMIC is an enormous challenge given the multiple social and biological determinants of health inequity. However, interventions that can improve household food insecurity and maternal nutritional status in the periconceptional period may reduce the prevalence of low birthweight and subsequent stunting (Krebs et al., 2020; Lassi et al., 2020). Improving maternal nutritional status in the first 1000 days is an important first step to mitigate the intergenerational transfer of poor health and developmental outcomes.

Author Contribution AH conceptualized the study, conducted the analysis and drafted the manuscript. AR assisted with conceptualizing the study, advised on analysis and interpreted the results. WS assisted with merging panel data across waves and advised on analysis. EC assisted with analysis and imputation for BMI results. SM assisted with conceptualizing the study, interpreted the analysis and co-authored the manuscript. All authors read and approved the final manuscript.

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Data Availability Deidentified data from the South African National Income Dynamics Study (NIDS) can be accessed via the NIDS website (http://www.nids.uct.ac.za/). Alternatively, data that contains confidential information can be accessed via an application process with Datafirst at the University of Cape (www.datafirst.uct.ac.za).

Code Availability NA.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval The SA-NIDS was approved by the Ethics Committee of the Commerce Faculty, University of Cape Town, and the de-identified datasets are publicly available. Ethics approval for this secondary analysis was obtained from the University of the Witwatersrand Research Ethics Committee (Protocol No: M1909101).

Consent to Participate This was a secondary analysis of de-identified publicly available data.

Consent for Publication NA.

References

Baron, E. C., Davies, T., & Lund, C. (2017). Validation of the 10-item centre for epidemiological studies depression scale (CES-D-10) in Zulu, Xhosa and Afrikaans populations in South Africa. *BMC Psychiatry, 17*(1), 1–14. https://doi.org/10.1186/s12888-016-1178-x

Bauserman, M., Nowak, K., Nolen, T. L., Patterson, J., Lokangaka, A., Tshefu, A., & Bose, C. (2020). The relationship between birth intervals and adverse maternal and neonatal outcomes in six low and lower-middle income countries. *Reproductive Health, 17*(Suppl 2), 1–10. https://doi.org/10.1186/s12978-020-01008-4

Black, R. E., Allen, L. H., Bhutta, Z. A., Caulfield, L. E., de Onis, M., Ezzati, M., & Rivera, J. (2008). Maternal and child undernutrition: Global and regional exposures and health consequences. *The Lancet, 371*(9608), 243–260. https://doi.org/10.1016/S0140-6736(07)61690-0

Blencowe, H., Krasevec, J., de Onis, M., Black, R. E., An, X., Stevens, G. A., & Cousens, S. (2019). National, regional, and worldwide estimates of low birthweight in 2015, with trends from 2000: A systematic analysis. *The Lancet Global Health, 7*(7), e849–e860. https://doi.org/10.1016/S2214-109X(18)30565-5

Budree, S., Stein, D. J., Brittain, K., Goddard, E., Koen, N., Barnett, W., & Zar, H. J. (2017). Maternal and infant factors had a significant impact on birthweight and longitudinal growth in a South African birth cohort. *Acta Paediatrica International Journal of Paediatrics, 106*(11), 1793–1801. https://doi.org/10.1111/apa.14015

Casale, D., Desmond, C., & Richter, L. M. (2020). Catch-up growth in height and cognitive function: Why definitions matter. *Economics and Human Biology*. https://doi.org/10.1016/j.ehb.2020.100853

Casale, D., Espi, G., & Norris, S. A. (2018). Estimating the pathways through which maternal education affects stunting: Evidence from an urban cohort in South Africa. *Public Health Nutrition, 21*(10), 1810–1818. https://doi.org/10.1017/S1368980018000125

Chowdhury, M., Dibley, M. J., Alam, A., Huda, T. M., & Raynes-Greenow, C. (2018). Household food security and birth size of infants: Analysis of the Bangladesh demographic and health survey 2011. *Current Developments in Nutrition, 2*(3), 1–8. https://doi.org/10.1093/cdn/nzy003

Christian, P., Lee, S. E., Angel, M. D., Adair, L. S., Arifeen, S. E., Ashorn, P., & Black, R. E. (2013). Risk of childhood undernutrition related to small-for-gestational age and preterm birth in low- and middle-income countries. *International Journal of Epidemiology, 42*(5), 1340–1355. https://doi.org/10.1093/ije/dyt109

Coates, J., Frongillo, E. A., Rogers, B. L., Webb, P., Wilde, P. E., Houser, R., et al. (2013). What are we assessing when we measure food security? A compendium and review of current metrics.

Advance in Nutrition, *4*, 481–505. https://doi.org/10.3945/an.113.004119

Cois, A., & Ehrlich, R. (2014). Analysing the socioeconomic determinants of hypertension in South Africa: A structural equation modelling approach. *BMC Public Health*. https://doi.org/10.1186/1471-2458-14-414

de Onis, M., & Branca, F. (2016). Childhood stunting: A global perspective. *Maternal and Child Nutrition*, *12*, 12–26. https://doi.org/10.1111/mcn.12231

Dewing, S., Tomlinson, M., Le Roux, I. M., Chopra, M., & Tsai, A. C. (2013). Food insecurity and its association with co-occurring postnatal depression, hazardous drinking, and suicidality among women in peri-urban South Africa. *Journal of Affective Disorders*, *150*(2), 460–465. https://doi.org/10.1016/j.jad.2013.04.040

Fisher, J., de Mello, M. C., Patel, V., Rahman, A., Tran, T., Holton, S., & Holmesf, W. (2012). Prevalence and determinants of common perinatal mental disorders in women in low-and lower-middle-income countries: A systematic review. *Bulletin of the World Health Organization*, *90*(2), 139–149. https://doi.org/10.2471/BLT.11.091850

Getaneh, T., Negesse, A., Dessie, G., & Desta, M. (2020). The impact of pregnancy induced hypertension on low birth weight in Ethiopia: systematic review and meta-analysis. *Italian Journal of Pediatrics*, *46*(1), 1–11. https://doi.org/10.1186/s13052-020-00926-0

Gladstone, M. E., Salim, N., Ogillo, K., Shamba, D., Gore-Langton, G. R., Day, L. T., & Lawn, J. E. (2021). Birthweight measurement processes and perceived value: qualitative research in one EN-BIRTH study hospital in Tanzania. *BMC Pregnancy and Childbirth*, *21*(Suppl 1), 1–11. https://doi.org/10.1186/s12884-020-03356-2

Headey, D., & Ecker, O. (2013). Rethinking the measurement of food security: From first principles to best practice. *Food Security*, *5*(3), 327–343. https://doi.org/10.1007/s12571-013-0253-0

Jeena, P. M., Asharam, K., Mitku, A. A., Naidoo, P., & Naidoo, R. N. (2020). Maternal demographic and antenatal factors, low birth weight and preterm birth: findings from the mother and child in the environment (MACE) birth cohort, Durban, South Africa. *BMC Pregnancy and Childbirth*, *20*(1), 1–11. https://doi.org/10.1186/s12884-020-03328-6

Kana, M. A., Correia, S., Peleteiro, B., Severo, M., & Barros, H. (2017). Impact of the global fi nancial crisis on low birth weight in Portugal: a time-trend analysis. *BMJ Global Health*. https://doi.org/10.1136/bmjgh-2016-000147

Kennedy, G., & Ballard, T. (2010). M. D. *Guidelines for measuring household and individual dietary diversity. FAO*

Krebs, N. F., Hambidge, K. M., Westcott, J. L., Garc, A. L., Figueroa, L., Tsefu, A. K., & First, W. (2020). Growth from birth through six months for infants of mothers in the "women first" preconception maternal nutrition trial. *The Journal of Pediatrics*. https://doi.org/10.1016/j.jpeds.2020.09.032

Lassi, Z. S., Kedzior, S. G. E., Tariq, W., Jadoon, Y., & Das, J. K. (2020). Effects of preconception care and periconception birth outcomes in low- and middle-income countries: A systematic review. *Nutrients, 12*, 606.

Leibbrandt, M., Woolard, I., & De Villiers, L. (2009). *Methodology: Report on NIDS Wave 1*

Melchor, I., Burgos, J., Campo, A., Aiartzaguena, A., Gutiérrez, J., & Melchor, J. C. (2019). Effect of maternal obesity on pregnancy outcomes in women delivering singleton babies: a historical cohort study. *Journal of Perinatal Medicine , 47*(6), 625–630.

Naqvi, S., Naqvi, F., Saleem, S., Thorsten, V. R., Figueroa, L., Mazariegos, M., & Tshefu, A. (2022). Health care in pregnancy during the COVID- 19 pandemic and pregnancy outcomes in six low- and- income countries: Evidence from a prospective observational registry of the Global Network for Women's and Children's, & Health. *BJOG: An International Journal of Obstetrics & Gynaecology, 2019*(March), 1298–1307. https://doi.org/10.1111/1471-0528.17175

Prendergast, A. J., & Humphrey, J. H. (2014). The stunting syndrome in developing countries. *Paediatrics and International Child Health*, *34*(4), 250–265. https://doi.org/10.1179/2046905514Y.0000000158

Radimer, K. L., Olson, C. M., Greene, J. C., Campbell, C. C., & Habicht, J. P. (1992). Understanding hunger and developing indicators to assess it in women and children. *Journal of Nutrition Education, 24*(1, Supplement 1), 36S-44S. https://doi.org/10.1016/S0022-3182(12)80137-3

Sawyer, C. C. (2012). Child mortality estimation: Estimating sex differences in childhood mortality since the 1970s. *PLoS Medicine*. https://doi.org/10.1371/journal.pmed.1001287

Teran, J. M., Varea, C., Juarez, S., Bernis, C., & Bogin, B. (2018). Social disparities in low birth weight among Spanish mothers during the economic crisis (2007–2015). *Nutrición Hospitalaria*. https://doi.org/10.20960/nh.2095

Thurstans, S., Opondo, C., Seal, A., Wells, J., Khara, T., Dolan, C., & Kerac, M. (2020). Boys are more likely to be undernourished than girls: A systematic review and meta-analysis of sex differences in undernutrition. *BMJ Global Health*, *5*(12), 1–17. https://doi.org/10.1136/bmjgh-2020-004030

van Heyningen, T., Myer, L., Onah, M., Tomlinson, M., Field, S., Honikman, S., & Honikman, S. (2016). Antenatal depression and adversity in urban South Africa. *Journal of Affective Disorders*, *203*, 121–129. https://doi.org/10.1016/j.jad.2016.05.052

WHO. (2008). *WHO Child Growth Standards, Vol. 7*. World Health Organization.

Young, M. F., Nguyen, P. H., Casanova, I. G., Addo, O. Y., Tran, L. M., Nguyen, S., & Ramakrishnan, U. (2018). Role of maternal preconception nutrition on offspring growth and risk of stunting across the first 1000 days in Vietnam. A prospective cohort study. *PLos One*. https://doi.org/10.1371/journal.pone.0203201

Zar, H. J., Pellowski, J. A., Cohen, S., Barnett, W., Vanker, A., Koen, N., & Stein, D. J. (2019). Maternal health and birth outcomes in a South African birth cohort study. *Plos One*, *14*(11), 1–16. https://doi.org/10.1371/journal.pone.0222399

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Dietary diversity, food insecurity and the double burden of malnutrition among children, adolescents and adults in South Africa: Findings from a national survey

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Childhood stunting remains a global public health problem. Many stunted children live in the same household as overweight or obese adults (the so-called double burden of malnutrition), evidence that quality as well as quantity of food is important. In recent years, food security measurement has shifted away from anthropometry (e.g., stunting) to experiential measures (e.g., self-reported hunger). However, given the continued problem of stunting, it is important that national surveys identify malnutrition.

Objectives: To examine the associations between a variety of food security indicators, including dietary diversity, with adult, child (0–4 years) (5–9 years) and adolescent (10–17 years) anthropometry. To estimate the prevalence of double burden households.

Methods: The study utilized cross-sectional data from the South African National Income Dynamics Survey NIDS (2008). We examined the associations between five food security indicators and anthropometry outcomes. The indicators were adult and child hunger in the household, self-reported household food sufficiency, food expenditure>60% of monthly expenditure and household dietary diversity. Multinomial and logistic regression models were employed to examine the associations with adult BMI categories and children's stunting and BMI.

Results: The prevalence of stunting was 18.4% and the prevalence of wasting and overweight was 6.8 and 10.4%, respectively. Children <5 and adolescents with medium dietary diversity were significantly more likely to be stunted than children with high dietary diversity. Among children <5, child hunger and medium dietary diversity were significantly associated with wasting. None of the food security indicators were associated with stunting in children aged 5–9. Among stunted children, 70.2% lived with an overweight or obese adult. Among adults, increased dietary diversity increased the risk of overweight and obesity.

Conclusion: Dietary diversity can be used as a proxy for poor nutritional status among children <5 years and adolescents but the relationship between dietary diversity and adult obesity is more complex. Given the double burden of malnutrition in many low- and middle-income countries, indicators of dietary quality remain important. These tools can be further refined to include an extra category for processed foods. Given the relative simplicity to collect this data, national surveys would be improved by its inclusion.

KEYWORDS

dietary diversity, food security measurement, experiential indicators, stunting, obesity, national surveys, double burden of malnutrition, food expenditure

Introduction

Stunting in children remains an urgent public health problem in low- and middle-income countries (LMIC). Research suggests that stunting is consistently associated with poorer cognitive function, schooling outcomes and reduced earning potential (1–3). However, stunting is a multifaceted problem associated with a variety of factors including chronic malnutrition, infectious diseases in early childhood and adverse birth and pregnancy outcomes like low birthweight and intrauterine growth restriction (3–6).

In many LMIC, there is an obesity epidemic occurring alongside high rates of stunting. This is primarily driven by fundamental changes in the food system including the ease and availability of cheap processed foods, reduced physical activity and the high cost of healthy varied diets (7, 8). Childhood stunting and adult overweight and obesity often occur in the same household, the so called double burden of malnutrition (DBM) (3, 7, 9–12).

In recent years, food security measurement has shifted away from the measurement of anthropometry to self-reported experiential measures. These measures, focused on individual perceptions of hunger and anxiety around access to food (13, 14), are premised on the concept that hunger and food insecurity are universal experiences that exist along a spectrum of severity (15). However, such measures do not capture the nutritional quality of food consumed. One indicator that has potential as an effective proxy for malnutrition are dietary diversity indicators. These have been found to be an effective indicator for overall dietary quality in some studies and are often associated with child anthropometry outcomes (16, 17).

A systematic review of household food insecurity and dietary diversity in relation to stunting in Sub-Saharan Africa (SSA) noted that two thirds of the included studies found that household food insecurity and low dietary diversity were linked to stunting (6). Another systematic review that examined dietary diversity and undernutrition across 32 demographic and health surveys in SSA found that children with adequate dietary diversity had a 12% lower likelihood of being stunted than those with inadequate dietary diversity (18). A study from Nigeria found that children's age, maternal age, and food expenditure were among the significant determinants of children's dietary diversity (19). Although the prevalence of food insecurity, low dietary diversity and stunting are subject to geographical variations, the linkages between them are often observed across regions. These findings suggest that both food insecurity and low dietary diversity are common in Sub-Saharan Africa and have adverse implications for growth and development, particularly among young children.

In South Africa, an estimated 27% of children under 5 years are stunted as a result of chronic malnutrition and a generally deficient growth environment (2, 3). The prevalence of stunting has remained virtually unchanged in the past two decades, despite a decrease in reported hunger in national statistics and one of the largest social protection systems in the world (2, 20, 21). National surveys in South Africa currently rely primarily on experiential measures of food security that measure hunger, skipping meals and running out of money to purchase food (the most severe forms of food insecurity). However, such measures may miss households that don't necessarily experience hunger but where child growth is faltering due to poor quality diets.

The findings from two recent national surveys suggest that food insecurity remains a serious problem in South Africa. Results from the 2017 general household survey (GHS) noted that about 13.4 million households had inadequate or severely inadequate access to food and about 1,6 million households experienced hunger (22). The NIDS coronavirus rapid mobile survey found that a lack of money to buy food remained high in 2020, due to the protracted nature of the COVID-19 pandemic and the subsequent economic and social impact (23, 24).

In this paper we estimate the prevalence of malnutrition among children, adolescents and adults and describe the proportion of double burden of malnutrition (DBM) households. Then, we examine whether different food security indicators are associated with adult BMI categories (normal weight, underweight, overweight or obese) and

child height (normal height or stunted/severely stunted) and child BMI (normal weight, wasted/severely wasted and overweight/obese) and whether dietary diversity is an effective proxy for nutritional status.

Methods

The national income dynamics study

The South African National Income Dynamics Study (SA-NIDS) is a nationally representative panel survey of over 28,000 individuals in 7,300 households across South Africa. A stratified, two-stage cluster sample design was used in sampling the households to be included in the first wave (2008). In the first stage, 400 primary sampling units (PSUs) were selected from Stats SA's 2003 master sample of 3000 PSUs. This master sample was the sample used by Stats SA for its Labor Force Surveys and General Household Surveys between 2004 and 2007. The surveys were conducted on non-overlapping samples drawn within each PSU to ensure that households did not have to participate in both surveys (25). NIDS is a government funded survey to track inequality over time and examines several exposures (e.g., social capital, labor market participation, household composition and structure) in relation to poverty and inequality. Data on health outcomes, fertility and mortality were also collected. The survey is conducted by the Southern Africa Labor and Development Research Unit based at the University of Cape Town. Food security indicators were dropped in subsequent waves of the NIDS study and in this paper, we therefore use data from the baseline wave, conducted in 2008.

Food security indicators

Household hunger

Data on adult and child hunger were collected separately using the following question: In the past year did an adult/child go hungry? never, seldom, sometimes, often, always. These are questions from the Household Food Insecurity Access Scale (HFIAS). We created a binary hunger indicator for adult and child hunger with households that reported never or seldom experiencing hunger scoring a 0 and households that reported sometimes, often or always experiencing hunger scoring a 1, using the same methodology as Statistics South Africa (26).

Food sufficiency

Respondents were also asked a question about household food consumption in relation to the household's needs in the past 12 months. Respondents reported if food consumption was less than adequate, just adequate or more than adequate for household needs. The data was converted into a binary indicator, with households who reported more than adequate or just adequate scored a 0 and households that reported less than adequate scored a 1.

Dietary diversity

We calculated household dietary diversity score (HDDS) from the NIDS data using the Food and Agriculture Organization (FAO) guidelines (27). The HDDS is comprised of 32 individual food types and 12 different food groups with a minimum score of 1 and a maximum score of 12. The 12 food groups are; (i) cereals and grain produces (ii) starchy roots and tubers (iii) Legumes (iv) vegetables (v) Fruits and nuts (vi) Sugars (vii) Meat and poultry (viii) Eggs (ix) Fish and shellfish (x) Milk and dairy products (xi) Oils and fats (xii) Miscellaneous (including beverages). Dietary diversity scores (DDS) was summed up by counting each of the 12-food groups, and classified as low ($\leq$4), medium (5–8) and high (9–12) with high dietary diversity being the reference standard. There is no gold standard for dietary diversity cut-offs and we used these cut-offs based on a recent study that examined stunting and dietary diversity in South Africa (28). We also included dietary diversity as a continuous variable (ascending order from 1 to 12).

Food expenditure

Food expenditure was calculated by dividing the amount spent on food each month by total household expenditure. A cut-off of total monthly expenditure above 60% was used to define a household as food insecure, as recommended by the FAO (29, 30).

Child and adult anthropometry

Child anthropometry for children up to the age of 5 years was classified according to the WHO child growth standards, weight for height, BMI for age, and height-for-age (HAZ) scores. A HAZ score of −2SD of the mean is classified as stunted and a HAZ score of −3SD is classified as severely stunted. Child wasting and overweight/obesity was also classified according to the WHO growth standards with BMI for age below −2SD classified as wasted and BMI above 2SD classified as overweight (31). For children older than 5 years the WHO growth standards for school aged children and adolescents were used as a reference in the calculation of z-scores for height for age, BMI for age (32). Due to the low proportion of children who were severely stunted, we grouped stunted and severely stunted children together in the regression model. We also grouped wasted and severely wasted children together, and overweight and obese children together for the multinomial model. Child anthropometry data were calculated by the NIDS team (25). Children were grouped according to the following age categories: <5 years, 5–9 years

TABLE 1 Prevalence of household food insecurity by each item.

Indicator (*n* households)	Percentage who reported food insecurity% (*n*) (95% CI)
High dietary diversity (9–12)	65.2 (4 724) (64–66%)
Medium dietary diversity (5–8)	30.7 (2 219) (30–32%)
Low dietary diversity (1–4)	4.1 (297) (3–4%)
Food expenditure	17.3 (7 291) (16–18%)
Adult hunger	23 (7 266) (22–24%)
Child hunger	14.5 (5 359) (13%−15%)
Food Insufficiency	38.1 (7 291) (37–39%)

and 10–17 years. People aged 18 and older were classified as adults and their BMI measurements were categorized according to the WHO growth standards and considered underweight (BMI<18.5), normal weight, (BMI 18.5–24.9) overweight (BMI 25–29.9) and obese (BMI >29.9) with normal weight used as the reference standard (33).

Data analysis

Logistic and multinomial regression models were used to examine child stunting and BMI status in relation to food security indicators. The explanatory variables were dietary diversity both as a continuous score and as a categorical indicator, food expenditure >60% of total monthly expenditure, child hunger in the past year and household food sufficiency in the past year. For the stunting model, the response variable was children's stunting status (normal height or stunted/severely stunted). For children's BMI the response variables were normal weight, wasted or overweight/obese. We examined each explanatory variable individually for both the stunting and BMI models (Tables 4, 5). Analyses were clustered at the household level on the assumption that children in the same household had similar access to food.

Multinomial regression models were used to examine adult BMI (underweight, normal weight, overweight and obese) in relation to food security indicators. The explanatory variables for both models were identical to the child variables except for hunger. The adult model used adult hunger as an explanatory variable in place of child hunger. For adult BMI, the response variable was adult BMI status. These results are presented in Table 6.

Food security indicators and outcome categories were generated from datasets with imputation values created by the NIDS data team (25). All analyses were conducted using Stata 15.1 (Stata Corporation, College Station, TX).

TABLE 2 Prevalence of childhood stunting by age category.

Category	>5 years % (*n*)	5–9 yrs % (*n*)	10–17 yrs % (*n*)	Total % (*n*)
Normal height	73.8 (1 526)	86.5 (2 156)	82.1 (3 457)	81.3 (7 139)
Stunted/severely stunted	28.2 (543)	13.5 (338)	17.9 (757)	18.7 (1 638)
Total	100 (2 069)	100 (2 494)	100 (4 214)	100 (8 777)

Results

Insufficient food over the past 12 months was the most frequently reported food insecurity indicator (38.1%) followed by medium household dietary diversity scores (30.7 %). Low dietary diversity scores were the least common indicator (4.1%) followed by child hunger in the past 12 months (14.9%). These findings are presented in Table 1.

Height for age scores were available for 8 777 children across 3 831 household clusters. Children of normal height ($n = 7\,139$) were the reference category. A total of 18.66% of children ($n = 1\,638$) were classified as stunted as seen in Table 2. Children aged <5 years had the highest proportion of stunting (28.2%) followed by adolescents (17.9%). Children in the 5–9-year age category had the lowest prevalence of stunting (13.5%). These findings are presented in Table 2.

BMI scores were available for 7 385 children across 3 559 household clusters. Children of normal weight ($n = 6118$) were the reference category. A total of 6.8% of children were classified as wasted or severely wasted ($n = 500$) and 10.4% of children were classified as overweight or obese ($n = 767$). The prevalence of wasting was highest among adolescents (7.7%) while the prevalence of overweight and obesity was highest among children aged <5 years (17.5%). These findings are presented in Table 3.

For the full sample, each unit increase of dietary diversity offered a protective effect against stunting and reduced the risk of stunting by 5%. Children and adolescents children with medium dietary diversity were significantly more likely to be stunted than children with high dietary diversity (OR 1.35). When we stratified the children by age group, medium dietary diversity was significantly associated with stunting for children aged <5 years and adolescents. Low dietary diversity scores were associated with stunting among adolescents but not among other age groups. However, the prevalence of low dietary diversity was only 3.9% in this sample which likely contributed to the null finding. Medium dietary diversity and food expenditure >60% of monthly expenditure were associated with stunting among the adolescent group. None of the experiential indicators (child hunger and household food insufficiency) were associated with stunting for any age group in the sample. These findings are presented in Table 4.

Medium dietary diversity and child hunger was associated with wasting in children <5. Child hunger represents the most severe form of food insecurity and households that reported

TABLE 3 Prevalence of childhood wasting and overweight by age category.

Category	<5 years % (*n*)	5–9 yrs % (*n*)	10–17 yrs % (*n*)	Total) % (*n*)
Normal weight	77.2 (1 373)	85.7 (1 756)	84 (2 989)	82.8 (6 118)
Wasted/severely wasted	5.3 (95)	6.5 (133)	7.7 (272)	6.8 (500)
Overweight/obese	17.5 (311)	7.8 (160)	8.3 (296)	10.4 (767)
Total	100 (1 779)	100 (2 049)	100 (3 557)	100 (7 385)

TABLE 4 Logistic regression model of food security in relation to childhood stunting.

Indicators	Odds ratio of being stunted (*p*-Value) Bivariate regressions			
	<5 years *n* = 2,069	5–9 years *n* = 2,494	10–17 years *n* = 42,14	Full sample *n* = 8,777
Dietary diversity (continuous)	0.97 (0.195)	0.96 (0.153)	**0.91 (*P* < 0.000)**	**0.94 (*P* < 0.000)**
Medium dietary diversity (5–8)	**1.27 (0.028)**	1.12 (0.386)	**1.53 (*P* < 0.000)**	**1.35 (*P* < 0.000)**
Low dietary diversity 1–4	0.86 (0.628)	0.87 (0.667)	**1.88 (0.002)**	1.29 (0.115)
Food expenditure (>0.6)	1.26 (0.056)	1.09 (0.576)	**1.24 (*P* < 0.000)**	**1.24 (*P* < 0.000)**
Child hunger	0.97 (0.774)	0.99 (0.926)	0.97 (0.713)	0.97 (0.642)
Food insufficiency	1.08 (0.453)	0.89 (0.380)	1.14 (0.100)	1.07 (0.276)

Bold values indicate to highlight statistically significant results.

TABLE 5 Multinomial regression model of food security in relation to childhood wasting and overweight.

Indicators	<5 years *n* =1,779	5–9 years *n* = 2,049	10–19 years *n* = 3,557	Full sample *n* = 7 385
Relative risk ratio of being wasted or severely wasted (*n* = 500)				
Dietary diversity (continuous)	0.93 (0.145)	0.96 (0.387)	**0.93 (0.017)**	**0.94 (0.008)**
Medium dietary diversity (5–8)	**1.76 (0.014)**	0.88 (0.541)	1.23 (0.160)	1.22 (0.086)
Low dietary diversity (1–4)	2.28 (0.071)	1.05 (0.802)	1.37 (0.389)	**1.88 (0.011)**
Food expenditure>0.6	1.51 (0.087)	0.81 (0.387)	0.81 (0.244)	0.92 (0.594)
Child hunger	**2.0 (0.003)**	1.11 (0.651)	0.97 (0.842)	1.17 (0.216)
Food insufficiency	1.0 (0.984)	1.16 (0.444)	0.95 (0.690)	1.01 (0.945)
Relative risk ratio of being overweight or obese (n =767)				
Dietary diversity (continuous)	0.98 (0.496)	1.06 (0.147)	1.05 (0.088)	1.03 (0.143)
Medium dietary diversity (5–8)	0.96 (0.782)	0.83(0.329)	0.87 (0.330)	0.89 (0.183)
Low dietary diversity (1–4)	1.35 (0.352)	0.84 (0.335)	0.93 (0.841)	1.04 (0.883)
Food expenditure>0.6	1.21 (0.189)	0.89 (0.607)	0.75 (0.098)	0.98 (0.841)
Child hunger	0.87 (0.392)	**0.50 (0.005)**	**0.56 (0.002)**	**0.66 (*P* < 0.000)**
Food insufficiency	0.92 (0.541)	**0.63 (0.011)**	**0.62 (0.001)**	**0.74 (*P* < 0.000)**

Bold values indicate to highlight statistically significant results.

children going hungry in the past year likely represent the most poor and deprived households. Each unit increase of dietary diversity decreased the risk of wasting in adolescents. Child hunger and food insufficiency decreased the risk of obesity among children in the 5–9-year age group and adolescents. These findings are presented in Table 5.

Anthropometry measurements were available for 12 199 adults aged 18 and above across 6 483 household clusters. The prevalence of underweight, overweight and obesity was 7.6, 23.4 and 26.3%, (respectively). Adult hunger and household food insufficiency were the indicators most strongly associated with an increased risk of underweight (RR 1.25 and 1.34).

TABLE 6 Multinomial regression model of food security in relation to adult anthropometry.

Indicators	Relative risk ratios (95% CI) Bivariate regressions	*p*-Value
Relative risk ratio of being underweight ($n = 927$)		
Dietary diversity (continuous)	0.98 (0.96–1.01)	0.214
Medium dietary diversity (5–8)	1.09	0.321
Low dietary diversity (1–4)	0.94 (0.89–1.17)	0.730
Food expenditure>0.6	0.99 (0.85–1.19)	0.942
Adult hunger	**1.25 (1.10–1.45)**	**0.007**
Food insufficiency	**1.34 (1.10–1.43)**	***P* < 0.000**
Relative risk ratio of being overweight ($n = 2,857$)		
Dietary diversity (continuous)	**1.05 (1.03–1.07)**	**P<0.000**
Medium dietary diversity (5–8)	**0.86**	**0.003**
Low dietary diversity (1–4)	**0.70 (0.76–0.92)**	**0.004**
Food expenditure>0.6	0.90 (0.81–1.01)	0.087
Adult hunger	**0.67 (0.61–0.75)**	***P* < 0.000**
Food insufficiency	**0.81 (0.74–0.90)**	***P* < 0.000**
Relative risk ratio of being obese ($n = 3,219$)		
Dietary diversity (continuous)	**1.11 (1.07–1.14)**	***P* < 0.000**
Medium dietary diversity (5–8)	**0.69**	***P* < 0.000**
Low dietary diversity (1–4)	**0.57 (0.52–0.65)**	***P* < 0.000**
Food expenditure>0.6	**0.81 (0.71–0.91)**	**0.001**
Adult hunger	**0.71 (0.64–0.78)**	***P* < 0.000**
Food insufficiency	**0.90 (0.80–0.96)**	**0.022**

The reference category was adults of normal weight N = 5,229. Bold values indicate to highlight statistically significant results.

Other food security indicators followed a similar pattern with an increased risk for underweight among adults and a decreased risk for overweight and obesity. However, each unit increase of dietary diversity increased the risk of overweight and obesity, but a reduction in dietary diversity was not associated with being underweight. These findings are presented in Table 6.

There was a total of 3,720 households that had anthropometry measurements for both adults and children in the household and 850 (22.8%) of these households included stunted children as well as obese adults (Table 7). The DBM describes the coexistence of overnutrition (overweight and obesity) with undernutrition (stunting). In this sample, among households with stunted children, 70.2% of stunted children lived with overweight or obese adults. For ease of interpretation, we have grouped overweight and obese adults together as well as stunted and severely stunted children. When examining the double burden of malnutrition, households with one or more stunted child and one or more overweight or obese adults were classified as double burden households while households with stunted children and normal weight adults were classified as single burden households.

Discussion

Our results show that 18.43% of children are stunted, and that the double burden of malnutrition is evident in our sample with over 70% of stunted children living in the same household as an overweight or obese adult. Among children aged <5 years, children with medium dietary diversity are significantly more likely to be stunted than children with high dietary diversity. Among adolescents, medium dietary diversity, low dietary diversity and food expenditure are associated with stunting. Child hunger in the household and medium dietary diversity are significantly associated with wasting among children aged <5 years.

We did not find any of the food security indicators to be associated with stunting in children aged 5–9 years. There are several potential reasons for this. Children aged 5–9 had the lowest prevalence of stunting (13.5%) across age groups, with 28.2% of children <5 yrs and 18.6% of adolescents classified as stunted. The primary drivers of stunting among <5 yrs may be different (i.e., diarrhea and other infectious diseases or babies born small for gestational age) to those among older children. Moreover, stunting is a cumulative process and the

TABLE 7 Prevalence of the double burden of malnutrition by household.

Category	Normal/underweight BMI	Overweight/obese adult	Total
	% (*n*)		
Normal height child/ren	24% (602)	76% (1 908)	100 (2 510)
Stunted or severely stunted child/ren	29.8% (360)	**70.2% (850)**	100 (1 210)
Total	25.9% (962)	74.1 (2 758)	100 (3 720)

Bold values indicate to highlight statistically significant results.

consequence of chronic malnutrition and a deficient growth environment over time (3), hence the greater prevalence among adolescents. Thus, stunting in adolescence is a continuation from stunting in early childhood for most stunted adolescents. Adolescence is a critical period of development as 15–20% of total height is achieved during this phase. This may present the final opportunity to increase adult height but there is a lack of high-quality longitudinal evidence on whether catch up growth during adolescence is even possible (34). A South African cohort study found that found that <2% of children experienced late incident stunting between the ages of 2 and 5 (35). In other words, most of the linear growth deficit had already occurred by the age of 2 years. In addition, only a quarter of children who were stunted at age 2 experienced enough catch up growth to no longer be stunted by age 5 (35). Interventions to increase dietary diversity among vulnerable groups can still improve nutritional outcomes and wellbeing but this may not necessarily translate into a meaningful reduction in stunting (36).

Neither hunger nor food insufficiency were associated with stunting for any age group, highlighting the limitations of experiential indicators in relation to stunting. The South African General Household Survey (GHS) uses the Household Food Insecurity Access Scale (HFIAS), an experiential scale which classifies households into three separate categories of severity (food secure, moderately food insecure or severely food insecure) for monitoring food security at a population level (37, 38). The HFIAS was originally developed for food security surveys in the US population, where child stunting is very low and not considered a public health problem, unlike South Africa. Furthermore, responses to experiential scales like the HFIAS may vary dependent upon cultural and social contexts and this limits comparison of food insecurity prevalence across countries (16, 39). However, there is substantial evidence for the protective effect of household dietary diversity against childhood stunting and this has been observed in numerous studies from LMIC (6, 17, 40, 41). We found that medium dietary diversity was moderately associated with stunting among children <5 years and strongly associated with stunting among adolescents (OR 1.27 and 1.53). This suggests that children in the low to medium dietary diversity category are more likely to be malnourished and dietary diversity is an effective proxy for malnutrition.

While we did find that high proportion of food expenditure was associated with stunting among adolescents and reduced the risk of obesity among adults, expenditure data has several limitations as an indicator. These include that it is challenging to collect, and may be subject to recall bias and lacks generalizability across different regions and currency systems (16). However, food expenditure is associated with both children's linear growth and dietary diversity in a number of studies (19, 42). Furthermore, such data are routinely included in national surveys in many LMIC and so the association between longitudinal household food expenditure patterns, dietary diversity and children's linear growth could be the subject of more detailed research.

Although South Africa does not have public policies designed specifically to address childhood stunting, South Africa has an extensive Child Support Grant (CSG) program with over 12 million monthly disbursements to the caregivers of children aged 18 and under. The CSG is an unconditional cash transfer of R 400 (25 USD) per month to the primary caregiver. The CSG is intended to purchase food, school supplies and other essentials for low-income children. However, the CSG has not been effective in reducing the burden of stunting in South Africa. One potential reason for this is that the funds are insufficient to purchase even a basic food basket or that the funds are not used to purchase food (43, 44). However, some studies have found that when coupled with maternal education (grade 8 or higher) the CSG has a small but significant impact on increasing children's HAZ scores (45). These findings suggest that the CSG may be more effective over time if maternal education levels improve. A study from Mexico also found that maternal education mitigated the effects of child stunting and maternal overweight in a rural area (46).

However, the existing evidence suggests that even if they do experience catch up growth, children who were stunted at age 2 years perform almost as poorly in cognitive tests as children who remained stunted (35). This suggests that the first 2 years of life are critical for both linear growth and cognitive development and reinforces the need for interventions that can mitigate stunting in the first 1,000 days of life (35). Thus, improvements

in household dietary diversity may reduce stunting during this critical period of development. However, dietary diversity needs to be consistently measured at the population level if policymakers are to identify vulnerable groups and develop effective interventions.

The double burden of malnutrition (DBM) is particularly common in LMIC countries like South Africa that have undergone a nutrition transition characterized by rapid changes in the food system and the availability of cheap and highly processed foods (7, 47). Of the stunted children in this study, over 70% lived in households with overweight or obese adults (Table 7). Many stunted children may not experience hunger but will still be malnourished by a nutrient poor diet that consists primarily of starchy staples. This "hidden hunger" may also extend to many of their overweight or obese parents. The double burden of malnutrition is also visible among stunted children who are also overweight or obese. Although this study found that *low* dietary diversity was associated with stunting, we also found an inverse relationship with adult BMI whereby *increased* dietary diversity was associated with being overweight or obese. However, increased dietary diversity did not increase the risk of overweight/obesity among children or adolescents. As the direction of the associations go in opposite directions for stunting and obesity, further research is also needed to elucidate the relationship between dietary diversity and anthropometry across the full income range.

A longitudinal analysis of NIDS data that examined changes in BMI found that higher household income per capita was associated with a higher rate of change in weight gain (48). Thus, an improvement in living standards and economic progress is also a driver of the obesity epidemic in South Africa. Cultural preferences around different body types, sedentary lifestyles as well as a lack of knowledge and education around healthy foods and nutrition also play a role (49–52). Discerning to what extent rising obesity rates are driven by higher income and broader choices of food, or food insecurity coping strategies such as increased consumption of cheap processed foods requires rigorous longitudinal research (7, 47).

Limitations

While dietary diversity is a good proxy for dietary quality and micronutrient adequacy, it also has limitations, as most dietary diversity measures do not include a separate category for processed foods, an important risk factor for overweight and obesity (16, 17, 53). In addition, dietary diversity does not capture the quantities of the diverse foods consumed and there is a lack of formal cut-offs or theory that links a number of food groups consumed to nutrient adequacy or overall sufficient quantity of food (13). Currently, there is no gold standard dietary diversity measure and the most widely used scales vary from between 7 and 15 food different food groups (16).

Conclusion

Stunting is a cumulative process and interventions to mitigate stunting at the beginning of the life course may be most effective for long term growth and developmental outcomes. Accurate monitoring of food and nutritional security at a population level is essential if LMIC hope to improve nutritional outcomes, particularly among vulnerable children. However, measures that are focused on hunger fail to capture important dimensions of dietary quality. Given the time and budget constraints of conducting large surveys, household dietary diversity data are relatively simple to collect and national surveys would be improved by their inclusion in addition to existing measures of food security.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: http://www.nids.uct.ac.za/nids-data/data-access.

Ethics statement

The studies involving human participants were reviewed and approved by the University of Cape Town (UCT) Commerce Faculty Ethics Committee. Approval for this secondary analysis of the NIDS data was approved by the Humanities Research Ethics Committee at the University of the Witwatersrand Research Ethics Committee (protocol number M1909101). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

AH, SM, and AR were involved in conceptualizing the study design. AH performed the analyses while EC provided statistical oversight. WS assisted with data management and merging datasets across waves. AH, JG, and SM contributed to writing the article. All authors read and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

1. Dewey KG, Begum K. Long-term consequences of stunting in early life. *Matern Child Nutr.* (2011) 7(Suppl. 3):5–18. doi: 10.1111/j.1740-8709.2011.00349.x

2. May J, Witten C, Lake L. *South African Child Gauge 2020*. Cape Town: Children's Institute, University of Cape Town (2020).

3. Leroy JL, Frongillo EA. Perspective: what does stunting really mean? A critical review of the evidence. *Adv Nutr.* (2019) 10:196–204. doi: 10.1093/advances/nmy101

4. Mosites E, Dawson-Hahn E, Walson J, Rowhani-Rahbar A, Neuhouser ML. Piecing together the stunting puzzle: a framework for attributable factors of child stunting. *Paediatr Int Child Health.* (2017) 37:158–65. doi: 10.1080/20469047.2016.1230952

5. Prendergast AJ, Humphrey JH. The stunting syndrome in developing countries. *Paediatr Int Child Health.* (2014) 34:250–65. doi: 10.1179/2046905514Y.0000000158

6. Gassara G, Chen J. Household food insecurity, dietary diversity, and stunting in sub-saharan africa: a systematic review. *Nutrients.* (2021) 13:4401. doi: 10.3390/nu13124401

7. Popkin BM, Corvalan C, Grummer-Strawn LM. Dynamics of the double burden of malnutrition and the changing nutrition reality. *Lancet.* (2020) 395:65–74. doi: 10.1016/S0140-6736(19)32497-3

8. FAO, IFAD, UNICEF, WFP, WHO. *The State of Food Security and Nutrition in the World 2021. Transforming Food Systems for Food Security, Improved Nutrition and Affordable Healthy Diets for All*. Rome: FAO (2021). doi: 10.4060/cb4474en

9. Pourmotabbed A, Moradi S, Babaei A, Ghavami A, Mohammadi H, Jalili C, et al. Food insecurity and mental health: a systematic review and meta-analysis. *Public Health Nutr.* (2020) 23:1778–90. doi: 10.1017/S136898001900435X

10. Leung CW, Epel ES, Willett WC, Rimm EB, Laraia BA. Household food insecurity is positively associated with depression among low-income supplemental nutrition assistance program participants and income-eligible nonparticipants. *J Nutr.* (2015) 145:622–7. doi: 10.3945/jn.114.199414

11. Laraia B, Vinikoor-Imler LC, Siega-Riz AM. Food insecurity during pregnancy leads to stress, disordered eating, and greater postpartum weight among overweight women. *Obesity.* (2015) 23:1303–11. doi: 10.1002/oby.21075

12. FAO, IFAD, UNICEF, WFP, WHO. *The State of Food Security and Nutrition in the World 2019*. Safeguarding Against Economic Slowdowns and Downturns. Rome: FAO (2019).

13. Cafiero C, Melgar-Quiñonez HR, Ballard TJ, Kepple AW. Validity and reliability of food security measures. *Ann N Y Acad Sci.* (2014) 1331:230–48. doi: 10.1111/nyas.12594

14. Maxwell S. *Food Security: A Post-Modern Perspective*. Brighton: Institute of Development Studies, University of Sussex (1994). Available online at: https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/3787

15. Nord M. *Introduction to Item Response Theory applied to Food Security Measurement: Basic Concepts, Parameters, and Statistics. Technical Paper*. Rome: FAO (2014). Available online at: http://www.fao.org/economic/ess/ess-fs/voices/en

16. Headey D, Ecker O. Rethinking the measurement of food security: from first principles to best practice. *Food Secur.* (2013) 5:327–43. doi: 10.1007/s12571-013-0253-0

17. Steyn NP, Nel JH, Nantel G, Kennedy G, Labadarios D. Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy? *Public Health Nutr.* (2006) 9:644–50. doi: 10.1079/PHN2005912

18. Aboagye RG, Seidu A, Ahinkorah BO, Arthur-holmes F, Cadri A, Dadzie LK, et al. Dietary diversity and undernutrition in children aged 6-23 months in Sub-Saharan Africa. *Nutrients.* (2021) 13:3431. doi: 10.3390/nu13103431

19. Otekunrin OA, Otekunrin OA, Ayinde IA, Sanusi RA, Onabanjo OO, Ariyo O. Dietary diversity, environment and health - related factors of under - five children : evidence from cassava commercialization households in rural. *Environ Sci Pollut Res.* (2022) 29:19432–46. doi: 10.1007/s11356-021-17221-y

20. Hunter W, Patel L, Sugiyama NB. How family and child cash transfers can empower women: comparative lessons from Brazil and South Africa. *Glob Soc Policy.* (2021) 21:258–77. doi: 10.1177/1468018120981421

21. Steyn NP, Nel JH, Drummond L, Malczyk S, Senekal M. Has food security and nutritional status improved in children 1–<10 years in two provinces of South Africa between 1999 (National Food Consumption Survey) and 2018 (provincial dietary intake study (PDIS)). *Int J Environ Res Public Health.* (2022) 19:1–21. doi: 10.3390/ijerph19031038

22. Stats SA. *Towards Measuring Food Security in South Africa: An Examination of Hunger and Food Inadequacy. Pretoria: Statistics South Africa, Private Bag X44, Pretoria 0001.* (2019). Available online at: www.statssa.gov.za (accessed April 16, 2022).

23. van der Berg S, Patel L, Bridgman G. *Hunger in South Africa: Results from Wave 4 of NIDS-CRAM Working Paper 11*. (2021). Available online at: https://cramsurvey.org/wp-content/uploads/2021/05/11.-Van-der-Berg-S.-Patel-L.-_-Bridgman-G.-2021-Hunger-in-South-Africa-Results-from-Wave-4-of-NIDS-CRAM.pdf

24. Spaull N, Tomlinson M. *Feeding a Family on $ 300 a Month*. Business Live (2020).

25. Leibbrandt M, Woolard I, De Villiers L. *Methodology: Report on NIDS Wave 1. Technical Paper No.1*. University of Cape Town (2009).

26. Lehohla P. Food security and agriculture 2002 – 2011: In-depth analysis of the general household survey data Vol. IV. *Pretoria, South AFrica: Statistics South Africa, Private Bag X44, Pretoria 0001.* (2012). Available online at: http://www.statssa.gov.za/Publications2/Report-03-18-03/Report-03-18-032011.pdf (accessed May 4, 2022).

27. Kennedy G, Ballard T. *Guidelines for Measuring Household and Individual Dietary Diversity*. Rome: FAO (2010). p. 1–60.

28. Modjadji P, Molokwane D. Dietary diversity and nutritional status of preschool children in North West Province, South Africa : a cross sectional study. *Children.* (2020) 7:174. doi: 10.3390/children7100174

29. Smith L, Subandoro A. *Measuring Food Security Using Household Expenditure Surveys. Food Security in Practice Technical Guide Series*. Washington, DC: International Food Policy Research Institute (2007).

30. Ryan J, Leibbrandt M. *Multidimensional Food Insecurity Measurement*. Saldru Working Paper No 160. Cape Town: University of Cape Town (2015).

31. WHO. *WHO Child Growth Standards*. Geneva: World Health Organization (2008).

32. De Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. *Bull World Health Organ.* (2007) 85:660–7. doi: 10.2471/BLT.07.043497

33. World Health Organization. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. *World Health Organ Tech Rep Ser.* (2000) 894:1–253.

34. Campisi SC, Carducci B, Söder O, Bhutta ZA. *The Intricate Relationship between Chronic Undernutrition, Impaired Linear Growth and Delayed Puberty?: Is 'catch-up' growth possible during adolescence? Office of Research - Innocenti Working Paper.* Florence: UNICEF (2018).

35. Casale D, Desmond C, Richter LM. Catch-up growth in height and cognitive function: why definitions matter. *Econ Hum Biol.* (2020) 37:100853. doi: 10.1016/j.ehb.2020.100853

36. USAID Nutrition Activities. *Beyond Stunting Complementary Indicators for Monitoring and Evaluating USAID Nutrition Activities.* (2021). Available online at: https://www.advancingnutrition.org/resources/beyond-stunting-complementary-indicators-monitoring-and-evaluating-usaid-nutrition (accessed June 15, 2022).

37. Coates J, Frongillo EA, Rogers BL, Webb P, Wilde PE, Houser R, et al. What are we assessing when we measure food security? a compendium and review of current metrics. *Adv Nutr.* (2013) 4:481–505. doi: 10.3945/an.113.004119

38. Cafiero C, Viviani S, Nord M. Food security measurement in a global context: the food insecurity experience scale. *Meas J Int Meas Confed.* (2018) 116:146–52. doi: 10.1016/j.measurement.2017.10.065

39. Leroy JL, Ruel M, Frongillo EA, Harris J, Ballard TJ. Measuring the food access dimension of food security: a critical review and mapping of indicators. *Food Nutr Bull.* (2015) 36:167–95. doi: 10.1177/0379572115587274

40. Kaibi FKM, Steyn NP, Ochola SA, Plessis L Du. The relationship between agricultural biodiversity, dietary diversity, household food security, and stunting of children in rural Kenya. *Food Sci Nutr.* (2016) 5:243–54. doi: 10.1002/fsn3.387

41. Chandrasekhar S, Aguayo VM, Krishna V, Nair R. Household food insecurity and children's dietary diversity and nutrition in India. Evidence from the comprehensive nutrition survey in Maharashtra. *Matern Child Nutr.* (2017) 13:1–8. doi: 10.1111/mcn.12447

42. Weingarten SE, Dearden KA, Crookston BT, Penny ME, Behrman JR, Humphries DL. Are household expenditures on food groups associated with children's future heights in Ethiopia, India, Peru, and Vietnam? *Int J Environ Res Public Health.* (2020) 17:1–23. doi: 10.3390/ijerph17134739

43. Devereux S, Waidler J. *Why does malnutrition persist in South Africa despite social grants?* Food Security SA Working Paper Series No.001. DST-NRF Centre of Excellence in Food Security, South Africa. (2017).

44. Khosa P, Kaseke E. The utilisation of the child support grant by caregivers: the case of Ba-Phalaborwa municipality in Limpopo Province. *Soc Work.* (2014) 50:504–15.

45. DSD, SASSA, UNICEF. *The South African Child Support Grant Impact Assessment: Evidence Form a Survey of Children.* (2012). Available online at: https://www.unicef.org/southafrica/media/1116/file/ZAF-South-African-child-support-grant-impact-assessment-2012.pdf (accessed May 4, 2022).

46. Leroy JL, Habicht J-P, González de Cossío T, Ruel MT. Maternal education mitigates the negative effects of higher income on the double burden of child stunting and maternal overweight in Rural Mexico. *J Nutr.* (2014) 144:765–70. doi: 10.3945/jn.113.188474

47. Popkin BM, Gordon-Larsen P. The nutrition transition: worldwide obesity dynamics and their determinants. *Int J Obes Relat Metab Disord.* (2004) 28(Suppl. 3):S2–9. doi: 10.1038/sj.ijo.0802804

48. Cois A, Day C. Obesity trends and risk factors in the South African adult population. *BMC Obes.* (2015) 2:1–10. doi: 10.1186/s40608-015-0072-2

49. Venter F, Walsh C, Slabber M, Bester C. Body size perception of African women (25-44 years) in Manguang. *J Fam Ecol Consum Sci.* (2009) 37:12–23. doi: 10.4314/jfecs.v37i1.48942

50. Mwaka1 NPSMLNNM. Affiliations: nutrition knowledge, attitudes and practices of primary school children in Tshwane. *African J Prim Heal Care Fam Med.* (2019).

51. Van Den Berg VL, Okeyo AP, Dannhauser A, Nel M. Body weight, eating practices and nutritional knowledge amongst university nursing students, Eastern Cape, South Africa. *African J Prim Heal Care Fam Med.* (2012) 4:1–9. doi: 10.4102/phcfm.v4i1.323

52. Shisana O, Labadarios D, Rehle T, Simbayi L, Zuma K, Dhansay A, et al. *The South African National Health and Nutrition Examination Survey, 2012 SANHANES-1.* Cape Town: HSRC (2014). p. 423.

53. Purushotham A, Mittal N, Ashwini BC, Umesh KB, von Cramon-Taubadel S, Vollmer S. A quantile regression analysis of dietary diversity and health outcomes among children and women in the rural-urban interface of India. *Food Policy.* (2003) 107:6–8. doi: 10.1016/j.foodpol.2021.102216