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RELATIONSHIPS BETWEEN ADOLESCENT PREGNANCY, INCOME INEQUALITY, AND INCIDENT DEPRESSION FROM A PANEL STUDY IN SOUTH AFRICA FROM 2013-2017

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Declaration

The contents of this research report are the original work of the authors. The report has been completed as a requirement for completion of the Master of Science in Epidemiology and Biostatistics program at the University of the Witwatersrand School of Public Health. The degree candidate formulated the research question, managed and analysed the data, and first-authored the paper. The other authors fulfilled supervisory roles in the project providing guidance at every step of the way when it came to research question formulation, data analysis, and approval of the final manuscript of the paper.

August 2020

Madelyn Goodman

Dedication

I would like to dedicate this work to Kathleen Bradley and Sanford Goodman for their endless love and support during this endeavor and beyond. Without such, this project would not have been possible, nor would I have been able to complete the challenging course work in preparation for the completion of this project. Their generosity is boundless and is received with infinite gratitude.

Presentations and publications from the study

A poster-summary of this report was presented at the 2020 Wits School of Public Health Research Day on October 15th.

Chapter two of this report will be submitted to the *American Journal of Epidemiology* for publication.

Abstract

Unipolar depressive disorders were the second leading cause of morbidity among adolescent girls in Africa in 2012. Yet, little research had been conducted in sub-Saharan Africa to examine correlates of depression in adolescent girls. This study aimed to examine relationships between adolescent pregnancy, income inequality, and depression through a retrospective cohort analysis in South Africa from 2013 to 2017. Members of this cohort were between the ages of 15 and 19 at their baseline interview for the National Income Dynamics Study (NIDS) (N = 1,660). Adolescents who had experienced a pregnancy were compared with adolescents who had not been pregnant over two years of follow-up. Logistic and linear regression models were employed to examine participants' risk of the onset of depression and depressive symptom severity using the Centre for Epidemiological Studies Depression Scale. The incidence of depression in the study sample was 18.4%, with 306 having developed depression. Results suggested that neither adolescent pregnancy (*P* = 0.093; 95% CI: 0.935 , 2.387) nor income inequality (*P* = 0.517; 95% CI: 0.945 , 1.029) were related to incident depression in this cohort. There was marginally significant evidence, however, that adolescent pregnancy was related to depressive symptom severity (*P* = 0.055; 95% CI: -0.014 , 1.441). Further, none of the selected covariates showed significant relationships with either outcome. These findings were consistent with other studies looking at these exposures separately. This study aims to fill the gap in the literature on adolescent depression in South Africa. Further research, particularly prospective cohort studies, should be conducted to examine correlates of depression among adolescents in sub-Saharan Africa. Such observational research may elucidate risk factors for incident depression in this group and inform interventions for depression.

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I would like to extend sincere gratitude to the following group of people, for without whom it would have been impossible for me to complete this course or this project.

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LIST OF ABBREVIATIONS/ NOMENCLATURE

BL Baseline
CES-D Center for Epidemiologic Studies Depression Scale-10
CI Confidence interval
Coef. Coefficient
DAG Directed acyclic graph
DALY Disability-adjusted life years
DSM-V Diagnostic and Statistical Manual of the American Psychiatric Association 5th edition
FU Follow-up
HH Household
IPV Intimate partner violence
IQR Inter-quartile range
KZN KwaZulu-Natal
NIDS National Income Dynamics Study
No. Number
OR Odds ratio
SD Standard deviation
SES Socio-economic status

UNFPA The United Nations Population Fund

US United States

WHO World Health Organization

WMHS World Mental Health Survey

YLD Years lived with disability

Chapter one: Introduction

1.1 Chapter overview

The first component of this introductory chapter is a background (1.2) which aims to place adolescent depression, the outcome of this study, in context by providing definitions and prevalence data (1.2.3-5). Second, the epidemiology and definitions of the primary exposures, adolescent pregnancy and income inequality, are described (1.2.6-11). Third, a comprehensive review of the literature on the outcome and exposures of interest is presented highlighting the gaps that this study will fill (1.3). Finally, the problem statement, justification, aim, and objectives of the study will be presented (1.4-7).

1.2 Background

1.2.1 Definitions and global epidemiology of depression

The fifth edition of the Diagnostic and Statistical Manual of the American Psychiatric Association (DSM-V) defines the following symptoms as depressive in nature: frequently having a depressed mood, less interest in most daily activities, decrease or increase in appetite, slowing down of thoughts and physical activity, fatigue, feelings of worthlessness, lower ability to concentrate, and recurring thoughts of death or suicide (2). These symptoms can manifest either as unipolar or bipolar disorders of varying severities that have the potential to impede functioning as well as recur (3). For the purpose of this study, depression will be referred to as a manifestation of this set of DSM-V symptoms instead of a formal clinical diagnosis, more appropriate to an epidemiological study.

There are many scales and tools used in epidemiological and population-based studies that examine DSM-V criteria for various psychopathologies, including depression, such as those of the World Mental Health Survey (WMHS) (4–10). Studies from the WMHS using these various tools and scales will be reviewed later in this chapter. The use of these different tools has been found to lead to variations in prevalence estimates of depression across studies. Ferrari et al found in their 2013 systematic review of literature on the prevalence and incidence of depression that these data were very sensitive to the type of study design and

measurement tool being used. For example, they observed higher reported prevalence among young people in studies that measured depression using a symptoms scale rather than those using DSM-V symptom-criteria (11). Given this evidence, when critically examining the literature on prevalence of depression, it must be kept in mind that the components of measurement tools eg. symptoms of depression versus DSM criteria and methods can bias results.

Global prevalence of depression was estimated as 4.4% in 2015 (12). The Global Burden of Disease Study examined prevalence, incidence, and global years lived with disability (YLD) in relation to 354 causes in 195 countries in 2017. An analysis of data from this assessment suggested that YLDs due to depressive disorders increased by 14.3% between 2007 and 2017 (13). Further, prevalence estimates from the World Health Organization (WHO) stratified by sex have been observed as showing females to have a 1% greater prevalence of depression than males globally, and that prevalence was highest among females aged 55-74 (12). While observations of prevalence can be valuable to demonstrate the public health significance of a particular mental disorder, further epidemiological insight is required to understand why prevalence measures might differ across and within countries. Further, as with any measure of prevalence, however, these estimates should be interpreted with caution due to prevalence data being specific to the point and time they were collected in. Studies, including a systematic review by Ferrari and colleagues, further suggested that these estimates could be subject to measurement biases associated with the varying characteristics of measurement tools and participants (11,13,14). Additionally, recent growth in prevalence may be attributed to a general increase in the global population and of the age groups in which depression is more common (12).

1.2.2 Epidemiology of depression in Africa

Global prevalence studies suggested that the global burden of depression disproportionately affected low- and middle-income countries as 80% of the global prevalence of depression was found in these settings in 2017 (12,14). The WHO African regions (including all 46 sub-Saharan African countries), for example, made up 9% of the global prevalence of depression, with 7.9% of total years lost to disability being attributable to depression in the region (11).

Depression has been found to be highest among women in this region as well with a prevalence 0.8% higher than the global average for women (12).

1.2.3 Global epidemiology of adolescent depression

The United Nations Population Fund (UNFPA) defines adolescence as being between the ages of 10 and 19 years of age (16). Using data from the 2010 Global Burden of Disease Study, Ferrari et al used a meta-regression to suggest that the prevalence of depression increased steadily between the ages of 3 and 19 (14). It has been well established in the literature that this age group is at particular risk of depression and other psychopathologies. Adolescents are at a critical stage in their psychological, neurobiological, and sexual development, facing more stressors and changes than when they were children (17–19). The burden of depression is, therefore, significant in adolescents, demonstrated by findings that unipolar depressive disorders were the second leading cause of morbidity among those between the ages of 15 and 19 in 2012 globally (20). This finding comes from a report by the WHO on disability-adjusted life years (DALYs) among adolescents. Along with depression, "road injuries, iron-deficiency anaemia, HIV, and intentional self-harm" were among the leading contributors to DALYs in adolescents in 2012 (20). Further, by the age of 15, data suggested that a gender divide emerged with adolescent girls being twice as likely to be depressed than adolescent boys (21,22). Data examined and presented through two meta-analyses specifically of nationally representative samples covering the life-span (mainly in the US, Canada, and Europe) by Salk and colleagues suggested that women have 0.95 greater odds of being diagnosed with major depression than men (23).

One study of adolescent depression from the US suggested that factors associated with depression in adolescents were: being female, being older (i.e. between the ages of 15 and 19 compared to the ages of 10 to 14), having ever been bullied, and being from an unsupportive household as measured by a composite score (23). The variable, "supportive household," in one study was measured using parental availability for school work and parental understanding of emotional problems experienced by the adolescent (24).

1.2.4 Epidemiology of adolescent depression in Africa

Though it has been found that depression was highest in low- and middle-income countries, especially among women in the African region, there were less available prevalence data for this area compared to high-income countries in 2013 (26). Prevalence data on depression among children and adolescents found in systematic reviews conducted for the Global Burden of Disease Study in 2010 and 2013 surveyed no more than 2% of the population in sub-Saharan Africa. This study demonstrated the sparse coverage of data collection on depression in this population (26). The observational epidemiological data that do exist provide only a rough picture of the burden of disease. For example, a cross-sectional study conducted at the household level by Nyundo et al in several sub-Saharan African countries (Tanzania, Ethiopia, Nigeria, Uganda, Ghana, and Burkina Faso) found that an average of 28% of adolescents across all the countries reported having felt depressed in the last week (24).

The Nyundo et al study also looked at risk factors for depression and found that self-reported depressive symptoms in adolescents were related to loneliness, anxiety, and feelings of extreme worry (24). Berhane et al conducted a similar study in 2019 that corroborated several of Nyundo et al's findings in different country-contexts (Burkina Faso, Ethiopia, Eswatini, Ghana, Nigeria, Tanzania, and Uganda) (27). It was found that those who were between the ages of 15 and 19 reported more symptoms of depression than those between the ages of 10 and 14, demonstrating a dose-response relationship between severity of symptoms and adolescents' age. Females also consistently reported more symptoms of depression than males (24,27). According to the WHO, unipolar depressive disorders accounted for 2,973 DALYs per 100,000 girls aged 15-19 in Africa in 2012 (20). These findings suggested that older girls are at a higher risk of depression among adolescents in sub-Saharan Africa.

1.2.5 Epidemiology of adolescent depression in South Africa

A 2016 study investigating lasting mental health effects of the apartheid era in Cape Town reported prevalence of common mental disorders, including depression, to be 41% in a sample of adolescents (28). When analysed by racial categories, 58% of black children, 45% of coloured children[i], 29% of white children, and 24% of Indian children were found to have a common mental disorder (28). Black and coloured children were significantly more likely to be in the poorest wealth quintile, with access to fewer material resources being associated

with common mental disorders (28). This study highlighted the complex associations between race, socio-economic status (SES), access to resources, and depression among adolescents in South Africa. These findings that alluded to relationships between race, SES, and inequality were corroborated by several previous studies among adults and adolescents in other low- and middle-income countries as well as high-income countries (29–32).

There has been mixed evidence, however, that suggest significant differences exist in the epidemiology of depression among adolescent girls and boys in South Africa. In the Eastern Cape, it was found that 20% of adolescent girls aged 15 to 26 and 13% of adolescent boys experienced depression (33). Depressive symptoms among these girls were shown to be significantly associated with having been forced to have sex before the age of 18 and having had 2 or more experiences of sexual or intimate partner violence from partners or non-partners (33). While this evidence in the Eastern Cape suggested that depression was more common among adolescent girls in South Africa, another study at a rural university in KwaZulu-Natal (KZN) found no statistically significant difference in signs of depression between males and females. Further, it found no difference in depressive symptoms between students from urban and rural areas, or between older and younger adolescents. Instead, it was found that these factors significantly interacted with different symptoms of depression including, being more tired, being disappointed in themselves, not coping well, and others (34).

1.2.6 Definitions and global epidemiology of adolescent pregnancy

Adolescent pregnancy, is defined as a pregnancy occurring in girls after menarche until age 19 (16). Adolescent pregnancy remains a common occurrence globally with 16 million girls between the ages of 15 and 19 becoming pregnant every year according to the UNFPA (16). Adolescents were also found to have more unmet need for contraceptives and lower rates of contraceptive use than any other age group, heightening their risk of pregnancy (16). A study in South Africa found that having a sexual debut at age 15 or later was associated with more consistent contraceptive use than an having an earlier introduction to sex. This corroborated a finding in a 2019 study in Malawi that found an earlier sexual debut was associated with pregnancy (35,36). Sexual violence was also found to be associated with inconsistent use of contraceptives, as well as a risk factor for adolescent pregnancy in sub-Saharan Africa

(37,38). Further, adolescent girls in the lowest income quintiles were found to be at increased risk of pregnancy globally, a factor that will be further discussed in the literature review (16).

Many studies have looked into factors associated with adolescent pregnancy. A systematic review of cross-sectional studies in high- middle- and low-income countries found in nine out of 12 studies that lower education levels or no education increased the odds of adolescent pregnancy between two and nine-fold (39).

1.2.7 Epidemiology of adolescent pregnancy in Africa

Sub-Saharan Africa was found to have higher rates of adolescent pregnancy as compared to other low- and middle-income country regions (42). According to a meta-analysis of prevalence and determinants of adolescent pregnancy conducted in 2018, the prevalence of adolescent pregnancy in sub-Saharan Africa was around 19.3%, and 20.4% in the Southern African region, the area with the second highest rate in the region (42). Prevalence of adolescent pregnancy increased from 18.2% in Southern Africa before 2015 to around 20.5% in 2018 (42).

It is important to note that there is a wide range of prevalence estimates between countries on the African continent. A study that looked at variations in adolescent pregnancy in sub-Saharan Africa reported that Rwanda had a 10% adolescent pregnancy rate while Mozambique was around 35% (43). Using multi-level regression it was found that country-level factors accounted for 11% of the variance in global adolescent pregnancy rates (43). Areas within countries also presented different epidemiological landscapes. It was found in the previously mentioned meta-analysis, sourcing data from 24 African countries, that adolescents who lived in rural area were found to be twice as likely to have been pregnant as compared to those living in urban areas (42).

Several different factors have been found to be related to prevalence of adolescent pregnancy in sub-Saharan Africa. As mentioned in section 1.2.5, socio-economic and individual-level factors play significant roles in risk of adolescent pregnancy in sub-Saharan Africa. Examples include, lower education of the adolescent and/or their parents, poverty, and child marriage (38,42). Results from a systematic review looking at studies measuring factors influencing

adolescent pregnancy in sub-Saharan Africa from 2018 found factors such as history of sexual abuse, peer influence, timing of sexual debut, substance use, and others to be associated with adolescent pregnancy (38).

1.2.8 Epidemiology of adolescent pregnancy in South Africa

South Africa struggles with a high rate of adolescent pregnancy with 43 births per 1,000 girls aged 15 to 19 in 2017 (44). A nationally representative cross-sectional survey in South Africa by Jonas et al in 2016 found that 38.8% of adolescent boys and girls between the ages of 11 and 19 reported to have ever had sex in a combined sample of three cross-sectional surveys from 2002, 2008, and 2011 (45). It was found, however, that rates of engaging in sex decreased between 2002 and 2011 among both boys and girls. Rates among girls decreased from 34% in 2002 to 29.8% in 2011 with only 10.9% of girls in this sample reporting to have ever been pregnant (45). A separate study in KZN among sexually active school-aged girls found that 44.4% of girls who were sexually active reported to have ever been pregnant (46). This is in contrast with a nationally representative study which found that 21.3% of sexually active adolescent girls had ever been pregnant, demonstrating varying rates of adolescent pregnancy by province (45).

Jonas et al also found that 72.4% of adolescent girls reported using condoms for contraception in 2011, while only 5.2% reported use of birth control pills, the least used method (45). There was a weak, negative association between condom use and adolescent pregnancy while, surprisingly, girls who reported using birth control injections pills were found to have higher odds of adolescent pregnancy (45).

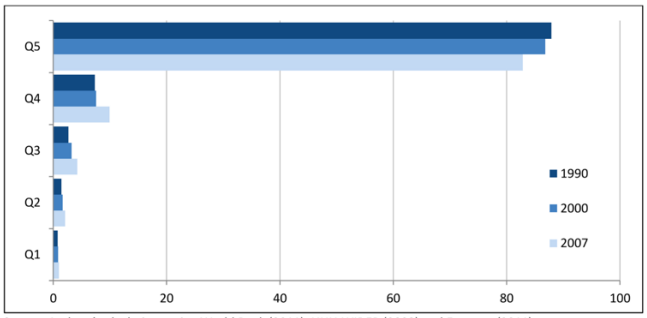
Having a support system also proved to be important in preventing adolescent pregnancies in South Africa. One study conducted in KZN found that living with both parents and having a consistent sexual partner were associated with a reduced risk of adolescent pregnancy (46). Moreover, those who reported having little to no emotional support in general were found to be at a significantly higher risk of having more than one pregnancy as an adolescent (47–49).

There was mixed evidence when it came to the association of SES with adolescent pregnancy. Both Jonas et al and the above cited study from KZN by Galappaththi-Archchige

et al looked at parents' employment status as a proxy for SES. In the nationally representative sample, having an unemployed father was significantly associated with having 43% higher odds of having an adolescent pregnancy compared to those whose fathers worked 5 or more days a week (45). In the KZN study, however, the percentage of adults employed in the household was not found to be significantly associated with adolescent pregnancy (46). This difference could be due to the distinct characteristics of the different provinces in South Africa.

1.2.9 Definitions and the global context of income inequality

Income inequality refers to the extent to which a society is considered hierarchical, or a scale by which to measure the extent of the separation of classes (50). There are several methods to measure income inequality with the most common being the Gini index. An area with an index of 0 indicates a perfectly equal distribution of wealth, and an index of 1 indicates that one person or household holds all of the wealth (51). Global intra-country income inequality has risen since the early 19th century, remaining steady around 1950 with a recent increase in the global Gini coefficient to 70.2 in 2002 (52). As the world was allegedly changing for the better between 1990 and 2007, income for the bottom two wealth quintiles only changed by one percent (1).



Source: Authors' calculations using World Bank (2011), UNU-WIDER (2008) and Eurostat (2011)

Figure 1.1 "Global income distribution by population quintiles, 1990-2007 (or latest available) in constant 2000 US dollars" (1)

1.2.10 Global income inequality and health

High levels of income inequality should be of concern as high income inequality has been found to lead to adverse health outcomes, especially when it is being used as a measure of the

magnitude of the difference between social classes (50,53). Adolescents are particularly vulnerable to these differences as about half of the world's population of youth are distributed among the bottom two wealth quintiles (1). A global cross-sectional study in 2015 examined the World Values Surveys and European Values Study and found that income inequality was negatively associated with self-rated health among those 16 to 25 years old, demonstrating the greater burden income inequality has on adolescents compared to adults (54).

1.2.11 Income inequality and health in South Africa

South Africa had one of the highest levels of country-specific income inequality in the world with a Gini index of 0.63 in 2014 (51). The Apartheid era policies played a significant role in the drastic income inequality seen in the country. Though average income for the Black population increased between 1993 and 2008, there is evidence that income inequality also increased in the country as a whole during this period (55). This is seen numerically in the increase of the overall Gini index during this period from 0.66 in 1993 to 0.70 in 2008 (55). The major cause of this phenomenon was a greater share of income going to the top wealth decile over this period while social grants became a major source of income for those in the bottom half of the income distribution (55). This manifested in greater increases in inequality within racial groups rather than between them accounting for 62% of overall inequality in 2008 (55).

Studies have examined the relationship between income inequality and depression, however, these have some contradicting results, to be further unpacked later in this chapter (56,57).

1.3 Literature review

1.3.1 Literature review overview

A review of current literature was conducted to establish what is known about relationships between income inequality and adolescent pregnancy, income inequality and depression, and adolescent pregnancy and depression. These key words were entered into the PubMed and PsychInfo databases. A study was considered relevant to the review if it was quantitative and focused on adolescent pregnancy or income inequality and depression, similar to the design

of the research report under review. Studies using proxies for these factors were included if they had other relevant qualities, such as being conducted in South Africa.

1.3.2 Adolescent pregnancy and income inequality

1.3.2.1 Socio-economic status

Though there is limited research on the relationship between income inequality and adolescent pregnancy, SES has been previously examined in this context. In the poorest countries in the world, there were 106 births per 1,000 girls aged 15 to 19 in 2010, a rate four times higher than that in high-income regions (16). A study of factors related to adolescent pregnancy in low- and middle-income countries specifically found that low SES, being married before age 20, and living in a rural area made girls three to four times more likely to have an adolescent pregnancy (39). More research and policies about the relationship between economic conditions and high rates of adolescent pregnancy is necessary in low- and middle-income settings to get a better understanding of this persisting issue.

One piece of evidence in the literature explaining this relationship was the trend of adolescents of lower SES engaging in transactional relationships with older men (38). The power dynamic in these relationships in which girls have less agency to negotiate safe sex has resulted in greater risk of pregnancy (58,59). A systematic review by Yakubu and Salisu found that access to contraceptives was lower among girls of low SES, again, further highlighting the economic inequalities of this issue (38). These findings, however, have also been refuted in a nationally representative survey in South Africa that found a higher proportion of adolescents from low SES households used contraceptives than those from middle or high SES households (35).

1.3.2.2 Income inequality

Ecological studies have been conducted mainly in high-income, Western contexts examining the relationship between income inequality and adolescent pregnancy. Much of this research looked at the interaction of income inequality with other economic and social factors. For example, it was found in two different studies in the US looking at income inequality and adolescent pregnancy that adolescents in a low SES bracket were around 5 percentage points

more likely to experience adolescent pregnancy in areas with high income inequality as compared to those in areas with low inequality (60,61). This demonstrates that SES may interact with income inequality. In a study using US census data from 1990 it was found that the impact of inequality varied by age-range of pregnancy in an area. Areas with younger mothers showed a stronger relationship between inequality and rates of adolescent pregnancy than areas with older adolescent mothers (61). These conclusions from ecological data should be approached with appropriate caution as to not subscribe these ideas at the individual level.

Some studies have looked into the mechanisms behind the positive relationship between income inequality and adolescent pregnancy. One such mechanism was that of social capital, defined as the interactions between people in a society that can be seen as resources, such as trust and mutual assistance (62–64). The logic here was that income inequality would reduce the social capital in a community which would then affect health. A study done in the US investigating mechanisms behind income inequality and poor health outcomes found that income inequality was not correlated with higher adolescent birth rates alone, but rather was significant through its relationship with diminished social capital (64). This is in contrast with the aforementioned studies that found direct relationships with income inequality alone.

A study by Castro et al (2017) examined the effect of income inequality on adolescent fertility rates in low- and middle-income countries. They found a significant association, however, they saw it in the negative direction. A 1% increase in income inequality resulted in a reduction of adolescent fertility in predictive models by as much as 0.5% (65). As most analyses focused on high-income countries, this study suggested that dynamics differed in low- and middle-income settings.

Filho et al also saw this gap when they conducted a study in Brazil, a low- and middle-income country with similarly high levels of income inequality as South Africa, that looked at income inequality's effect on adolescent pregnancy. In contrast with conclusions from Castro et al, Filho et al showed that there was a significant relationship between income inequality and adolescent pregnancy with rising inequality being associated with rising adolescent pregnancy at the municipal level (66). This analysis also showed that an increase of 0.1 in the Gini coefficient was associated with a rise in adolescent pregnancy of 0.41 births per 100 girls (66). Due to contrasting results suggested by studies cited above, it is important

to continue to investigate this relationship in low- and middle-income countries, as they are also the most impacted areas.

1.3.3 Income inequality and depression

There is mixed evidence of whether or not a relationship exists between income inequality and depression among adolescents. A systematic review by Patel et al looking at the potential association between income inequality and population prevalence of depression found that two thirds of the identified studies reported significant and positive relationships between the two factors (67). Another systematic review looking at income inequality and general mental health problems, however, found dramatically fewer studies (nine out of 27) supporting this conclusion (68). Both reviews also found few studies reporting no significant relationship between income inequality and depression, demonstrating a lack of consensus on the association in the literature (67,68).

Meta-analyses demonstrated more consistent results on the effect of income inequality on depression. The meta-analysis of the systematic review conducted by Patel et al in 2018 found those living in areas with higher income inequality had 1.19 times the risk for depression compared to those living in areas of lower income inequality (67). Another meta-analysis by Ribeiro et al found with every unit increase in income inequality, there was a 0.12 point increase in risk of depression (68). Though these reviews found mixed results, their meta-analyses reflected that income inequality had a significant and positive relationship with depression. There was more agreement in the literature to establish a relationship between income inequality and depression among ecological studies. Studies both in the US and Brazil found that income inequality was positively associated with depression (69,70).

1.3.3.1 Factors associated with income inequality and depression

Two major factors influencing the relationship between income inequality and depression are income level and gender. The systematic review mentioned above by Patel et al found several studies that reported that income inequality only affected risk for depression among those with low income and proved that this effect was stronger (67). Pabayo et al also found a significant relationship between income inequality and depression among adolescents living

in Boston in a cross-sectional study, however, it was in the negative direction. Those living in moderate and high economic deprivation had fewer depressive symptoms (71). These disparate findings further added to the uncertainty of evidence about income inequality's relationship to depression and suggest that further studies must be undertaken in the area.

There were more consistent findings that women were disproportionately impacted by income inequality when it comes to its influence on depressive symptoms. A systematic review by Patel et al in 2018, as well as one cross-sectional and one longitudinal study both based in the US, showed that women in areas with high income inequality had higher odds of depression compared to women living in areas with lower income inequality (67,71,72). This interaction suggested a focus on women is necessary when confronting the effect of income inequality on depression. Patel et al, however, also found other evidence which suggested that there was no association, as well as associations only among males, further emphasizing the need to look more closely at gender's effect on the relationship between income inequality and depression (67).

1.3.3.2 Income inequality and depression in South Africa

With the highest amount of income inequality in the world, there has been a unique interest in looking at its impact on depression in South Africa (51). The effects of social causation and social drift have been looked into to pinpoint the nature of this relationship. Social causation suggests that lower SES increases the risk for mental health problems while social drift purposes that mental health problems can lead to diminished SES. It was found in 2018 by Lund and Cois that social causation, rather than social drift, related income inequality and depression in South Africa, with a significant negative association seen between SES at an earlier time point and depression at the following time point (73).

A nationally representative longitudinal study in South Africa by Adjaye-Gbewonyo et al aimed to start filling the gap in the literature in South Africa examined district-level income inequality and its effect on mental health. They found that depressive symptoms decreased over time while income inequality increased. In addition to having the opposite trend than expected, further analysis showed there wasn't a relationship between income inequality and depressive symptoms, nor was there any interactive effect with income, age, or race (56).

These findings came in contrast with those of another study by Burns et al looking to quantify the interactive effect between income inequality and SES on depression done on the same nationally representative dataset. They found a significant relationship between income inequality and depression. Further, being female was found to be associated with higher odds of depression as compared to being male (57). Evidence from South Africa simply adds to the conflicting conclusions about this relationship. Further exploration is needed in the country, particularly in nationally representative samples.

1.3.3.3 Income inequality and depression among adolescents

There has also been interest in the field into the impact of income inequality on adolescent's health. Rozer and Volker found in 2015 that there was a dose-response relationship between level of income inequality experienced during adolescence and resulting self-rated adulthood health (54). This effect, however, appeared to be dependent on which measure of income inequality was used and the method of testing for significance (53). It was found in the previously mentioned Boston study by Pabayo et al that adolescents in areas with greater economic deprivation had lower depression scores than those in areas of lower economic deprivation (71). Another study among adolescents in Iceland, however, found that income inequality did not influence emotional distress at all (74).

Though there is conflicting evidence on whether there is even an association between income inequality and depression among adolescents, the following studies have looked into social cohesion and social capital as underlying factors, as previously mentioned. Patel et al found in the 2018 meta-analysis mentioned extensively above that mechanisms behind the effect of income inequality on depression, such as social trust and group membership, were stronger in adolescents, explaining that these factors were typically established at this point in life (67). The addition of social capital to predictive models of depression in another Icelandic study also lead to income inequality showing a significant relationship with depression among adolescents (75). Pabayo et al, however, found no evidence in Boston that social cohesion played a role in the relationship between income inequality and depression in adolescents (71).

There is a significant body of evidence that establishes no association between income inequality and depression in adolescents, additionally, there is no evidence that depressive symptoms respond to changes in inequality (71,75–77). A longitudinal study in Iceland examining the relationship between income inequality and emotional distress found that while decreasing income inequality was related to decreasing symptoms of anxiety, there was no significant relationship with decreasing symptoms of depression (75). It was also found in a study by that same group that there was no interaction between income inequality, household deprivation, and depression among adolescents (77). The conflicting findings of whether or not a relationship between income inequality and depression exists both in adults and adolescents makes it of interest for further investigation in diverse populations.

1.3.4 Adolescent pregnancy and depression

1.3.4.1 Factors associated with adolescent pregnancy

Risk factors associated with pregnancy in adolescence have been studied at length. Both a meta-analysis and a 29-country study on determinants of adolescent pregnancy found that higher education attainment reduced the odds of adolescent pregnancy with odds decreasing by around 17% with every additional year of schooling (43,49). The relationship between use of contraceptives and adolescent pregnancy, however, was not as straight forward in the meta-analysis. Counter-intuitively, use of contraceptives was found to be positively associated with adolescent pregnancy (49). There is, however, conflicting evidence on the direction of this association. In line with other studies around the world, a study in KZN identified that current contraceptive use was associated with having ever been pregnant with 29.7% of girls reporting use (46). The results of this study suggested that many girls were at a higher risk of adolescent pregnancy given how many of them used hormonal contraceptives.

Parental factors have also been identified as being associated with adolescent pregnancy. These include parental education and communication between parent and child (38,42). A meta-analysis looking at determinants of adolescent pregnancy in sub-Saharan Africa found that those with mothers without an education were twice as likely to have a child during adolescence as those with mothers who had an education (42). Parental factors were also relevant when it came to communication concerning reproductive health issues. No communication between parent and child was found to be associated with a three times

higher likelihood of adolescent pregnancy compared to those with open communication in the meta-analysis, as well as in a systematic review looking at determinants of adolescent pregnancy (38,42). The context in which an adolescent is raised can have a significant impact on their risk for pre-mature pregnancy.

1.3.4.2 Pregnancy-related depression in South Africa

There has been research into pregnancy-related depression in South Africa among adults. Prevalence of depressive symptoms among pregnant adults was around 22-24% in different populations in the Western Cape (78,79). Factors such as social support, unwanted pregnancy, alcohol consumption, SES, food insecurity, and having past mental health issues were found in two studies in Cape Town to impact prevalence and severity of depression (79,80). Pellowski et al found in the Western Cape that depressive symptoms decreased over the postpartum period among most women, although they tended to increase among those who experienced intimate partner violence (IPV) (78). It was further found by van Heyningen et al in 2016 in Cape Town that those who experienced IPV were twice as likely to be depressed as those who had not experienced IPV (79). More experiences of IPV were associated with more depressive symptoms, as one standard deviation increase in IPV lead to a 13% increase in depressive symptoms as found in studies conducted in Cape Town and Durban (81,82).

This literature review only found one study that examined depression among adolescent mothers in South Africa. Comparing depressive symptoms in pregnant adolescents with pregnant adults, Le Roux et al found that symptoms were similar among the comparison groups. It was also found that both adolescents and adults had a reduction in depressive symptoms over time (83). Such findings suggest that adolescents aren't at particular risk for depression during pregnancy in South Africa, although the limited data on this issue leaves room for further investigation.

1.3.4.3 Prevalence of depression among pregnant adolescents

Studies examining prevalence of depression in pregnant adolescents have been conducted in a variety of settings. These studies have also used different tools to measure depressive

symptoms, therefore, discretion must be used when comparing these prevalence measures. Studies in Mexico and in one state in the US (Iowa) have found prevalence of depression among adolescent mothers to be around 12-16% (84,85). Studies in sub-Saharan Africa have found differing results with a study in Kenya reporting 58% of pregnant girls having had a likelihood of depression and a study in Nigeria finding just 18% of pregnant girls screening positive for depression (86,87). Levels of depression can vary quite a bit in different populations. Several studies have also looked into how participants' depressive symptoms were distributed from mild, moderate, to severe. Among those testing positive for depression, prevalence of minor depression ranged from 24 to 86%, moderate depression from 22 to 32%, and severe depression from 13 to 33% in the previously mentioned studies (85,86,88).

Further research has looked at trends of depressive symptoms in pregnant adolescents even after birth. Two studies, one in the US and one in Mexico, found that prevalence of depression was highest in the latter half of pregnancy and just after delivery with a gradual decline over the postpartum period (88,89). There was not consistency in the reporting of the prevalence of depression over the postpartum period, however. Lara et al found in Mexico in 2012 that just 2.3% of adolescents in their sample exhibited symptoms of depression while Brown et al found in a longitudinal study in the US that 53-57% of adolescents experienced depression throughout the postpartum period (89,90).

1.3.4.4 Relationships between adolescent pregnancy and depression

In the literature reviewed here, adolescent mothers were either compared to adult mothers or non-childbearing adolescents in order to examine the relationship between adolescent pregnancy and depression. Eight different studies found that pregnant adolescents had significantly higher rates of depression as compared to pregnant adults (91–98). Agnafors et al found in a sample from Sweden that mothers 20 years and younger were twice as likely to have postpartum depression compared to those 21 years and older (91). Another study of a cohort of adolescents in Australia showed depressive symptoms improved the greater the mother's age at first birth (84). Further, it was also found in another cohort of mothers that adolescents were more likely to have consistent depression over time (98). There was mixed evidence on this relationship, however, as Xavier et al found in a Canadian study and Oladeji

et al found in a Nigerian study that depression among pregnant adolescents did not differ significantly with depression among pregnant adults (87,99).

There was even less evidence that pregnancy in adolescence lead to a greater likelihood of depression when depressive symptoms in adolescent mothers were compared with symptoms in non-childbearing adolescents. It has been found by Lara et al in Mexico and Hipwell et al in the US that there was no difference in depressive symptoms among adolescents with and without children, as well as little difference in the change of depressive symptoms over time (89,100). A literature review of studies looking at adolescent pregnancy as a determinant of depression, however, reported significantly higher rates of depression among pregnant adolescents when compared to their non-pregnant peers (92). These varied results suggest that there may be underlying mediating or confounding factors affecting this relationship (101). This could be due to the different settings the studies were conducted in, different definitions of adolescent pregnancy, and different measurement methods of depression.

1.3.4.5 Factors associated with depression among pregnant adolescents

Many studies reported a history of depressive symptoms as a major contributing factor to postpartum depression among adolescents (85,96,102–104). One systematic review, however, found several conflicting studies with evidence of positive, negative, and no relationships (102). Several other socio-demographic factors were also found to be associated with depression among adolescent mothers as well. Strong correlates with depression were not being in school, a history of alcohol consumption and/or smoking, and experiencing stress from multiple sources (86,89,102,104,105).

A systematic review by Hymas and Girard and a study in the US both found no evidence of a difference in frequency of depression among adolescent mothers between racial groups. This evidence suggested that, though the many socially-determined factors that race serves as a proxy for often confound relationships between various exposures and depression, it did not seem to act as a confounder with adolescent pregnancy (102,105). Further, Hymas and Girard as well as a study in Kenya found that younger pregnant adolescents had a higher risk of depression than those who were nearing adulthood (86,102). There was evidence of other factors being related to depression among pregnant adolescents as well as of no relationships

with any socio-demographic factors (85,86,89,102). The important take away is that the context adolescents find themselves in is usually relevant to whether or not they develop depression during pregnancy.

The potential unplanned nature of pregnancies has been examined as a risk factor for depression among pregnant adolescents as well. Whitworth found in 2017 looking at data from the National Longitudinal Study of Adolescent Health in the US that every unit increase in attitude towards the pregnancy corresponded to depressive symptom levels in adolescents being closer to those in adult mothers (106). Not all studies, however, found such a strong relationship, with some finding no association with unplanned pregnancy among adolescent mothers alone (102,103,107). A study by Phipps and Nunes looking at consequences of unintended pregnancies in adolescents found that those who reported not being emotionally ready to be pregnant had 2.2 times the odds of being depressed as those who were emotionally ready (103). Given the mixed evidence, it is unclear whether a pregnancy being planned or not significantly impacted the development of depression among adolescent mothers.

There is a plethora of evidence examining the relationship between social support and adolescent mothers' depressive symptoms. In general, most studies found more social support, or greater satisfaction with social support, was related to lower severity of depressive symptoms and lower likelihood of depression (86,90,92,104,105,108–112). It was found in a global literature review in 2014, however, that adolescent mothers received a lower level of social support than adult mothers on average (92). A study in Brazil in 2013 and a study in Mexico in 2011 both found that lower social support lead to around 3-3.5 times higher odds of depression compared to those with more social support (104,108). It was also found in a cohort study of adolescent mothers in the US that more social support would lower the odds of experiencing increased depressive symptoms by an average of 25%, thus demonstrating that this factor had an impact in both directions (111).

A 2007 literature review by Reid and Meadows-Oliver reported identifying studies that reported no association between social support and depression or an association in the opposite direction (101). Kleiber and Dimidjian postulated in their 2014 literature review on postpartum depression among adolescents that conflicting results could be due to adolescents' perceptions of their social support. They cited a study that suggested there was

inconsistency in the rating of the social support received by the adolescent by those in their support network compared to the adolescent's own perceptions. This study concluded that adolescent's own perceptions of their social support were more predictive of their depressive symptoms (92).

Key members of an adolescent's support network were their family members. Reid and Meadows-Oliver found in their literature review, as well as Edwards et al in their 2012 longitudinal study in the US, that higher levels of parental support were correlated with lower levels of depression and lower levels of parental support were correlated with higher levels of depression (110,113). Further, adolescents living with both their parents had lower depressive scores in many cases (92,96,113). Edwards et al also found a significant negative relationship between depression and social support among those who lived with their parents, however, there was no association among those who did not (113).

Strong relationships between the adolescent and her mother have been found to be especially important for their mental health. Reid and Meadows-Oliver in their 2007 review, as well as Recto and Champion in their 2017 review, found that the more support an adolescent had from her mother, the lower her depressive symptoms. Further, it was found that the more conflict she had with her mother, the higher her depressive symptoms (110,112). Kleiber et al found evidence that there was no association between parental support in general and specifically the mothers' support (92). It would be reasonable, however, to conclude that there was a strong relationship between the level of support from the adolescent's family and their risk for depression during and around their pregnancy as there is a great volume of evidence supporting such.

The only other relationship the adolescent had that was more important than the one she had with her mother, was with the father of her child. Overall, the more support she received from the father of her child, the lower her depressive symptoms, and the less support she received the higher her depressive symptoms (90,92,110,112–114). A cross-sectional study in Jamaica found that lower levels of support from the father could be not being happy about the baby, being unfaithful, or not being communicative (108). Those who had limited contact with the father of their child were overwhelmingly more likely to be depressed as those who had more frequent contact (89,108,110,112,113,115).

As stated previously, measuring the adolescent's opinion on the quality of their social support, rather than simply if it was present or not, was more common in studies of depression. The review by Kleiber et al and a study on father involvement in the US found that the greater the mother's satisfaction with the father's support, the lower her postpartum depressive symptoms (92,114). Further, the nature of the adolescent mother's relationship with the father was found by Recto and Champion to mediate any effect of his support on her depressive symptoms, as being partnered with him had a more preventative effect (113). Other factors, such as self-efficacy, were also found to mediate this relationship (112). Social support is a complex, yet important, factor when it comes to its effect on depression among adolescent mothers and must be explored from many perspectives.

Abuse is one determinant that is often thought of as having an impact on the risk of developing depression among anyone, and especially among pregnant adolescents. It has been found that adolescents who experienced verbal/emotional, physical, or sexual abuse were more likely to be depressed generally and in the postpartum period (102,115–118). Two cross-sectional studies reported evidence that the more abuse one adolescent experienced, the more severe her depressive symptoms (117,118). There was mixed evidence, however, on if this association was significant, with two cross-sectional studies, one in the US and one in Turkey, demonstrating that it fell short (116,119).

The size of the effect of different types of violence on depression among adolescent mothers was serious. Ribeiro et al found in Brazil in 2019 that those who experienced verbal abuse or emotional neglect were between 1.4 and 1.8 times as likely to have depressive symptoms compared to those who did not experience such (118). Further, those who experienced physical violence were 1.3 to two times as likely to have depression, which was substantiated by Bernard et al in Jamaica in 2018 (108,118). There was more evidence from the systematic review by Recto et al and a longitudinal study in Canada that a history of sexual abuse significantly impacted adolescents' risk of developing depressive symptoms at any point during pregnancy (112,120).

In South Africa in 2016, it was found that experiencing intimate partner violence was a significant predictor for both ante-natal and postpartum depression among adults. Further, greater frequency of violence lead to more severe depressive symptoms (82). Evidence from South Africa in adults builds a convincing case to look into such a factor among adolescents

as well, especially since prevalence of IPV among those 15 to 19 year olds was found to be around 37% (121,122)

These issues need to be taken seriously in South Africa, not only to protect adolescents' general wellbeing, but also to prevent depression in adolescent mothers that can have lasting effects for them and their children.

1.4 Problem statement

Depression has a variety of consequences for adolescents that can directly impact public health. A systematic review by Clayborne, Varin, and Colman reported that adolescent depression was found to be associated with higher odds of incomplete secondary education, not starting post-secondary education, and unemployment (123). Further, more severe depressive symptoms were found to lead to lower future income (124). It should also be noted that adolescent pregnancy itself has been found to lead to these same outcomes, leaving the potential for compounding consequences (39,125).

Depression does not only have consequences for the adolescent mother, but it also poses serious consequences to the development of the child. Compared to adolescent mothers without depression, it was found in a study in Nigeria in 2019 that those with depression had children with lower gestational weight and age (87). Another study in the US found adolescents who had a depression score one standard deviation above the mean had 30% greater odds of having a preterm birth (126). Children born in this situation were also more likely to experience developmental delays in a study of African American and Latina mothers and their children in the US in 2014 (109). Further, Ride suggests in her 2019 study that children born to mothers with postnatal depression in income unequal environments have been found to be at greater risk for "special education needs, emotional problems, and low self-assessed health in early adolescence," (127). Her research highlighted the dangerous role income inequality could play for children's outcomes as well.

The severity in the outcomes for adolescent mothers and their children bring to light the serious nature of depression among adolescent mothers and the threat it poses to public health. The most serious consequences are those experienced by children, as they can

perpetuate such social and health challenges for generations. It is most important to look into these dynamics in a variety of different settings to understand how they play out and exactly what the different consequences may be.

1.5 Justification

Given the gravity of the public health problem, it is important for there to be strong evidence in many different contexts of the contributing factors of depression among adolescent mothers. Most studies that have examined this issue have been conducted in Western and high-income countries. While these studies provide basic evidence for the possibility of a connection between depression, adolescent pregnancy, and income inequality, dynamics differ by setting and therefore need to be explored in diverse contexts in order to understand the full picture. The lack of evidence from low- and middle-income countries and sub-Saharan Africa presents a gap in the literature that must be filled to establish a better understanding of these associations.

One of the central issues on the researchers' minds when developing this research question was the likelihood that depression and adolescent pregnancy share common causal factors. In considering this issue, income inequality came up as one of these common factors. It was hypothesised that income inequality could interact with adolescent pregnancy to lead to depression. The researchers felt it necessary to point out that there were several factors that could have also been explored as having an interactive relationship with adolescent pregnancy in this causal pathway such as lower socioeconomic status, lower education level, early sexual debut, and history of trauma (24,33,39,43). Income inequality was ultimately chosen to be explored given its relevance to the South African context and the availability of data on it in the primary study.

Despite having the highest income inequality in the world, there has been limited research into the impact of income inequality on health in South Africa, and especially among adolescents (56,57,128,129). The effect of income inequality on depression among adolescents has also been found to vary by method of measurement, suggesting that further research be done on the validity of different tools (54).

There are also limited data on depression among adolescents in South Africa. This is of great concern as the youth population continues to grow. Identifying causal factors is an essential step to mitigating this serious public health problem. Further, it is important to look at how an issue as ubiquitous as income inequality in South Africa impacts its youth.

With more evidence on contributing factors, effective interventions to mitigate the effects of adolescent pregnancy and income inequality on the development of depression among the adolescent girls in South Africa is possible. Further, programs can be developed and integrated with antenatal care services to prevent these factors from having negative consequences for public health. There are clear gaps in the literature on these relationships in the unique country-context of South Africa that this research attempts to fill.

1.6 Aim

In order to address gaps in the literature, an analysis was conducted to examine the associations between adolescent pregnancy and income inequality with depression and their potential interaction leading to this outcome. This analysis addressed the question: Do adolescent pregnancy and income inequality interact to influence the incidence of depression among adolescent girls age 15 to 19 in South Africa?

1.7 Objectives

The following objectives were addressed to answer the research question:

1. To determine the characteristics of incident depression among adolescent girls in South Africa.
2. To investigate relationships between adolescent pregnancy and incident depression.
3. To investigate relationships between income inequality and incident depression.
4. To investigate the potential interactive effect of adolescent pregnancy and income inequality on incident depression.

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Unipolar depressive disorders were the second leading cause of morbidity among adolescent girls in Africa in 2012. Yet, little research has been conducted in sub-Saharan Africa to examine correlates and predictors of depression in this population. This study aimed to examine relationships between adolescent pregnancy, income inequality, and depression in a cohort of adolescent girls in South Africa from 2013 to 2017. Data from the National Income Dynamics Study were used to analyze a retrospective cohort. Pregnant adolescents and adolescent mothers were compared with non-childbearing adolescent girls over 2 years of follow-up. Logistic regression was used to examine relationships with incident depression and linear regression to examine relationships with depression severity. Results suggested that neither adolescent pregnancy nor income inequality were significantly related to incident depression. Adolescent pregnancy was marginally associated with experiencing more symptoms of depression. Further, none of the selected covariates showed significant relationships with incident depression or severity of depression. These findings were consistent with other studies. This study began to fill the gap in the literature on adolescent depression in South Africa. Further research, particularly prospective cohort studies, should be conducted to examine depression among adolescent mothers in sub-Saharan Africa. Such observational research may inform interventions for depression in this population.

Keywords:
Adolescent girls, Depression, Income inequality, South Africa, Adolescent pregnancy, NIDS

Between 2007 and 2017 global years lived with disability due to depressive disorders increased by 14.3% (13). Adolescents, defined as those between the ages 10-19, are at particular risk of developing depression and other psychopathologies due to being at a critical stage in their psychological, neurobiological, and sexual development, facing more stressors and changes than when they were children (16–19). This vulnerability was reflected in unipolar depressive disorders being the second leading cause of morbidity among adolescent girls in the World Health Organization's Africa region in 2012 (20). There were several psychosocial correlates of adolescent depression in both high- and low- and middle-income countries including being older (15-19 compared to 10-14), having ever been bullied, and being from an unsupportive household as measured by a composite score (24,25)

A few studies examining social determinants of adolescent depression suggested that income inequality may have been associated with depression in adolescents. Income inequality refers

to the extent to which a society is considered hierarchical, or a scale by which to measure the extent of the separation of classes (50). Pabayo and colleagues who analysed cross-sectional data of a sample of 1,878 adolescents from the US suggested that girls living in areas of high income inequality have been found to have greater risk of experiencing depressive symptoms compared to those in areas with lower income inequality (71,130).

South Africa is a country characterized by inequality (131,132). The country had the highest level of income inequality in the world in 2014 with a Gini coefficient of 0.63 (51). Adolescent pregnancy was also relatively common in South Africa with 43 births per 1,000 girls aged 15-19 being reported in 2017 (44).

In many different contexts, adolescent pregnancy has been found to be associated with greater odds of pre-natal, antenatal, and postpartum depression compared to adults and non-childbearing adolescents (93–98). It has also been found that adolescent pregnancy was related to income inequality in areas in the US with high levels of income inequality. Adolescents were more likely to fall pregnant in these areas than in those areas with lower inequality (60,61).

While it is well established that adolescents experience a high burden of depression globally, there is notably little prevalence data in sub-Saharan Africa on mental disorders in this age group (20,26). Further, there is a clear gap in the literature examining the relationship between income inequality and adolescent pregnancy as well as conflicting evidence on the relationship between adolescent pregnancy and depression (87,99,100).

It appears that the majority of evidence relating income inequality to higher rates of adolescent pregnancy is from high-income country contexts, with one exception from Brazil (66). This relationship has been left largely unexplored in low- and middle-income countries (65). Further, of the studies examining income inequality and depression in South Africa, it seems that none have examined adolescent depression, nor have they looked at the relationship between depression and pregnancy during the adolescent period (56,57,73,133).

Longitudinal data provide useful insights into the dynamics of depression over time as well as the incidence of depression (56,72,134). One notable study by Lund and Cois in South Africa used longitudinal data on depression to look at the nature of the relationship between

poverty and depression. They were able to examine that two dynamics were at play, those with depression at baseline were more likely to have become impoverished at follow-up as well as those who were impoverished at baseline were more likely to have developed depression at follow-up (134). Further, longitudinal data allows for an examination of consequences of depression in adolescence such as not completing secondary education, unemployment, and substance use (123,135).

More research into adolescent mental health must be done in South Africa. This study aimed to fill the gap in the literature by looking into the relationships between adolescent pregnancy, income inequality, socio-demographic characteristics, and depression among adolescent girls. The results from this study aimed to provide more insight into the incidence and severity of depression among adolescent girls in South Africa, and associated factors thereof.

2.1 METHODS

2.1.1 Participants

This cohort study was a secondary analysis of data from the South African National Income Dynamics Study (NIDS). The NIDS is an ongoing nationally representative panel study conducted by the Southern Africa Labour and Development Research Unit based at the University of Cape Town School of Economics. This study has collected data from all 9 provinces in South Africa to track inequality and related factors. These data include indicators associated with income and socioeconomic determinates as well as basic health data (136). The NIDS uses stratified two-stage cluster sampling of private households and those who live in workers' hostels, monasteries, and convents (136). Data are available from individual adults, households, and children (136). There have been several publications from the NIDS analysing mental health indicators (56,57,134,137–139).

Fieldworkers visited selected households and interviewed eligible individuals and followed-up with them every 2 years from 2008 to the most recent wave of surveys in 2018, as younger household members aged into the adult cohort every year (136). Members of households were defined as those who ate together and shared resources (136). All those who were eligible residents of the sampled households became a part of the NIDS sample (136). The

NIDS has been described and used in several previous publications (56,57,73,134,136–139) and more information on NIDS can be found on their website, <http://www.nids.uct.ac.za/>.

It was chosen to have 2 time points for each participant to properly address the research question, to examine the effect of adolescent pregnancy on depression over the 2 year follow up period by controlling for key baseline indicators. Previous studies suggested that a history of depression or depressive symptoms could predict future depression (79,85,102). In line with this epidemiological thinking, baseline depressive symptoms were controlled for as a confounder to further isolate depression as the outcome. Further, as the main exposure in the study, adolescent pregnancy was measured at follow-up in order to understand how the experience of the incidence of pregnancy and adolescent motherhood impacted the likelihood of developing depression during the study period. Whether or not a girl had experienced a pregnancy at baseline was controlled for as a confounder in order to isolate the analysis to examine the effect of pregnancy during the study period. As these key confounders were measured at baseline, this gave the study a quality of temporality, a key component of a cohort study design. *Figure 1* presents the temporal distribution of the exposures, outcomes, and covariates.

Having 2 time points also helped define the cohort as explained in further detail later in this section. Given the inclusion criteria, using just two waves of data from the NIDS did not yield a robust sample, therefore, data from 2 age cohorts were appended to create a larger sample, controlling for the cohort effect in the analysis (140). Though there were 5 waves of NIDS data available, the most recent 3 waves were chosen for this analysis. The idea behind drawing on the most recent waves was to utilize the most current data available. This allowed for conclusions that reflect the most current population of respondents to NIDS. Consecutive waves were chosen to ensure that girls in the sample were still young enough to be considered adolescents or young adults at follow-up.

The appended cohorts consisted of 49,261 participants. This study only included adolescent females aged 15-19 at the first time point. The NIDS only started interviewing participants for the adult surveys starting at age 15, making this our lower bound for adolescence. This inclusion criteria brought the sample size to 3,330. Further, those who reported having symptoms indicating depression were excluded from the sample in order to look at incidence, resulting in a sample of 2,816 adolescent girls without depression at baseline.

2.1.2 Measures

Primary exposure measures. A binary variable was created to indicate adolescent pregnancy at follow-up. This variable reflected whether an adolescent never had a pregnancy (no pregnancy) or was either currently pregnant or had ever given birth (pregnancy).

Income inequality was calculated using the p90/p10 score (141). This score was generated by taking the average upper 90th percentile of monthly income in a district municipality and dividing it by the mean of the lowest 10th percentile to get a proportion (57,67,141). These proportions were assigned to observations by the district municipalities in which they lived separately at follow-up and baseline. This method tests differences in relative income at the population level and has been thought to be more closely correlated to health differences at the local level than other measures of income inequality, such as the Gini coefficient (142).

Outcome measure. Depression was measured using the Center for Epidemiologic Studies Depression Scale-10 (CES-D). Participants responded to a list of 10 statements on a Likert scale from 0-3 to rate severity of depressive symptoms. Statements included, “during the past week I was bothered by things that usually don’t both me,” “during the past week I had trouble keeping my mind on what I was doing,” and “during the last week I felt depressed.” Using these ratings by participants, scores ranging from 0 to 30 signified depression symptom severity. Both the continuous measure and a binary variable for depression were used in the analysis. The CES-D has been widely used in South Africa previously and has been validated for a cut-off score of 10 signifying depression (33,56,57,121,133,134,137–139,143–146).

Covariates. Demographics, adolescent pregnancy-related, and income inequality-related covariates were explored for use in multi-variate models. These factors were selected referencing the literature relating adolescent pregnancy and depression and income inequality and depression. A directed acyclic graph was constructed using those selected factors available in the dataset (available in the *Web Appendix*) (147).

Demographics Participants' self-reported information on age, race (Black, White, Asian/Indian, or Coloured - the Apartheid system in South Africa created these racial categories which are still used in the national census as well as other statistical data in the country), province of residence, geography of residence (urban, farm, or traditional), and highest level of education attained at baseline and follow-up.

Adolescent pregnancy-related Participants self-reported the highest level of education attained by their mother and alcohol intake at baseline. A binomial variable was created in the same fashion as follow-up adolescent pregnancy to indicate pregnancy status as baseline. Baseline pregnancy was considered for inclusion in the model to preserve the effect of the experience of pregnancy and motherhood during the follow-up period on the development of depression. Further, an index was created to measure socioeconomic status (SES) by using the household asset index as used by Lund and Cois (73). This index was based on certain items present in the household, structural characteristics of the dwelling, and energy sources for the household (73).

Income inequality-related SES at follow-up was measured with the aforementioned index. Participants also self-reported information on monthly household income and employment status at follow-up.

2.1.3 Analysis

STATA CI-15 (Stata Corp LLC; College Station, Texas) was used for data cleaning, management, and analysis. Individual variables were tested to ensure randomness in missing data, including an analysis to ensure that missing data was not related to the outcome of incident depression. There was no association between missing data and demographic variables. Around 25% of the original sample, however, did not have observations at follow-up. Using a pooling test, it was determined that participants had missing follow-up data at random. Further, since there were multiple waves of the study, it was tested to see if participants who did not have observations at one point of follow-up could have observations at the next point to determine whether these participants were lost to follow up or just not available on the day the survey was administered. Some of these participants did indeed appear in later waves and therefore cannot be considered lost to follow up. It is reasonable,

therefore, to conclude that for these participants that appeared in later waves of the study it was by chance that they missed the collection of data for the follow-up wave in this study and this missing information introduces little bias. Participants who did not have an observation at follow-up were therefore dropped from the sample, which resulted in a final sample of 1,660 participants with observations both at follow-up and baseline.

An exploratory bivariate analysis was conducted to determine inclusion of covariates in the multi-variate models with two-sided *P*-values reported. Continuous variables were tested for normality and equal variance in each outcome group and appropriate bivariate methods were chosen. It was found that household monthly income was skewed to the right. To correct for this dramatic trend, monthly household income was log transformed. For categorical variables, Fisher's exact and Chi-squared tests were conducted based on category size. Variables that were significantly related to binomial adolescent pregnancy, were included in the final models.

Logistic regression was conducted to test for associations between incident depression and adolescent pregnancy and income inequality. Linear regression was conducted to test for associations with continuous CES-D scores and exposures. Robust standard errors were used in the analysis to account for the clustering of participants within households due to the nature of the sampling method in the primary study. Further, NIDS-defined design weights were applied to both types of models to adjust for the sampling method of the survey.

Models were built by first running the regression on the exposures of interest and the outcome, then h demographic variables were added, and finally all other covariates.

2.1.4 Ethics

Ethics approval for the NIDS was originally granted by the University of Cape Town Faculty of Health Sciences Human Research Ethics Committee in 2007 and was extended by the same committee in 2017. The protocol for this study was reviewed and granted ethics approval by the University of the Witwatersrand Human Research Ethics Committee (Medical) prior to the initiation of analysis in 2019.

2.2 RESULTS

The mean age of the participants at follow-up was 19.6. This is higher than the definition of the cohort because the cohort was defined at baseline and therefore at follow up, participants will be two years older. The majority of participants in the sample were Black, 86.6%, compared to 13.4% of other races, Coloured, Asian/Indian, and White. Half (50.3%) of the sample lived on traditional lands with only 5.1% on farms and the other 44.6% in urban areas. Most participants (69.7%) had not finished high school, similar to their mothers with 78.0% having not finished high school. At baseline, 85.7% of participants had not had a pregnancy, and the mean baseline depression score was around 4.3 out of 30.0 (Tables 1 and 2).

There was an even distribution of participants between SES levels. At follow-up, however, it appears there was a drift from the high SES bracket to the middle bracket as it grew to 45.1% from 30.4% (Tables 1 and 2).

Baseline pregnancy, age, province and geography of residence, education level, SES at baseline and follow-up, and household income all demonstrated overwhelmingly significant associations with adolescent pregnancy in the bivariate analysis ($P < 0.001$) (Table 2).

2.2.1 Adolescent pregnancy, income inequality, and incident depression

Among those who had no pregnancy, 17.5% were depressed at follow-up and 20.7% of those who had had a pregnancy were depressed at follow-up ($P = 0.126$). While there was an apparent difference in frequency of incident depression between those who had had a pregnancy and those who had not, there was only a 0.1-point difference in mean income inequality score between those who were and were not depressed ($P = 0.796$) (Table 1).

Income inequality was found to be significantly associated with adolescent pregnancy in the bivariate analysis ($P = 0.004$), strengthening the case for a potential interactive effect (Table 2). In Model 1a, however, neither adolescent pregnancy nor income inequality were found to

be significantly associated with incident depression (adolescent pregnancy OR = 1.43, 95% CI: 0.967 , 2.15 ; income inequality OR = 0.99, 95% CI: 0.96 , 1.03) (Table 3).

The effect size of income inequality on the odds of acquiring did not shift when adding covariates and remained insignificant in models 1a, 1b, and 1c (Table 3). The odds of depression associated with adolescent pregnancy increased from 1.43 when adding covariates to 1.49 in the fully adjusted model, however, the relationship remained insignificant (95% CI: 0.94 , 2.39). None of the other covariates were found to be significantly associated with incident depression in the model (Table 3).

2.2.2 Adolescent pregnancy, income inequality, and depression symptom severity

The average CES-D score among those who had had a pregnancy was 6.3 while those who had never had a pregnancy has a mean score of 5.8. This association was overwhelmingly significant in the bivariate analysis ($P = 0.006$). Income inequality also demonstrated marginal significance with CES-D score in an unadjusted linear regression where CES-D increased by an average of 0.04 points with every increase of 1.00 in income inequality score ($P = 0.078$) (Table 1).

Though in Model 2a, adolescent pregnancy was found to be significantly associated with CES-D score (Coef. = 0.67, 95%CI: 0.05 , 1.30) income inequality remained insignificant (Coef. = 0.03 , 95% CI: -0.02 , 0.09).

In the fully adjusted model, the effect size of adolescent pregnancy on CES-D score increased with those being pregnant having a score 0.71 points higher on average (95% CI: -0.01 , 1.44). Adolescent pregnancy, however, was only marginally significant in the fully adjusted model. Income inequality remained insignificant as its effect size diminished to 0.02 (95% CI: -0.04 , 0.08). None of the other covariates displayed a relationship with CES-D score, only adolescent pregnancy (Table 4).

2.3 DISCUSSION

This study suggested several important findings. First, adolescent pregnancy was found to be marginally associated with depression severity in adjusted models among this sample of adolescent girls in South Africa. Those who were pregnant at follow-up had depression scores that were 0.71 points higher on average than those adolescents who were not pregnant (95% CI: -0.01 , 1.44). Second, income inequality did not demonstrate any significant impact on depression score in any of the tested models. Third, neither adolescent pregnancy nor income inequality were found to be associated with the incidence of depression.

Previous studies suggested conflicting evidence of a relationship between adolescent pregnancy and depression severity (94,100,150). Data from Lara et al in Mexico in 2012 suggested that adolescent pregnancy had a significantly positive relationship with symptoms of depression (89). Depressive symptoms were more frequent in this study among adolescent mothers in the second trimester of pregnancy compared to those who had never been pregnant or those who were postpartum (89). This came in contrast with evidence from two cohort studies in the US that found changes in mental health scores did not significantly differ between adolescent mothers and non-childbearing adolescents from a nationally representative cohort and a population-based cohort in the US (100,148). The results of our analyses fit with those of the other cohort studies reporting no significant difference in changes in mental health. It should be noted, however, that Lara et al and the nationally representative US cohort also used a symptom scale to measure depression, whereas the population-based cohort used DSM-IV criteria (89,100,148). It has been found that prevalence estimates of depression among adolescents tend to be higher when using symptom scales (11). Given this trend it is noteworthy that our analysis and the nationally representative US cohort both reported no significant relationships as the measurement tools used lend themselves to bias results away from the null.

The finding that income inequality was not related to severity of depression has been corroborated by previous studies. One nationally representative study in the US and one focused on the Boston metro area reported no significant relationship between neighbourhood-level income inequality and depression severity among adolescents (71,76). The study in Boston did find an interaction between income inequality and sex. In this study adolescents girls in income unequal areas had more depressive symptoms than girls in income equal environments as well as boys in income unequal environments (71). Notably, another study in South Africa also found no significant relationship with depression severity

and income inequality, but in adults (56). These studies used the Gini coefficient, however, to measure income inequality which as discussed, is not thought to be as closely correlated to health outcomes (56,70,71,76,149). Validation studies should be done to find the best method of measuring income inequality to observe its relationship to depression.

The literature has not agreed about adolescent pregnancy's relationship to depression as a binary outcome. Comparing adolescent mothers with adult mothers, two separate studies found no relationship between adolescent pregnancy and poor mental health or depression (99,150). A study of women in Sweden in 2019, however, found mothers aged 20 and younger were about twice as likely to be depressed compared to mothers who were 21 and older (91). Another study in South Africa among adult women found a significant relationship between age at birth and depression, as those who were younger had greater odds of depression during pregnancy (151). Different comparison groups provide answers to different questions. When comparing adolescent mothers to non-childbearing adolescents, such as was done in our analyses, a study is addressing whether pregnancy is a significant factor for depression, however, when compared to pregnant adults, a study is addressing whether adolescence increases your risk for depression during pregnancy. While there are insights to be gained from observing relationships in studies comparing adolescent mothers to adult mothers, our study remains unique from these which accounts for differing results.

Our finding related to income inequality and incident depression also added to a base of literature that is in disagreement. Cross-sectional data has reflected more conflicting evidence of a relationship between income inequality and depression (70,149). A study in Brazil found that high income inequality was associated with a greater risk of depression in adults. This was especially true for women, as it was found that they were significantly more likely than men to have depression in income unequal areas (70). In Korea, however, it was found that income inequality was not significantly associated with depression (149). Another study in South Africa, that also used data from NIDS, found a significant relationship between income inequality and depression and measured income inequality with the P90/P10 ratio, as in this study (57).

One surprising trend found in our analyses was the direction of association of income inequality to depression. Though this relationship was not statistically significant, there was a decrease in the odds of depression with increasing income inequality. Though also

insignificant, income inequality had a positive relationship with depressive symptoms with an average 0.021-point increase with increasing income inequality. This was consistent with past studies in South Africa looking at income inequality and depression severity (56). These relationships call for further social epidemiological investigations into income inequality's effect on mental health in South Africa. The insignificance of the relationship of income inequality and depression may be due to the lack of racial diversity in the sample as 88.6% of the sample was Black compared to 0.7% being Asian/Indian. Given the nature of race as a proxy for other socially determined factors, it is possible that this study was not able to capture the true range of income levels due to this limitation. It would be useful if future nationally representative samples, could examine income inequality and depression, making sure that all races are represented proportionally. Further, as mentioned previously, the differing methods of measurement for income inequality could have led to these differing conclusions.

2.3.1 Strengths and limitations

Though this study failed to identify relationships between adolescent pregnancy, income inequality, and incident depression, it added to current knowledge on depression among adolescents by ruling these factors out. Further, adolescent pregnancy was a marginally significant risk factor for greater depression severity in adolescent girls in South Africa. These findings inform further research into causal factors of depression among adolescent girls. This study added another dimension to the growing body of literature about the impact of income inequality on mental health in South Africa as previous studies only looked at depression among adults, making this the first to investigate this relationship among adolescents in the country (56,57,73,133).

The nature of the study being a secondary analysis posed some limitations to the study. There were several variables that were not measured for in the NIDS that were relevant. The most important variables missing were those factors that had been found to be related to adolescent pregnancy and depression in other studies (82,86,90,92,102–104,106,108–118,120,152). Social support was found by many studies, including studies in Africa, to have a significant relationship with depression among pregnant adolescents (86,90,92,102,104,108–114,152). Further, there was no direct data on intimate partner violence, something that is very

important in the South African context due to the high prevalence of such cases. Several studies had found relationships between experiences of childhood trauma, intimate partner violence, and depression among adolescent mothers, indicating that these factors are important when looking at this outcome (82,108,112,115–118,120). There was also a lack of information on whether pregnancies were planned or unwanted, another factor found to be relevant to the potential relationship between adolescent pregnancy and depression (103,106,152).

The secondary nature of this analysis also meant that the sample size could not be controlled. As mentioned in the methods, since this was a sub-sample of NIDS, this analysis was under powered. This could have biased the results and be an explanation why no strong associations were found.

This study was vulnerable to several biases. Due to the nature of how the data was collected, there was the possibility of both interviewer and recall bias impacting the data. Under reporting of symptoms of depression and or adolescent pregnancy could have biased the results towards the null. In a systematic review in 1999 Newell et al found that self-reported measurement of health risk factors yielded results that dramatically under estimated the risk of disease in the general population (153). It is possible that this type of bias was an issue here too given the stigma of mental health problems as well as adolescent pregnancy that are often common in a variety of communities. Further, recall bias could have resulted in under or over reporting of monthly income, skewing the income inequality and household income estimates either towards or away from the null. Further, interviews were done on particular days, causing some household members to miss the interview should they have been out of the house. Though it was found that those who did not have a second interview had such at random, this still could have had a significant impact on the results and have implications for the generalizability of the study to the study population. Further, it was investigated if those who did not have a second interview shared any common characteristics and it was found that they did not, strengthening the case for generalizing to the study population. Since this study used a sub-sample of the NIDS, its generalizability outside of the study population was limited, and the widespread loss to follow up also challenged this as it further undermined the representative nature of the sample methods.

The way several key variables were measured could have also biased the results. It has been found that the association of depression and income inequality varied by the measure of income inequality used, therefore, should another measure have been used, the results could have differed (53). Further, data from the NIDS were used to calculate income inequality at the district level, introducing bias, as the NIDS was designed to only be representative at the national level. Similar to income inequality, measurement of depression in adolescents using a symptoms scale, such as the CES-D, has been shown to result in a higher prevalence measures than other methods (11). Finally, race was not controlled for in the final models, due to the previously mentioned overly dominant representation of Black Africans.

2.3.2 Implications

There is research that has reported poor outcomes for children born to adolescent mothers with depression such as, low birth weight and pre-term birth among others (80,87,92,95,109,126,154,155). Further, there were consequences for the mother such as increased risky sexual behaviors and even suicide (48,80,156–158). Research into causal factors of adolescent depression, especially among adolescent mothers, is important in order to understand how it can be prevented to avoid such consequences. More small-scale studies collecting specific information from adolescents in individual communities could help pin-point factors while respecting the heterogeneity of communities in South Africa. This study can be seen as the first step towards a deeper understanding of how adolescent pregnancy is related to depression and the impact of the adolescent's economic context on such. In this population adolescent pregnancy was only marginally related to depression and the level of income inequality in the area in which they lived did not have an apparent impact. These results can be seen as the broad strokes for a deeper understanding of these factors in South Africa.

2.4 Tables and figures

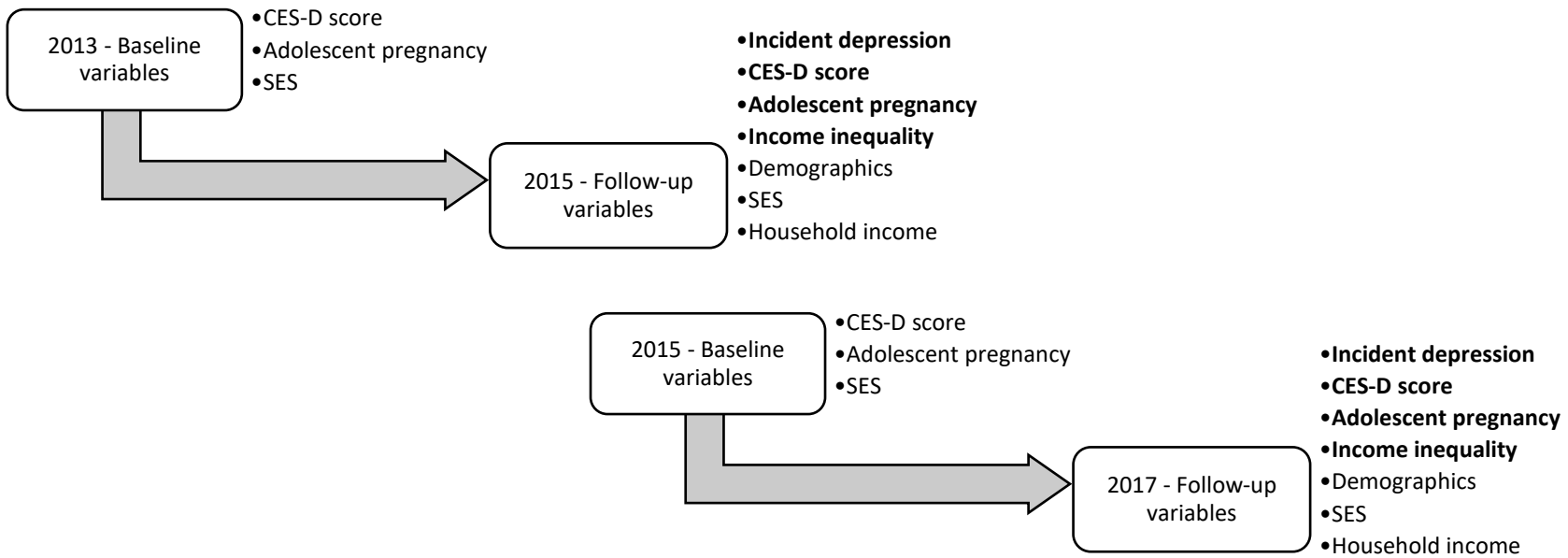

Figure 1 Temporal distribution of exposures, outcomes, and covariates

Table 1. Descriptive statistics by incidence of depression

Measure	Overall sample			Not depressed (n = 1,339)			Depressed (n = 306)			*P* value	CES-D score		*P* value
	No.	%	Mean/Median (SD/IQR)	No.	%	Mean/Median (SD/IQR)	No.	%	Mean/Median (SD/IQR)		Mean	Coef. (95% CI)	
Baseline depression score			4.3 (2.5)			4.3 (2.5)			4.3 (2.5)	0.759		0.03 (-0.04 , 0.11)	0.377
Baseline adolescent pregnancy										0.047			0.178
No pregnancy	1,423	85.7		1,158	86.5		251	82.0			5.9		
Pregnancy	237	14.3		181	13.5		55	18.0			6.4		
Adolescent pregnancy										0.126			0.006
No pregnancy	1,084	65.3		886	82.5		453	79.3			5.8		
Pregnancy	576	34.7		188	17.5		118	20.7			6.3		
Income inequality			8.7 (7.4 , 11.2)			8.6 (7.3 , 11.2)			8.7 (7.3 , 10.4)	0.796		0.04 (-0.01 , 0.09)	0.078
Age			19.6 (1.1)			19.6 (1.1)			19.6 (1.2)	0.982		0.06 (-0.11 , 0.23)	0.514
Race										0.066			0.023
African	1,438	86.6		1,160	86.7		264	86.3			6.1		
Coloured	199	12.0		165	12.3		33	10.8			5.3		
Asian/Indian	11	0.7		7	0.5		4	1.3			6.7		
White	12	0.7		7	0.5		5	1.6			7.2		
Geography										0.182			0.472
Traditional	835	50.3		685	51.2		141	46.1			5.9		
Urban	740	44.6		589	44.0		145	47.4			6.0		
Farms	85	5.1		65	4.8		20	6.5			6.5		
Education										0.212			0.994
Less than high school	1,155	69.7		925	69.2		222	73.0			6.0		
Completed high school or beyond	501	30.3		412	30.8		82	27.0			5.9		
Baseline SES										0.188			0.020

Low	562	34.2		465	35.0		89	29.6			5.6	
Middle	501	30.4		398	29.9		100	33.2			6.1	
High	583	35.4		467	35.1		112	37.2			6.2	
Follow-up SES										0.263		0.003
Low	547	33.4		451	34.2		89	29.4			5.6	
Middle	737	45.1		587	44.6		144	47.5			6.1	
High	351	21.5		279	21.2		70	23.1			6.4	
HH Income			4,497.2 (2,664.3 , 8,165.7)			4,590.0 (2,722.9 , 8,500.0)			4,267.3 (2,550.0 , 6,873.7)	0.086	-0.36 (-0.57 , -0.15)	0.001

Abbreviations: SD, standard deviation; IQR, inter-quartile range; No., number; Coef., coefficient; CI, confidence interval; SES, socio-economic status; HH, household.

Table 2. Descriptive statistics by adolescent pregnancy

Measure	Overall sample (N = 1,660)			No pregnancy (n = 1,084)			Pregnancy (n = 576)			
	No.	%	Mean/Median (SD/IQR)	No.	%	Mean/Median (SD/IQR)	No.	%	Mean/Median (SD/IQR)	*P* value
Baseline depression score			4.3 (2.5)			4.2 (2.5)			4.5 (2.6)	0.007
Baseline adolescent pregnancy										<0.001
No pregnancy	1,423	14.3		1,077	99.4		346	60.1		
Pregnancy	237	85.7		7	0.6		230	39.9		
Income inequality			8.7 (7.4 , 11.2)			8.7 (7.4 , 11.6)			8.6 (7.3 , 9.8)	0.004
Age			20.0 (19.0 , 21.0)			19.0 (19.0 , 20.0)			20.0 (19.0 , 21.0)	<0.001
Race										0.307
African	1,438	86.6		937	86.4		501	87.0		
Coloured	199	12.0		128	11.8		71	12.3		
Asian/Indian	11	0.7		10	0.9		1	0.2		

White	12	0.7		9	0.9		3	0.5	
Geography									<0.001
Traditional	835	50.3		509	47.0		326	56.6	
Urban	740	44.6		523	48.2		217	37.7	
Farms	85	5.1		52	4.8		33	5.7	
Education									<0.001
Less than high school	1,155	69.7		717	66.3		438	76.3	
Completed high school or beyond	501	30.3		365	33.7		136	23.7	
Baseline SES									<0.001
Low	562	34.2		411	38.3		151	26.4	
Middle	501	30.4		322	30.0		179	31.3	
High	583	35.4		341	31.7		242	42.3	
Follow-up SES									<0.001
Low	547	33.4		393	36.8		154	27.2	
Middle	737	45.1		459	43.1		278	48.9	
High	351	21.5		215	20.1		136	23.9	
HH Income			4,497.2 (2,664.3 , 8,165.7)			4,942.1 (2,655.0 , 9,008.3)			4,000.0 (2,685.0 , 6,636.9)	<0.001

Abbreviations: SD, standard deviation; IQR, inter-quartile range; No., number; SES, socio-economic status; HH, household.

Table 3. Adolescent pregnancy and income inequality regressed against incident depression

Covariates	Model 1a			Model 1b			Model 1c		
	OR	**95% CI**	***P* value**	**OR**	**95% CI**	***P* value**	**OR**	**95% CI**	***P* value**
Adolescent pregnancy									

No pregnancy	(ref)			(ref)			(ref)		
Pregnancy	1.43	0.97 , 2.15	0.081	1.46	0.96 , 2.24	0.078	1.49	0.94 , 2.39	0.093
Income inequality	0.99	0.96 , 1.03	0.776	0.99	0.95 , 1.03	0.529	0.99	0.95 , 1.03	0.517
Age				1.07	0.89 , 1.27	0.484	1.06	0.88 , 1.28	0.508
Geography									
Traditional				(ref)			(ref)		
Urban				1.20	0.81 , 1.80	0.366	1.21	0.80 , 1.82	0.361
Farms				1.86	0.92 , 3.77	0.083	1.87	0.92 , 3.83	0.086
Education									
Less than high school				(ref)			(ref)		
Completed high school or Beyond				1.14	0.72 , 1.80	0.570	1.12	0.71 , 1.77	0.621
Baseline SES									
Low				1.06	0.65 , 1.74	0.806	1.08	0.66 , 1.76	0.754
Middle				1.39	0.87 , 2.22	0.165	1.38	0.87 , 2.20	0.175
High				(ref)			(ref)		
Follow-up SES									
Low				0.73	0.43 , 1.25	0.258	0.72	0.41 , 1.28	0.264
Middle				1.27	0.78 , 2.06	0.329	1.25	0.78 , 2.02	0.350
High				(ref)			(ref)		
HH Income							0.99	0.80 , 1.24	0.978
Baseline adolescent pregnancy									
No pregnancy							(ref)		
Pregnancy							0.92	0.51 , 1.66	0.782
Baseline depression							0..98	0.91 , 1.05	0.513

Abbreviations: OR, odds ratio; CI, confidence interval; ref, reference category; SES, socio-economic status; HH, household.

Table 4. Adolescent pregnancy and income inequality regressed against depressive symptom severity

Covariates	Model 2a			Model 2b			Model 2c		
	Coef.	**95% CI**	***P* value**	**Coef.**	**95% CI**	***P* value**	**Coef.**	**95% CI**	***P* value**
Adolescent pregnancy									
No pregnancy	(ref)			(ref)			(ref)		
Pregnancy	0.67	0.05 , 1.30	0.034	0.66	0.01 , 1.31	0.046	0.71	-0.01 , 1.44	0.055
Income inequality	0.03	-0.02 , 0.09	0.255	0.02	-0.04 , 0.08	0.448	0.02	-0.04 , 0.08	0.496
Age				0.08	-0.18 , 0.33	0.554	0.07	-0.20 , 0.33	0.621
Geography									
Traditional				(ref)			(ref)		
Urban				0.22	-0.39 , 0.83	0.475	0.22	-0.40 , 0.85	0.482
Farms				0.87	-0.34 , 2.09	0.159	0.90	-0.34 , 2.14	0.155
Education									
Less than high school				(ref)			(ref)		
Completed high school or beyond				0.17	-0.49 , 0.83	0.612	0.18	-0.50 , 0.85	0.607
Baseline SES									
Low				-0.26	-1.02 , 0.50	0.503	-0.25	-1.03 , 0.53	0.531
Middle				-0.05	-0.81 , 0.70	0.893	-0.06	-0.82 , 0.70	0.879
High				(ref)			(ref)		
Follow-up SES									
Low				-0.45	-1.27 , 0.37	0.283	-0.40	-1.26 , 0.46	0.362
Middle				0.01	-0.73 , 0.75	0.976	0.02	-0.74 , 0.77	0.961

High	(ref)	(ref)		
HH Income		-0.08	-0.44 , 0.29	0.681
Baseline adolescent pregnancy				
No pregnancy		(ref)		
Pregnancy		-0.12	-1.10 , 0.87	0.814
Baseline depression		0.01	-0.10 , 0.12	0.860

Abbreviations: Coef., coefficient; CI, confidence interval; ref, reference category; SES, socio-economic status; HH, household.

2.5 Footnotes

2.5.1 Abbreviations

CI – Confidence interval

HH – Household

IQR – Inter-quartile range

NIDS – National Income Dynamics Study

No. – Number

OR – Odds ratio

Ref – reference category

SD – Standard deviation

SES – Socioeconomic status

Coef. – Coefficient

2.5.2 Correspondence address

ATTN: Madelyn B. Goodman

51 2193, 60 York Road

Parktown, Johannesburg, 2193

2.6 Web appendix

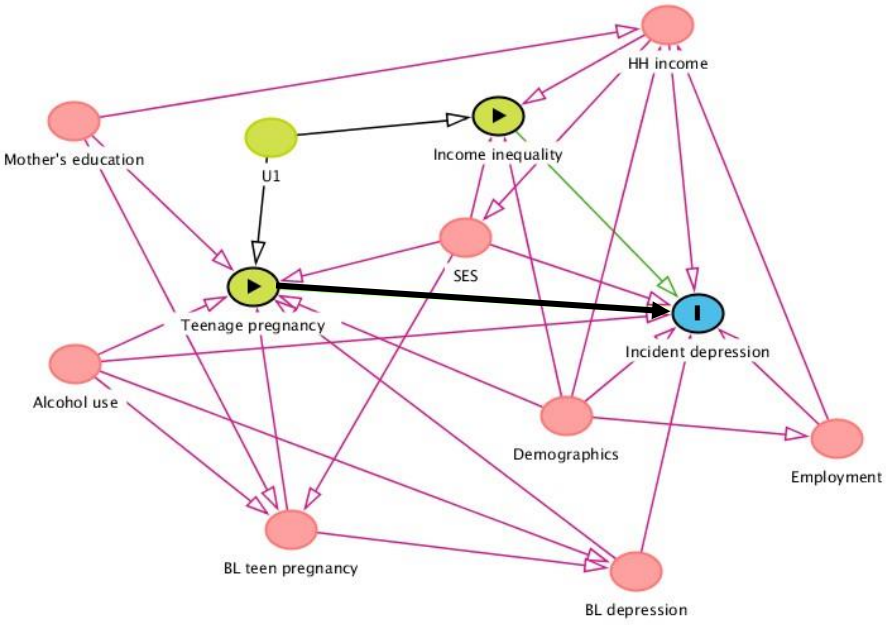

Figure 2. Directed acyclic graph

U1: Hypothesised interactive relationship; BL: Baseline

2.7 Appendix: Author guidelines for manuscript submission to the *American Journal of Epidemiology*

Correspondence and Manuscript Submission

Manuscripts must be submitted online in a double-spaced, blinded format, with pages numbered, in at least 12-point type, do not insert line numbers. Any manuscript without page numbers will not be considered and will be returned immediately to the author. Please note that a lack of proper formatting, spelling, and reference citations will slow down a paper's review and its ultimate disposition, so these items should be checked before submission. Once the manuscript has been prepared according to the information below, please visit this page to submit. Please follow this link for instructions on how to submit your manuscript online.

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Note: The abstract must be limited to 200 words . The *Journal* does not use structured abstracts. Type the abstract as 1 double-spaced paragraph.

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Second-level headings are flush left with only the first letter of the first word uppercased. Do not underline.

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Letters, numbers, decimal points, and symbols should be large enough and sharp enough to be readable when figures are reduced and scanned (no smaller than 8 pt in print). All figures will be reduced to fit either in 1 column or within the 2-column width of the Journal page. On maps, add scale (in kilometers or meters) and direction north.

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References to personal, written communications should be inserted in parentheses in the text rather than in the reference list. Give the person's name, institutional affiliation, "personal communication," and the year. Verbal communications are not acceptable as supporting documentation.

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Chapter three: Extended methods

3.1 Chapter overview

In this chapter, the methods outlined in the *Manuscript* chapter will be expanded upon. As this retrospective cohort study used secondary data, the methods of the primary study will also be explained further.

3.2 Primary study

3.2.1 Study design

As presented in the *Manuscript* chapter, data from the NIDS were used in this secondary analysis. De-identified data from all five waves of the study are available on an open access platform, Data First. The relevant waves were simply downloaded to the primary investigator's computer for analysis.

The NIDS is an ongoing nationally representative longitudinal panel study in South Africa. This survey to investigates changes in "incomes, expenditures, assets, access to services, education, health, and other dimensions of wellbeing," throughout the country (136). The sample was designed to be representative at the national level, not the provincial or district levels (136). Data collection started in 2009 with 28,255 participants from 7,305 sampled households (136).

The NIDS includes both individual adult surveys as well as household surveys to collect information on matters involving participants' living situations. An early paper on the study's methods defined its target population as "private households and residents in workers' hostels, convents, and monasteries," (p. 10). Stratified two-stage cluster sampling was used to select these households. Individuals were considered as living in the same household if they shared resources and food. All household members were included in the sample if at least one person agreed to participate in the study (136).

In the most recent wave of the study, it was found that attrition over the course of the previous waves was substantial enough to negatively affect the efficacy of the sample size.

Additional participants were therefore sampled and included in the sample of the 2017 survey to maintain a robust sample size (159).

3.2.2 Data collection

Fieldworkers attended a one week training ahead of the commencement of data collection. Fieldworkers interviewed all eligible participants in each sampled household using a standardized questionnaire and recorded responses systematically. A non-respondent household was one where a fieldworker visited the house three different times on three different days and no one was present at any visit. It was attempted to match fieldworkers to households on language and race to ensure that respondents were as comfortable as possible, however, this was not always possible. Data collection has been conducted every two years starting in 2009 until the most recent wave of data collection in 2017 (136).

3.3 Secondary study sample selection

3.3.1 Construction of the cohort/analytical sample

As mentioned above, the NIDS has conducted repeated surveys every two years between 2009 and 2017. Data from the most recent waves, 2013-2015 and 2015-2017, were chosen for use in this study to provide a more accurate insight into what is currently happening in South Africa. Though the UNFPA defines adolescents as those 10 to 19 years old, the adult survey in the NIDS only collects data on those 15 and older, therefore, this restricted our sample to focus on older adolescents. Those who were 17-19 in 2013, who would have been outside the age cohort in 2015, were added to the sample along with their follow-up data from 2015 in order to bolster the sample size due to insufficient numbers meeting the inclusion criteria with just the one wave cohort. Using prevalence measures from a study comparing depressive symptoms in adolescents and adults in Nigeria as a reference, the parameters used to calculate the power of the sample size were 7.0% prevalence of depression among adolescents who had not experienced a pregnancy and 18.0% depressed among those who had been pregnant as adolescents (87). Before adding the second age cohort, the sample size was 1,033 with a power of 99.8%. Once the 2013 to 2015 cohort was added to the sample, the sample size increased to 1,660 with the power remaining at 100%. With these reference proportions, a sample size of 400 would have sufficed.

Since secondary data were used, the actual power of the sample was calculated using the parameters of the dataset with 17.5% prevalence of depression among non-childbearing adolescents and 20.7% among those who had experienced an adolescent pregnancy. Using these parameters, the sample of 1,660 adolescent women had a power of 28.6%. It was found that to precisely detect a difference between these groups, a sample of 6,392 would have been required. The power of the sample was also calculated to compare mean depression score between the two groups. The power under these circumstances turned out to be 64.2%. Though this still did not indicate a robust enough sample size, the continuous outcome provided slightly more rigor than the binary outcome given the size of the sample.

Even though the sample size with just one age cohort had enough power using these estimates, it was still decided to use the appended dataset. Because the data were available and already cleaned, it was decided that the extra rigor these additional observations added to the analysis were worth risking the relatively small amount of bias it added to the study.

Combining two cohorts ran the risk of the analysis being impacted by the cohort effect. This type of bias relates to the assumption that different age cohorts are affected by specific factors having to do with the period in which they were developing, leading to latent confounding (140). In order to control for this, a variable was created to indicate which cohort each participant was a part of. For example if the participant's observations were from the 2013 to 2015 cohort, they would receive a value of one, to differentiate them from those whose observations were from the 2015 to 2017 cohort who were assigned a value of two. The cohort variable was included in all models to control for this latent confounding.

NIDS data downloaded from Data First came with different datasets for individual adults, children, households, and other derived information from the households. All such datasets were linkable to a single participant through individual and household ID numbers assigned during NIDS data collection.

For each separate wave and cohort of the study, variables from the adult questionnaire were labelled as baseline or follow-up in order to cohesively append cohorts. Variables were created for age based on the year the data were collected and the year the participant was born. From here, information about the district and province the participant was from was

added to the dataset from the household derived data file. Only relevant variables were kept, renamed, then merged with the individual data based on household ID. The data had to be merged many to one as some participants were from the same household. Information from the household questionnaire was also added to the dataset in the same fashion.

Another variable was created to indicate which wave the data were extracted from. For example, if the observation was from the 2013 wave of the study that would be indicated with a 3, and observations form the 2015 wave of the study were indicated as 4 and so on. After all the household information was added to the individual data, the baseline and follow-up waves were merged one-to-one based on individual ID. Because two cohorts were being combined, the same data management procedure was followed with the 2013 data as the baseline and 2015 data as the follow-up for those in that cohort. The only difference in this procedure was mentioned above; those who were aged 17 to 19 specifically in 2013 were kept, as these girls would have aged out of the cohort by 2015 and therefore would not have been included originally.

3.3.2 Inclusion criteria

Girls aged 15 to 19 at baseline and with a CES-D score of less than 10 were included in the study. The aim of this study was to investigate incident depression, therefore, anyone who already had depression had to be excluded from the sample.

If it was found through data cleaning that one participant reported being female at baseline and male at their second interview. This observation was dropped as the main exposure of interest, adolescent pregnancy, required the possibility of being pregnant at follow-up, which this individual would not have had.

Below is a flow chart presenting how the cohort was assembled as well as the inclusion and exclusion criteria for the analytical sample. Once all the inclusion criteria were applied to the dataset, 2,816 participants comprised the analytical sample.

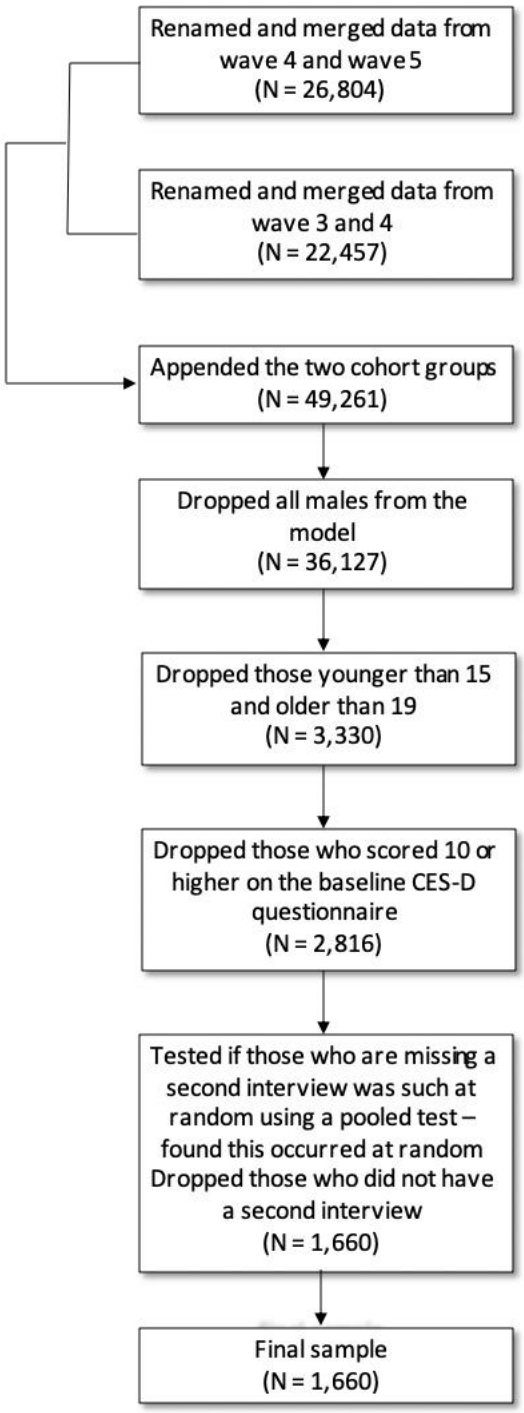

Figure 3.1 Flow chart of inclusion and exclusion criteria to create the sample

3.4 Missing data

3.4.1 Variables

The amount of missing information for each variable was assessed by tabulating the proportion of missing values. To determine whether or not imputation was necessary,

variables with 5.0% or fewer missing observations were to be left alone, while those with 5.0% or more missing values were to be imputed using multiple imputation. This assessment was first done with the variables used to create the CES-D score in order to be sure that the scores used in the exclusion criteria were accurately calculated. In testing all of the variables to be used in the analysis, there were no variables with missing observations in excess of 5.0% and, therefore, use of multiple imputation was not needed.

3.4.2 Follow-up data

1,156 participants had information at baseline, but did not have a follow-up interview. A variable was created to mark those with missing data at follow-up using the gender variable as a reference.

The data were tested for the possibility of having an interview at one wave, missing the interview for the next wave, then having an interview at the subsequent wave. This was to assess if participants without data at follow-up were truly lost to the sample, or if they simply did not have an interview at that time point. This was the case for 6.1% of participants with a missing interview at follow-up. Further, it could not be assumed that the rest of those without a second interview would be lost to follow-up in the subsequent surveys, demonstrating a limitation of using only two time points.

In order to determine if this data were missing at random or not, a pooling test was done. This analysis compared the coefficients at baseline with and without the data from those without a second interview to see if there was a significant difference (160). This test was chosen as it is generally useful for determining whether inverse probability weighting is necessary to impute missing data (160). This test involved performing a regression using depression score at baseline as the outcome and each variable, including one representing having had a missing second interview, and interaction variables of each variable with the one representing no interview at follow-up. An F-test was performed on this regression to see whether or not having a second interview and each interaction variable were jointly equal to zero. This test concluded that not having a second interview in fact occurred at random, coefficients with and without those without follow-up data did not differ significantly. Thus, those lacking a

follow-up interview were dropped from the sample, making the final sample size for analysis 1,660 participants.

3.5 Measures

3.5.1 Primary exposures

Adolescent pregnancy was the main exposure in this study. This was measured at follow-up in order to understand how the experience of the incidence of pregnancy and adolescent motherhood impacted the likelihood of developing depression during the study period. As explained in more detail later on in the *Methods*, whether or not a girl had experienced a pregnancy at baseline was controlled for in order to make sure the analyses were focusing on the effect of pregnancy during the study period. A binary variable was created using self-reported data on whether the girl was currently pregnant or had ever given birth, or had never been pregnant. Those who were not currently pregnant and had never given birth were defined as having "no pregnancy," while those who were currently pregnant or had given birth were defined as "pregnancy." Grouping those who were currently pregnant with those who had already given birth reflected the general lived experience of having been pregnant as an adolescent.

Income inequality was investigated as a second main exposure to interact with adolescent pregnancy. Income inequality was calculated using the P90/P10 score as Burns, Tomita, and Lund did in their analysis on income inequality's impact on depression among adults in South Africa using the NIDS (57). This score was calculated and assigned to participants by municipal district of residence. In order to get the most accurate score possible, the full datasets for each wave were used to get wave-specific scores for each district.

In order to calculate the P90/P10 score, the mean of the top ninetieth percentile of household incomes was divided by the mean of the bottom tenth percentile to get a proportion. It had been found that this method was most useful when used to measure relative incomes on a smaller scale, rather than the Gini coefficient, another commonly used measure globally (142). This score was calculated both at baseline and follow-up.

The data were assigned to each participant based on the wave their observations were from and the district municipality they lived in at follow-up. This variable was left as continuous in order to get an accurate measure of the relative income inequalities in each district municipality rather than ranking it as high, middle, and low. It was decided that income inequality at follow-up would be used in the analysis. Depression was measured at follow-up, thus participants' environment at that time would most impact how they would answer the CES-D questions.

3.5.2 Outcome

The NIDS coded CES-D component question responses one to four rather than the convention of zero to three, as in most manuals of how to use the CES-D (161). These variables thus had to be recoded in order to properly calculate the depression score. Further, some components needed to be reverse coded. Questions such as, "during the past week, I felt hopeful about the future," and, "during the past week I was happy" had to be reassigned reverse values. Other questions in the CES-D included: during the past week, "I was bothered by things that usually don't bother me," "I had trouble keeping my mind on what I was doing," "I felt depressed," "I felt that everything I did was an effort," "I felt fearful," "my sleep was restless," "I felt lonely," and "I could not 'get going'." As mentioned previously, each variable was assessed for proportion of missing values prior to constructing the score. As participants responded to these questions on a Likert scale that was recoded from zero to three, responses were summed to create a score for level of depressive symptoms at baseline and follow-up (161).

The CES-D was validated in South Africa among Zulu, Xhosa, and Coloured Afrikaans speaking populations. It was found, however, that different populations had differing optimal cut-off scores (146). Due to this variability it was decided for ease of analysis that the cut-off of 10 would be used as this was the generally accepted cut-off and the optimal cut-offs for all the groups did not stray too far from this number (126,146,162).

A binary variable for incident depression was created using participants' responses at follow-up to indicate whether or not they had an incidence of depression during the study period. This was decided as most reviewed studies used a binary variable for depression. Further, the

World Mental Health Survey, a major survey mentioned earlier in the report that measures depression in many different contexts, also measures depression as binary (5,163). The continuous score was also used in an additional analysis as there was information loss from creating a binary variable. This was due to the diminished variation in measurements by classifying participants in two groups. Further, this allowed the investigation of a potential linear relationship between the exposures and the outcome.

3.5.3 Covariates

A list of possible covariates for adolescent pregnancy and depression as well as income inequality and depression was created by examining what was available in the NIDS data as well as referring to the existing literature. These variables were extracted from the literature and included, education, mother's education, demographic variables, alcohol use, income and others were controlled for in several similar studies cited in the report (70,101,130,164,165). These variables were used to create a directed acyclic graph (DAG) which was used as a conceptual framework when building the models (166). All variables included in the DAG were considered for model inclusion, however, ultimately it was the bivariate analysis that determined what would be controlled for in the models in this report. When considering whether to use the variables measured at baseline or follow-up, it was considered which measurement time point would impact how the participant answered the CES-D questions at follow-up and which time point would impact whether or not the participant was pregnant or had a child at follow-up.

Baseline CES-D score was controlled for in every model. This was due to its potential impact on the likelihood of depression at follow-up and the causal effect on adolescent pregnancy found in several studies (49,157,164,167). It was hypothesised that should someone have had a higher depression score at baseline, they would have been more likely to be depressed at follow-up as symptoms and stressors could have built. Further, several studies found that depression could impact whether or not an adolescent became pregnant, thus this variable had to be controlled for in order to precisely measure the relationship in the opposite direction (37,157,164,167,168).

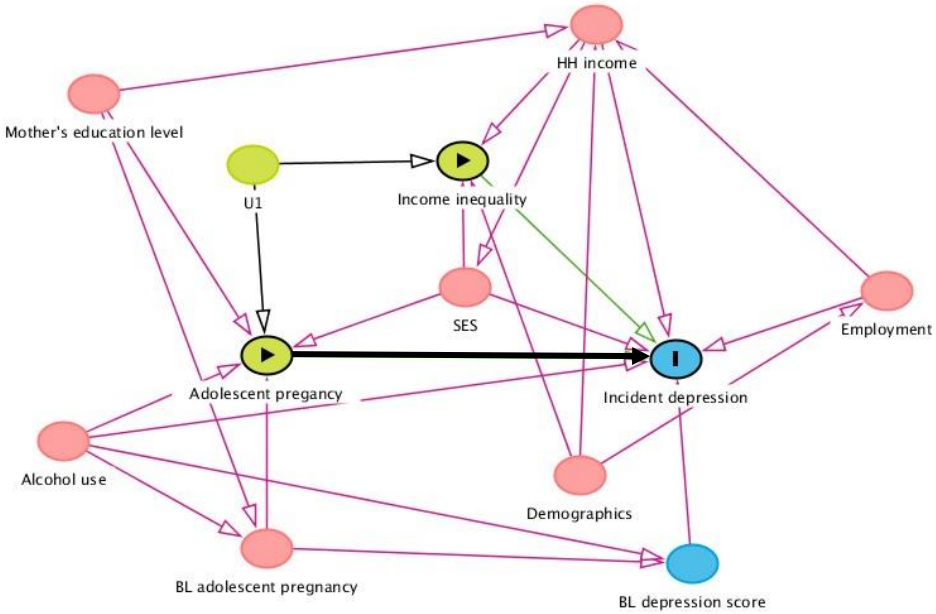

Figure 3.2 DAG to outline relevant covariates of adolescent pregnancy and depression and income inequality and depression
U1: Hypothesised interactive relationship; BL: Baseline

Baseline adolescent pregnancy status was also controlled for in every model that looked at the effect of adolescent pregnancy at follow-up on depression. Should a participant be in the cohort, this would mean that they were not depressed at baseline, therefore, if they were also pregnant at baseline this implies that this pregnancy did not lead to depression. In order to look at the effect of follow-up adolescent pregnancy, these instances needed to be controlled for so as not to confound the follow-up relationship.

As described in the *Manuscript* chapter, all other covariates were divided into different categories; demographics, adolescent pregnancy-related, and income inequality-related. During DAG construction, it became clear that a few key demographic variables (age, race, province of residence, geography of residence, and highest education level attained) were covariates measured by the same types of variables. These were grouped together for simplification of the conceptual framework. Looking at the DAG, it became apparent that certain covariates either impacted one exposure or the other, thus these were defined as being adolescent pregnancy-related or income inequality-related.

All demographic variables were analysed at follow-up so as to show their impact on incident depression as reported at that time point. Participants had self-reported their highest completed education level. Most studies that analysed the NIDS used three levels, "less than high school," "completed high school" and "beyond high school." There were too few participants in this sample, however, who had studied beyond high school, therefore, it was decided to combine these last two categories. A binomial variable was created to classify these terminal levels as "less than high school" and "completed high school or beyond."

Variables related to adolescent pregnancy were analysed at baseline, as it was determined that this timepoint would impact the likelihood of pregnancy or parity at follow-up most directly. Mother's education level was one such variable. In the same fashion as highest education level attained, mother's education level was also made into a binomial variable with "less than high school" and "completed high school or beyond," due to too few mother's having an education beyond high school.

As mentioned in the *Manuscript* chapter, a variable for SES at baseline as well as at follow-up was created employing the same method used by Lund and Cois in their study on depression and poverty in South Africa using the NIDS data (73). Using this score, a multi-level variable was created to represent "low, middle, and high" SES by assigning those with the highest 33% of scores as "high" SES and so on. It was thought that baseline SES would impact adolescent pregnancy at follow-up as the adolescent's environment at baseline was the best indication of influences on their behaviour during the study period and thus their risk of pregnancy.

Alcohol consumption at baseline was also thought to impact whether or not the adolescent would have had a pregnancy at follow-up (169). It was thought that the use of alcohol could influence their future behaviour and cause them to make riskier choices. There was also a limitation for alcohol in the dataset that lent itself to being analysed at baseline. Alcohol consumption was not measured in the 2017 wave of the study, making it impossible to create a follow-up variable for it regardless. In the waves that did investigate it, participants self-reported the frequency at which they drank alcohol. This was used to make a binary variable representing those who drank at all and those who had never drank.

As income inequality was analysed at follow-up, all covariates having to do with income inequality were also analysed at follow-up. This way they would be the most relevant in effecting income inequality at that time-point. SES at follow-up was simply measured in the same multi-level fashion as SES at baseline. Further, primary employment status was self-reported as a binary variable in the survey as either employed or not employed.

Monthly household income was reported in the household questionnaires. During analysis it was observed that household income was dramatically skewed to the right among both those with and without depression.

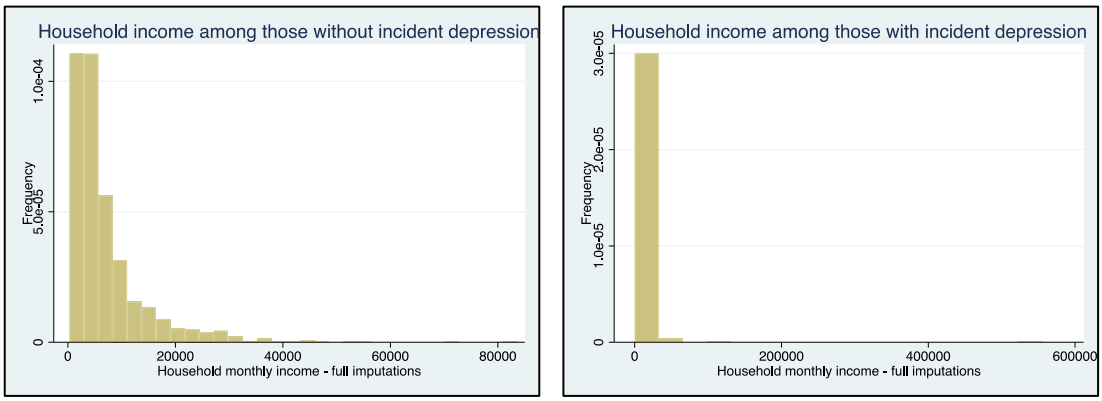

Figure 3.3 Histograms of the distribution of household income among those with and without incident depression

In order to adjust for skewness, household income was log-transformed before it was controlled for in the models.

3.6 Analysis

Prior to analysis, the data were inspected for outliers, finding that none of the variables displayed any outliers of note.

3.6.1 Bivariate analysis

Prior to conducting the bivariate analyses, the Shapiro-Wilk test was used to check if the continuous variables were normally distributed as well as the standard deviation test to test the assumption of equal variances. T-tests were then used to compare means across the

categories for incident depression. Non-parametric tests were used to compare medians of non-equal standard deviation and non-normal covariates. For the categorical covariates, a Fisher's exact test was executed on each variable unless the distribution of the variable required the use of a Chi-squared test.

3.6.2 Model building

It was found that there was no problematic multi-collinearity between continuous covariates. The panel design of the survey meant that the participants were clustered within households. There was a possibility of this clustering affecting the natural variability of responses as those in the same household may have had an influence on the others, impacting standard deviations. In order to correct for this, logistic regression models were built specifying robust standard errors. Logistic regression was chosen due to the binary nature of the outcome, as well as to allow multiple covariates to be adjusted for. The NIDS also defined design weights to adjust for the effects of the sampling design that were applied to these logistic models.

An additional analysis on continuous depression scores was conducted to examine the linear relationships of the exposures with depression severity. This additional analysis was also motivated by the higher power of the sample size when analysing the outcome as continuous. This analysis also employed robust standard errors and were adjusted for design weights. Instead of logistic regression, however, linear regression was conducted. This was done given the continuous nature of the depression scores as well as to continue to allow for the adjustment of multiple covariates. The same adjustments were made to the models to correct for the effects of the survey design.

Covariates that were significantly associated with binary adolescent pregnancy using an alpha value of 0.05 in the bivariate analysis were adjusted for in all models. As adolescent pregnancy was the main exposure being explored, it was rationalized that associated variables would most likely confound the effects of adolescent pregnancy on incident depression. Three groups of models were built corresponding to the study objectives. One looked at the relationship between adolescent pregnancy and incident depression, one looked at the relationship between income inequality and incident depression, and one looked at the interaction of adolescent pregnancy and income inequality and their effect on incident

depression together. For each different grouping of models, a model was first run on just the exposure(s) and the outcome. Demographic covariates were next added, then the rest of the covariates. This was done in order to see how controlling for these different sets of variables affected the relationships between exposure(s) and outcome. Further, the supplementary analysis with the continuous depression score as the outcome was built in a similar fashion, however, this was only done with both adolescent pregnancy and income inequality as exposures.

3.7 Ethics

Ethics approval for the NIDS was originally granted by the University of Cape Town Faculty of Health Sciences Human Research Ethics Committee in 2007 and was extended by the same committee in 2017. The protocol for this analysis was reviewed and granted ethics approval by the University of the Witwatersrand Human Research Ethics Committee (Medical) prior to the initiation of analysis in 2019.

Chapter four: Extended results

4.1 Chapter overview

In this chapter, the results presented in the *Manuscript* chapter will be expanded on. This includes a more detailed discussion of descriptive statistics and exploratory analyses.

4.2 Descriptive statistics

There were a few notable descriptive trends that were not discussed in the *Manuscript* chapter. Few participants in the sample reported ever drinking alcohol, as 93.4% reported that they did not drink alcohol at baseline. Further, the majority of the participants were unemployed with only 5.2% reporting having primary employment at follow-up and the mean monthly household income was 7,000.00 Rand. Income, however, varied between households as the standard deviation was around 15,500.00 Rand per month (Table 4.1 or 4.2).

Geographically, participants were distributed fairly evenly between the 9 provinces. The Free State had the lowest representation with just 5.5% of participants and KZN had the highest with 35.7% of participants, with the rest representing around 6.0-10.0% of the sample (Table 4.1 or 4.2).

4.2.1 Factors associated with incident depression and adolescent pregnancy

Only two covariates were found to be significantly related to incident depression (province of residence and adolescent pregnancy). Province of residence was one (*P*-value = 0.001). Several provinces had proportions of those depressed higher than the proportion of the sample they made up. For example, those from the Western Cape made up 8.6% of the sample population, while they made up 10.8% of those who were depressed. This trend was also seen among those who lived in the Eastern Cape, KZN, and Gauteng (see Table 4.1).

Binomial adolescent pregnancy at baseline was also found to be related to incident depression (*P*-value = 0.047). 14.4% of the sample had been pregnant at baseline, while 18.0% of those who were depressed at follow-up had had a pregnancy at baseline. This suggested that having had an adolescent pregnancy at baseline was significantly related to being depressed at follow-up (see Table 4.1).

Race showed a marginally significant relationship with incident depression (*P* = 0.066). Those who were Asian/Indian made up 0.7% of the sample but were 1.3% of those who were depressed. Similarly, Whites made up 0.7% of the same and represented 1.6% of those who were depressed. Household income also showed marginal significance with incident depression (*P* = 0.086). Those who were depressed on average had a monthly income 892.72 Rands higher than the overall sample. Of the characteristics explored there is no overwhelming evidence to determine what the characteristics of incident depression were in this population (See Table 4.1).

Table 4.1. Descriptive statistics as related to incident depression

Measure	Overall sample (N = 1,660)			Not depressed (n = 1,339)			Depressed (n = 306)			*P*-value
	No.	%	Mean/Median (SD/IQR)	No.	%	Mean/Median (SD/IQR)	No.	%	Mean/Median (SD/IQR)	
Pregnancy stage										0.236
No pregnancy	1,074	65.3		886	66.2		188	61.4		
Antenatal	78	4.7		64	4.8		14	4.6		
Postnatal	498	30.0		389	29.0		104	34.0		
Adolescent pregnancy										0.126
No pregnancy	1,074	65.3		886	66.1		188	61.4		
Pregnancy	576	34.7		453	33.9		118	38.6		
Income inequality			8.7 (7.4 , 11.2)			8.6 (7.3 , 11.2)			8.7 (7.3 , 10.5)	0.796
Age			19.6 (1.1)			19.6 (1.1)			19.6 (1.2)	0.982
Race										0.066
African	1,424	86.6		1,160	86.6		264	86.3		
Coloured	198	12.0		165	12.4		33	10.8		
Asian/Indian	11	0.7		7	0.5		4	1.3		
White	12	0.7		7	0.5		5	1.6		
Province										0.001
Western Cape	139	8.6		106	7.9		33	10.8		
Eastern Cape	195	11.8		145	10.8		50	16.3		
Northern Cape	101	6.1		89	6.6		12	3.9		
Free State	91	5.5		84	6.4		7	2.3		
KZN	588	35.7		468	34.9		120	39.2		
North West	95	5.8		79	5.9		16	5.3		
Gauteng	172	10.5		137	10.3		35	11.4		
Mpumalanga	111	6.7		99	7.4		12	3.9		

Limpopo	153	9.3	132	9.8	21	6.9	
Geography							0.182
Traditional	826	50.2	685	51.2	141	46.1	
Urban	734	44.6	589	44.0	145	47.4	
Farms	85	5.2	65	4.8	20	6.5	
Education level							0.212
Less than high school	1,147	69.9	925	69.2	222	73.0	
Completed high school or beyond	494	30.1	412	30.8	82	27.0	
Baseline pregnancy stage							0.113
No pregnancy	1,409	85.6	1,158	86.5	251	82.0	
Antenatal	56	3.4	42	3.1	14	4.6	
Postnatal	180	11.0	139	10.4	41	13.4	
Baseline adolescent pregnancy							0.047
No pregnancy	1,409	85.6	1,158	86.5	251	82.0	
Pregnancy	236	14.4	181	13.5	55	18.0	
Alcohol use							0.308
Does not drink	1,537	93.4	1,255	93.7	282	92.2	
Drinks	108	6.6	84	6.3	24	7.8	
Mother's education level							0.566
Less than high school	369	80.2	294	80.8	75	78.1	
Completed high school or beyond	91	19.8	70	19.2	21	21.9	
Baseline SES							0.188
Low	554	34.0	465	35.0	89	29.6	

Middle	498	30.5		398	29.9		100	33.2		
High	579	35.5		467	35.1		112	37.2		
Follow-up SES										0.263
Low	540	33.3		451	34.2		89	29.4		
Middle	731	45.2		587	44.6		144	47.5		
High	349	21.5		279	21.2		70	23.1		
Employment										0.887
Employed	85	5.2		70	5.2		15	4.9		
Not employed	1,556	94.8		1,265	94.8		291	95.1		
HH income			4,497.20 (2,664.30 , 8,665.70)			4,590.00 (2,722.90 , 8,500.00)			4,267.30 (2,550.00 , 6,873.70)	0.086
Baseline depression score			4.3 (2.5)			4.3 (2.5)			4.3 (2.5)	0.759

Abbreviations: No., number; SD, standard deviation; IQR, inter-quartile range; HH, household.

While only two covariates were related to incident depression, several were found to be associated with adolescent pregnancy. Income inequality showed a strong relationship with adolescent pregnancy (*P*-value = 0.004). Median income inequality among those who had no pregnancy was slightly higher than the median of the overall sample, suggesting that those who did not experience a pregnancy would had experienced more income inequality (8.7 and 8.6 respectively)(see Table 4.2).

Baseline measures for both adolescent pregnancy and CES-D score were associated with adolescent pregnancy at follow-up. Both pregnancy stage and adolescent pregnancy at baseline showed overwhelming significance in their relationship with adolescent pregnancy at follow-up (*P*-value < 0.001). Those with no pregnancy at baseline made up a large percentage of those who had no pregnancy at follow-up. There appears to have been a reporting error, miscarriage, or abortion represented by seven of those who reported being antenatal at baseline and reported no pregnancy at follow-up. When looking at adolescent pregnancy, while those who had had a pregnancy at baseline made up just 14.4% of the sample, they made up 39.9% of those who were pregnant at follow-up. This is logical, as this group would only grow between baseline and follow-up (see Table 4.2).

Baseline depression score also varied significantly between pregnancy stage categories at follow-up (*P*-value = 0.007). Those who had had a pregnancy at follow-up had a higher mean score than the overall sample, however, there was slightly more variance (4.5 and 4.3 respectively)(see Table 4.2).

Basic demographic variables, age and education level, were also significantly associated with adolescent pregnancy. The median age of participants increased with pregnancy and was overwhelmingly significant (*P*-value < 0.001). Further, a higher proportion of those who had less than a full high school education had had a pregnancy at follow-up compared to the overall sample (see Table 4.2).

Where participants lived was also significantly related to their pregnancy status at follow-up. Province of residence was significantly related to adolescent pregnancy as well as incident depression (*P*-value < 0.001). Distribution of participants between pregnancy stages varied differently per province. Residents of several provinces made up a greater proportion of those who had experienced a pregnancy at follow-up than they did in the overall sample. For

example, residents of KZN made up 35.7% of the sample and 44.3% of those who had been pregnant. This trend was also true for residents of the Eastern Cape and the Northern Cape (see Table 4.2).

General geography of residence also played a significant role (*P*-value < 0.001). Those who lived on traditional lands made up 50.2% of the sample, however, they made up 56.6% of those who had had a pregnancy. Further, those living in urban areas made up 44.6% of the sample but only 37.7% of those who had had a pregnancy. This demonstrated the difference living in different geographic areas made (see Table 4.2).

SES both at baseline and at follow-up were related to adolescent pregnancy (*P*-value < 0.001 at baseline and follow-up). Those who were in the high SES tier at baseline represented 35.5% of the sample but represented 42.3% of those who were pregnant at follow-up. This trend maintained with SES at follow-up, however, those in the middle tier of SES were also disproportionately represented among those who had had a pregnancy at follow-up (see Table 4.2).

Household income was also significantly related to adolescent pregnancy (*P*-value < 0.001). Those who had a pregnancy had a dramatically lower median monthly household income compared to the overall sample. Those who had had a pregnancy lived in a household that made a median 4,000.00 Rand a month, compared to the overall sample that made a median of 4,497.16 Rand a month (see Table 4.2).

Table 4.2. Descriptive statistics as related to adolescent pregnancy

Measure	Overall sample (N = 1,660)			No Pregnancy (n = 1,084)			Pregnancy (n = 576)			*P*-value
	No.	%	Mean/Median (SD/IQR)	No.	%	Mean/Median (SD/IQR)	No.	%	Mean/Median (SD/IQR)	
Income inequality			8.7 (7.4 , 11.2)			8.7 (7.4 , 11.6)			8.6 (7.3 , 9.8)	0.004
Age			20 (19 , 21)			19 (19 , 20)			20 (19 , 21)	<0.001
Race										0.307
African	1,438	86.6		937	86.5		501	87.0		
Coloured	199	12.0		128	11.8		71	12.3		
Asian/Indian	11	0.7		10	0.9		1	0.2		
White	12	0.7		9	0.8		3	0.5		
Province										<0.001
Western Cape	140	8.6		96	8.9		44	7.6		
Eastern Cape	196	11.8		125	11.5		71	12.4		
Northern Cape	102	6.1		58	5.3		44	7.6		
Free State	92	5.5		72	6.6		20	3.5		
KZN	591	35.7		336	31.0		255	44.3		
North West	95	5.8		68	6.3		27	4.7		
Gauteng	173	10.5		132	12.2		41	7.1		
Mpumalanga	111	6.7		77	7.1		34	5.9		
Limpopo	160	9.3		120	11.1		40	6.9		
Geography										<0.001
Traditional	835	50.2		509	47.0		326	56.6		
Urban	740	44.6		523	48.2		217	37.7		
Farms	85	5.2		52	4.8		33	5.7		
Education level										<0.001
Less than high school	1,155	69.9		717	66.3		438	76.3		
Completed high school or beyond	501	30.1		365	33.7		136	23.7		
Baseline pregnancy stage										<0.001
No pregnancy	1,423	85.6		1,077	99.4		346	60.1		
Antenatal	56	3.4		7	0.6		49	8.5		
Postnatal	181	11.0		0	0.0		181	31.4		
Baseline adolescent pregnancy										<0.001
No pregnancy	1,423	85.6		1,077	99.4		346	60.1		
Pregnancy	237	14.4		7	0.6		230	39.9		
Alcohol use										0.096
Does not drink	1,551	93.4		1,021	94.2		530	92.0		
Drinks	109	6.6		63	5.8		46	8.0		
Mother's education level										0.114

Less than high school	390	80.2		233	77.9		139	84.2		
Completed high school or beyond	110	19.8		66	22.1		26	15.8		
Baseline SES										<0.001
Low	562	34.0		411	38.3		151	26.4		
Middle	501	30.5		322	30.0		179	31.3		
High	583	35.5		341	31.7		242	42.3		
Follow-up SES										<0.001
Low	547	33.3		393	36.8		154	27.2		
Middle	737	45.2		459	43.0		278	48.9		
High	351	21.5		215	20.2		136	23.9		
Employment										0.101
Employed	85	5.2		48	4.4		37	6.4		
Not employed	1,571	94.8		1,032	95.6		539	93.6		
HH income			4,497.20 (2,664.30 , 8,165.70)			4,942.12 (2,655.00 , 9,008.30)			4,000.00 (2,685.00 , 66.36.88)	<0.001
Baseline depression score			4.3 (2.5)			4.1(2.5)			4.5 (2.6)	0.007

Abbreviations: No., number; SD, standard deviation; IQR, inter-quartile range; HH, household.

4.2.2 Participants by district

Distribution of participants by district was explored. This gave better insight into how income inequality was measured and represented in the sample.

The sample resided in the 52 district municipalities in South Africa. Each had relatively low representation, with the lowest in Buffalo City making up just 0.2% of the sample, 4 participants. Those who were either currently pregnant or had had a child at follow-up only made up 34.7% of the sample overall. Dividing this low proportion among the 52 districts resulted in few participants in these categories representing each district. Some districts had no participants within these categories at all. As incident depression was binary, representation of each category by district wasn't as drastically low as with adolescent pregnancy, however, it still posed a problem with some districts having no participants who were depressed or not depressed. eThekwini district had the highest proportion of depressed participants with 8.8%. Income inequality scores are notably higher in metropolitan districts such as the City of Cape Town (17.4), eThekwini (12.6), the City of Johannesburg (18.5), and the City of Tshwane (21.0) and notably lower in the more rural areas (see Table 4.3).

Table 4.3. Distribution of adolescent pregnancy stage, incident depression, and income inequality by district

District	Overall (N = 1,660)		Adolescent stage pregnancy						Depression				Income inequality
			No pregnancy (n = 1,084)		Antenatal (n = 78)		Postnatal (n = 498)		No depression (n = 1,339)		Depression (n = 306)		
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	Mean
West Coast	15	0.9	13	1.3	0	0.0	2	0.4	14	1.1	1	0.3	7.2
Cape Winelands	27	1.6	19	1.7	1	1.2	7	1.4	22	1.6	5	1.6	6.7
Overberg	22	1.3	9	0.8	2	2.6	11	2.2	13	1.0	9	2.9	8.4
Eden	15	0.9	10	0.9	1	1.3	4	0.8	12	0.9	3	1.0	8.7
Central Karoo	26	1.6	21	1.9	0	0.0	5	1.0	22	1.6	4	1.3	6.3
City of Cape Town	35	2.1	24	2.2	2	2.6	9	1.8	23	1.7	11	3.6	17.4
Cacadu	22	1.3	16	1.5	1	1.3	5	1.0	16	1.2	6	2.0	7.5
Amatole	10	0.6	5	0.5	0	0.0	5	1.0	9	0.7	1	0.3	6.8
Chris Hani	22	1.3	15	1.4	2	2.6	5	1.0	15	1.1	7	2.3	7.1
Joe Gqabi	20	1.2	14	1.4	0	0.0	6	1.2	12	0.9	8	2.6	7.8
O.R. Tambo	56	3.4	28	2.6	4	5.1	24	4.8	42	3.1	13	4.3	7.6
Alfred Nzo	34	2.1	24	2.2	4	5.1	6	1.2	27	2.0	7	2.3	6.6
Buffalo City	4	0.2	4	0.4	0	0.0	0	0.0	4	0.3	0	0.0	20.3
Nelson Mandela Bay	28	1.7	19	1.7	1	1.3	8	1.6	20	1.5	8	2.6	9.8
Namakwa	14	0.8	10	0.9	2	2.5	2	0.4	13	1.0	1	0.3	6.6
Pixley ka Seme	9	0.5	5	0.6	0	0.0	4	0.8	9	0.7	0	0.0	10.3
Siyanda	30	1.8	17	1.6	1	1.3	12	2.4	25	1.9	5	1.6	8.2
Frances Baard	37	2.2	19	1.7	3	3.8	15	3.0	32	2.4	4	1.3	8.0
John Taola Gaetsewe	12	0.7	7	0.6	1	1.3	4	0.8	10	0.7	2	0.6	8.2
Xhariep	19	1.1	8	0.7	1	1.3	10	2.0	14	1.1	5	1.6	7.5
Lejweleputswa	25	1.5	22	2.0	0	0.0	3	0.6	23	1.7	1	0.3	8.6
Thabo Mofutsanyane	22	1.3	18	1.7	1	1.2	3	0.6	21	1.6	1	0.3	7.1
Fezile Dabi	5	0.3	5	0.5	0	0.0	0	0.0	5	0.4	0	0.0	13.5

Mangaung	21	1.3	19	1.7	1	1.3	1	0.2	21	1.6	0	0.0	12.3
Ugu	67	4.0	33	3.0	2	2.6	32	6.4	60	4.5	7	2.3	8.8
Umgungundlovu	40	2.4	28	2.6	1	1.3	11	2.2	30	2.2	10	3.3	6.6
Uthukela	77	4.6	45	4.2	3	3.8	29	5.8	63	4.7	14	4.6	7.9
Umkhanyakude	24	1.5	8	0.7	2	2.6	14	2.8	18	1.3	6	2.0	5.6
Uthungulu	61	3.7	33	3.0	5	6.4	23	4.6	53	4.0	8	2.6	8.0
Sisonke	45	2.7	24	2.2	3	3.8	18	3.7	38	2.8	6	2.0	8.0
Umzinyathi	57	3.4	30	2.8	3	3.7	24	4.8	42	3.1	14	4.6	8.0
Amajuba	50	3.0	34	3.1	2	2.6	14	2.8	40	3.0	10	3.3	6.6
Zululand	40	2.4	22	2.0	2	2.6	16	3.2	32	2.4	8	2.6	8.3
iLembe	43	2.6	23	2.1	2	2.6	18	3.6	32	2.4	10	3.3	8.8
eThekwini	87	5.2	56	5.2	5	6.4	26	5.3	60	4.5	27	8.8	12.6
Bojanala	26	1.6	16	1.5	2	2.6	8	1.6	21	1.6	5	1.6	10.6
Ngaka Modiri Molema	29	1.7	24	2.2	0	0.0	5	1.0	26	1.9	3	1.0	12.6
Dr. Ruth Segomotsi Mompati	32	1.9	22	2.0	0	0.0	10	2.0	26	1.9	6	2.0	5.8
Dr. Kenneth Kaunda	8	0.5	6	0.6	0	0.0	2	0.4	6	0.4	2	0.7	14.2
Sedibeng	31	1.9	23	2.1	2	2.6	6	1.3	24	1.8	7	2.3	11.6
West Rand	15	0.9	14	1.3	1	1.3	0	0.0	13	1.0	2	0.6	11.8
Ekurhuleni	27	1.7	20	1.8	0	0.0	7	1.4	20	1.5	7	2.4	19.0
City of Johannesburg	61	3.7	44	4.1	2	2.6	15	3.0	51	3.8	9	2.9	18.5
City of Tshwane	39	2.4	31	2.9	2	2.6	6	1.3	29	2.2	10	3.3	21.0
Gert Sibande	33	2.0	20	1.8	1	1.3	12	2.4	30	2.2	3	1.0	11.6
Nkangala	26	1.6	22	2.0	0	0.0	4	0.8	18	1.3	8	2.6	11.6
Ehlanzeni	52	3.2	35	3.2	3	3.8	14	2.8	51	3.8	1	0.3	11.6
Mopani	23	1.4	16	1.5	1	1.3	6	1.2	20	1.5	3	1.0	11.0
Vhembe	27	1.6	22	2.0	0	0.0	5	1.0	19	1.4	5	1.6	10.0
Capricorn	32	1.9	26	2.4	1	1.3	5	1.0	25	1.9	5	1.6	11.1
Waterberg	35	2.2	26	2.4	3	3.8	6	1.2	29	2.2	5	1.6	10.9

Greater Sekhukhune	43	2.6	30	2.8	2	2.6	11	2.2	39	2.9	3	1.0	7.9

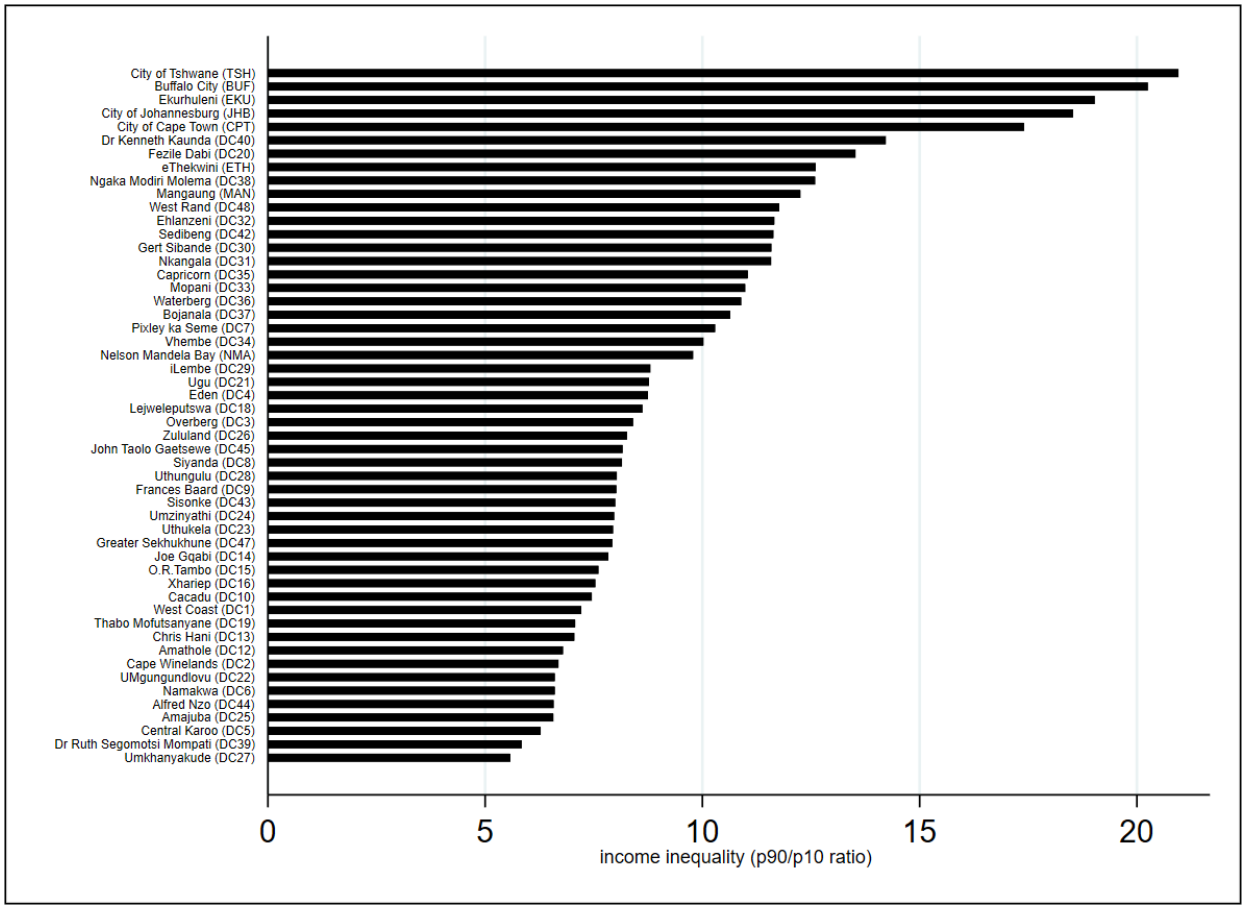

Figure 4.1 Density graph of P90/P10 ratio by district municipality

4.3 Models exploring relationships between adolescent pregnancy, income inequality, and depression

4.3.1 Adolescent pregnancy and incident depression

Looking at the proportions of those who were depressed in the different pregnancy stages, a higher percentage were depressed among those who were postnatal compared to those who had no pregnancy or those who were antenatal both at baseline and at follow-up.

Table 4.4. Distribution of incident depression among adolescent pregnancy stages at baseline and follow-up

Incident depression	Baseline								Follow-up							
	Total		No pregnancy (n = 1,409)		Antenatal (n = 56)		Postnatal (n = 180)		Total		No pregnancy (n = 1,074)		Antenatal (n = 78)		Postnatal (n = 493)	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Not depressed	1,339	81.4	1,158	82.2	42	75.0	139	77.2	1,339	81.4	886	82.5	64	82.1	389	78.9
Depressed	306	18.6	251	17.8	14	25.0	41	22.8	306	18.6	188	17.5	14	17.9	104	21.1

17.0-18.0% of those who had no pregnancy and were antenatal at follow-up were depressed compared to 21.0% of those who were postnatal at follow-up. This is in contrast with such proportions at baseline. Of those who were antenatal at baseline, 25.0% were depressed compared to 22.8% of those who were postnatal, and even lower, 17.8% of those who had no pregnancy (see Table 4.4).

Models were explored looking at how adolescent pregnancy related to incident depression without income inequality. As discussed in the *Manuscript* chapter, effect sizes changed when demographic variables and all covariates were added. As the model was adjusted with demographic and other variables, the confidence interval for adolescent pregnancy widened from (0.96 , 2.16) to (0.94 , 2.39). The effect size, however, grew as noted in the *Manuscript* chapter with the fully adjusted model reporting a 1.50 times greater odds of depression among those who had had a pregnancy compared to those who were never pregnant. Further, none of the covariates adjusted for were significantly related to incident depression in these models (see Table 4.5).

Table 4.5. Adolescent pregnancy and incident depression

Covariates	Model 1a			Model 1b			Model 1c		
	OR	95% CI	*P*-value	OR	95% CI	*P*-value	OR	95% CI	*P*-value
Adolescent pregnancy									
No pregnancy	(ref)			(ref)			(ref)		
Pregnancy	1.44	0.96 , 2.16	0.079	1.47	0.96 , 2.24	0.075	1.50	0.94 , 2.39	0.089
Age				1.06	0.89 , 1.27	0.516	1.06	0.88 , 1.28	0.536
Geography									
Traditional				(ref)			(ref)		
Urban				1.15	0.77 , 1.70	0.497	1.15	0.77 , 1.72	0.497
Farms				1.86	0.92 , 3.77	0.082	1.87	0.92 , 3.82	0.085
Education									
Less than high school				(ref)			(ref)		
Completed high school or beyond				1.13	0.72 , 1.70	0.604	1.11	0.70 , 1.75	0.659
Baseline SES									
Low				1.06	0.65 , 1.72	0.824	1.07	0.66 , 1.74	0.774
Middle				1.38	0.87 , 2.20	0.173	1.37	0.86 , 2.17	0.184
High				(ref)			(ref)		
Follow-up SES									
Low				0.74	0.43 , 1.27	0.271	0.73	0.41 , 1.28	0.272
Middle				1.29	0.80 , 2.09	0.293	1.27	0.79 , 2.05	0.314
High				(ref)			(ref)		
HH Income							1.00	0.80 , 1.24	0.991
Baseline adolescent pregnancy									
No pregnancy							(ref)		
Pregnancy							0.92	0.51 , 1.66	0.783
Baseline depression							0.98	0.91 , 1.06	0.491

Abbreviations: OR, odds ratio; CI, confidence interval; ref, reference category.

4.3.2 Income inequality and incident depression

The stratified median income inequality scores by incident depression stayed similar to the overall median score remaining around 8.7. This demonstrated that income inequality was not found to be significantly related to incident depression in the bivariate analysis (see Table 4.1).

Logistic regression models were also explored looking at income inequality without adolescent pregnancy. The effect size of income inequality did not change when models were adjusted by demographic or other variables. With every unit increase in income inequality, the odds of acquiring depression were reduced by 0.01, and remained around this level in all iterations of the model. This effect, however, was not significant in any model, adjusted or unadjusted. Like the adolescent pregnancy model, none of the covariates were significantly related to depression (see Table 4.6).

Table 4.6. Income inequality and incident depression

Covariates	Model 2a			Model 2b			Model 2c		
	OR	95% CI	*P*-value	OR	95% CI	*P*-value	OR	95% CI	*P*-value
Income inequality	0.99	0.95 , 1.03	0.689	0.98	0.95 , 1.03	0.473	0.98	0.94 , 1.03	0.483
Age				1.11	0.93 , 1.31	0.250	1.08	0.89 , 1.30	0.429
Geography									
Traditional				(ref)			(ref)		
Urban				1.16	0.78 , 1.74	0.463	1.16	0.77 , 1.75	0.467
Farms				1.82	0.89 , 3.69	0.100	1.79	0.88 , 3.67	0.109
Education									
Less than high school				(ref)			(ref)		
Completed high school or beyond				1.09	0.69 , 1.70	0.717	1.20	0.70 , 1.76	0.659
Baseline SES									
Low				1.01	0.62 , 1.66	0.954	1.04	0.64 , 1.71	0.870
Middle				1.38	0.87 , 2.20	0.174	1.37	0.86 , 2.18	0.188
High				(ref)			(ref)		
Follow-up SES									
Low				0.74	0.44 , 1.26	0.272	0.72	0.41 , 1.28	0.265
Middle				1.28	0.79 , 2.07	0.317	1.26	0.78 , 2.04	0.334
High				(ref)			(ref)		
HH Income							1.00	0.80 , 1.24	0.989
Baseline adolescent pregnancy stage									
No pregnancy							(ref)		
Antenatal							1.13	0.42 , 3.04	0.815
Postnatal							1.25	0.68 , 2.28	0.467
Baseline depression							0.98	0.91 , 1.05	0.486

Abbreviations: OR, odds ratio; CI, confidence interval; ref, reference category.

4.3.3 Interaction of adolescent pregnancy and income inequality and its effect on incident depression

As briefly explained in the *Manuscript* chapter, the models looking at the relationships of adolescent pregnancy and income inequality individually suggested that neither were significantly associated with incident depression. With this information, it can be determined that creating an interaction variable with these factors to explain incident depression would not work and only a model with both adolescent pregnancy and income inequality without the interaction should be explored.

The bivariate analysis looking at covariates' relationships with adolescent pregnancy, however, suggested that income inequality was significantly related (*P*-value = 0.004) (see Table 4.2). Due to the strong association between income inequality and adolescent pregnancy, and because this was a core objective of the study, this interaction was still explored after first looking at a model with both the variables.

The model with both variables showed that adolescent pregnancy was not significantly related to incident depression (95% CI: 0.94 , 2.39), however, in the fully adjusted model showed some marginal significance (*P*-value = 0.093) (see Table 4.7). Patterns seen in the effect sizes of variables in individual models for adolescent pregnancy and income inequality persisted in these models, as explained in the *Manuscript* chapter.

None of the other covariates showed any significance with incident depression in these final iterations of the model. (see Table 4.7).

Table 4.7. The interaction of adolescent pregnancy and income inequality and their effect on incident depression

Covariates	Model 3a			Model 3b			Model 3c		
	OR	95% CI	*P*-value	OR	95% CI	*P*-value	OR	95% CI	*P*-value
Adolescent pregnancy									
No pregnancy	(ref)			(ref)			(ref)		
Pregnancy	1.43	0.96 , 2.15	0.081	1.46	0.96 , 2.24	0.078	1.49	0.94 , 2.39	0.093
Income inequality	0.99	0.96 , 1.03	0.776	0.99	0.95 , 1.03	0.529	0.99	0.95 , 1.03	0.517
Age				1.07	0.89 , 1.27	0.484	1.06	0.88 , 1.28	0.508
Geography									
Traditional				(ref)			(ref)		
Urban				1.20	0.81 , 1.80	0.366	1.21	0.80 , 1.82	0.361
Farms				1.86	0.92 , 3.77	0.083	1.87	0.92 , 3.83	0.086
Education									
Less than high school				(ref)			(ref)		
Completed high school or beyond				1.14	0.72 , 1.80	0.570	1.12	0.71 , 1.77	0.621
Baseline SES									
Low				1.06	0.65 , 1.74	0.806	1.08	0.66 , 1.76	0.754
Middle				1.39	0.87 , 2.22	0.165	1.38	0.87 , 2.20	0.175
High				(ref)			(ref)		
Follow-up SES									
Low				0.73	0.43 , 1.25	0.258	0.72	0.41 , 1.28	0.264
Middle				1.27	0.78 , 2.06	0.329	1.25	0.78 , 2.02	0.350
High				(ref)			(ref)		
HH Income							1.00	0.80 , 1.24	0.978
Baseline adolescent pregnancy									
No pregnancy							(ref)		
Pregnancy							0.92	0.51 , 1.66	0.782
Baseline depression							0.98	0.91 , 1.05	0.513

Abbreviations: OR, odds ratio; CI, confidence interval; ref, reference category.

This model was run again, this time including an interaction term between adolescent pregnancy and income inequality. In the unadjusted interaction model, income inequality was found to have no effect on incident depression (OR = 1.01). Adolescent pregnancy had a greater effect on incident depression showing those with an adolescent pregnancy having 3.18 times the odds of incident depression as someone who had no pregnancy including the effect of rising income inequality (see Table 4.8). This effect estimate, however, was much more imprecise given the wider confidence interval (95% CI: 0.87 , 5.60) (see Table 4.8).

Table 4.8. Adolescent pregnancy and income inequality

Covariates	Model 3a			Model 3b			Model 3c		
	OR	95% CI	*P*-value	OR	95% CI	*P*-value	OR	95% CI	*P*-value
Adolescent pregnancy									
No pregnancy	(ref)			(ref)			(ref)		
Pregnancy	2.35	0.98 , 5.62	0.055	2.13	0.85 , 5.31	0.105	2.22	0.87 , 5.60	0.093
Income inequality	1.01	0.97 , 1.05	0.684	1.00	0.95 , 1.05	0.903	1.00	0.95 , 1.05	0.914
Income inequality and adolescent pregnancy									
No pregnancy	(ref)			(ref)			(ref)		
Pregnancy	0.95	0.88 , 1.04	0.268	0.97	0.89 , 1.05	0.420	0.96	0.88 , 1.05	0.400
Age				1.06	0.88 , 1.27	0.532	1.06	0.88 , 1.28	0.555
Geography									
Traditional				(ref)			(ref)		
Urban				1.22	0.82 , 1.82	0.332	1.22	0.81 , 1.84	0.333
Farms				1.86	0.91 , 3.77	0.087	1.86	0.90 , 3.82	0.092
Education									
Less than high school				(ref)			(ref)		
Completed high school or beyond				1.14	0.72 , 1.80	0.572	1.12	0.71 , 1.77	0.628
Baseline SES									
Low				1.06	0.65 , 1.73	0.823	1.07	0.66 , 1.75	0.776
Middle				1.39	0.88 , 2.22	0.160	1.38	0.87 , 2.19	0.172
High				(ref)			(ref)		
Follow-up SES									
Low				0.74	0.43 , 1.27	0.279	0.73	0.41 , 1.28	0.270
Middle				1.26	0.78 , 2.05	0.345	1.24	0.77 , 2.00	0.376
High				(ref)			(ref)		
HH Income							1.00	0.80 , 1.25	0.981
Baseline adolescent pregnancy									
No pregnancy							(ref)		
Pregnancy							0.93	0.51 , 1.69	0.812
Baseline depression							0.97	0.91 , 1.05	0.476

Abbreviations: OR, odds ratio; CI, confidence interval; ref, reference category.

4.3.4 Adolescent pregnancy and income inequality and their effect on CES-D score

In the unadjusted model, adolescent pregnancy showed a significant relationship with depression, with those who have had a pregnancy having an average 0.67 higher depression score as those who were never pregnant (95% CI: 0.05 , 1.30). When adjusted with all variables, however, adolescent pregnancy became only marginally significant. The fully adjusted model showed that those who had had a pregnancy had an average 0.71 higher depression score than those who had not (*P*-value = 0.055) (see Table 4.9).

Income inequality never demonstrated significance with depression score in this analysis whether in adjusted or unadjusted models. Further, after adjusting for demographic and other variables, the effect size of income inequality decreased from 0.03 in the unadjusted model (95% CI: -0.02 , 0.09) to 0.02 in the adjusted (95% CI: -0.04 , 0.08) (see Table 4.9).

No other covariates showed any significance with incident depression in the continuous analysis (see Table 4.9).

Table 4.9. Adolescent pregnancy, income inequality, and depressive symptom severity

Covariates	Model 3a			Model 3b			Model 3c		
	Coef.	**95% CI**	***P*-value**	**Coef.**	**95% CI**	***P*-value**	**Coef.**	**95% CI**	***P*-value**
Adolescent pregnancy									
No pregnancy	(ref)			(ref)			(ref)		
Pregnancy	0.67	0.05 , 1.30	0.034	0.66	0.01 , 1.31	0.046	0.71	-0.01 , 1.44	0.055
Income inequality	0.03	-0.02 , 0.09	0.255	0.02	-0.04 , 0.08	0.448	0.02	-0.04 , 0.08	0.496
Age				0.08	-0.18 , 0.33	0.554	0.07	-0.20 , 0.33	0.621
Geography									
Traditional				(ref)			(ref)		
Urban				0.22	-0.39 , 0.83	0.475	0.22	-0.40 , 0.85	0.482
Farms				0.87	-0.34 , 2.09	0.159	0.90	-0.34 , 2.14	0.155
Education									
Less than high school				(ref)			(ref)		
Completed high school or beyond				0.17	-0.49 , 0.83	0.612	0.18	-0.50 , 0.85	0.607
Baseline SES									
Low				-0.26	-1.02 , 0.50	0.503	-0.25	-1.03 , 0.53	0.531
Middle				-0.05	-0.81 , 0.70	0.893	-0.06	-0.81 , 0.70	0.879
High				(ref)			(ref)		
Follow-up SES									
Low				-0.45	-1.27 , 0.37	0.283	-0.40	-1.26 , 0.46	0.362
Middle				0.01	-0.73 , 0.75	0.976	0.02	-0.74 , 0.77	0.961
High				(ref)			(ref)		
HH Income							-0.08	-0.44 , 0.29	0.681
Baseline adolescent pregnancy									
No pregnancy							(ref)		
Pregnancy							-0.12	-1.10 , 0.87	0.814
Baseline depression							0.01	-0.10 , 0.12	0.860

Abbreviations: OR, odds ratio; CI, confidence interval; ref, reference category.

Chapter 5: Extended conclusions and recommendations

5.1 Chapter overview

This chapter highlights the implications for findings not presented in the *Manuscript* chapter. Not presented in the *Manuscript* chapter were the detailed descriptive statistics including distribution of participants by district municipality, models looking at relationships between adolescent pregnancy and incident depression and income inequality and incident depression separately, the impracticality of measuring any interaction between adolescent pregnancy and income inequality. Also, strengths and limitations of the study are discussed in more detail.

5.2 Implications

5.2.1 Sample demographics

Looking at the distribution of participants by district revealed interesting patterns that could help explain some results of the study. As there are 52 districts in South Africa, each district was only represented by a few participants. As is seen in *Table 4.3*, when participants are also stratified by pregnancy stage, the sample size is just not large enough to get good representation in each category and in each district. The same could also be said for incident depression, however, less so as there were only two categories there.

It was found that income inequality was only significantly associated with being postnatal as compared to having no pregnancy. This makes sense given the small sample size of those who were antenatal, and thus their sparse distribution among the different district municipalities making it difficult to have a fair analysis. The drastic differences in district representation in each pregnancy stage could explain the overwhelming significance between the two. Another study with a larger sample size would have to be done to verify this relationship.

The behaviour of province of residence in models was interesting given the results of the bivariate analyses. Though it varied significantly with both teenage pregnancy and incident depression, when it was added to the models it was an extremely unstable covariate with very wide confidence intervals. Even when a logistic mixed effect model was run with just adolescent pregnancy and province of residence against incident depression, it maintained no

significant relationship. For these reasons and because it wasn't felt that province of residence lent much to the interpretation of the analysis, it was left out of the final models.

Age and mother's education also displayed interesting patterns. Age did not vary significantly with incident depression. This was a surprise as most studies found that older adolescents are significantly more depressed than their younger counterparts (24,27). This could be due to the more limited age range of this cohort, as most of these studies were looking at young people aged 10-19.

Finally, it was interesting to observe similar patterns between mother's education and the education status of participants. They appeared to be a close match proportionally, however, only participants' educational status was significantly related to teenage pregnancy. The difference here could be due to there being more missing data on mother's education status than for participants', making it more difficult to get an accurate measure.

5.2.2 Analysis of depressive symptom severity

Several factors were found in the literature that contributed to depressive symptoms among adolescent mothers that were unfortunately not explored in this study. Experiencing adverse life events and living with HIV/AIDS were two that were found to significantly contribute (86,88). As with incident depression, social support was also found to be a factor contributing to the level of depression experienced by adolescent mothers (86,88,109). Further, IPV was found to be associated with more depressive symptoms (82,117). Not all studies, however, found factors that significantly contributed to depression levels. One study in America did not find any factors that played a significant role in increased levels of depression among adolescent mothers (85).

5.2.3 Adolescent pregnancy stage

Several studies looked at how the different stages of pregnancy in adolescents were related to depression. Unfortunately, the distribution of participants in this study did not lend itself to precisely measure this trend, however, it is still important to interpret results in this context. One study in 2019 found that the different stages of pregnancy were associated with different

levels of depression among adults in South Africa looking at the peri- and postpartum periods. Five distinct patterns were identified: mild depressive symptoms during pregnancy and a slight decrease postpartum, minimal depressive symptoms during pregnancy and an increase postpartum, unstable depressive symptoms with a peak at 12 months postpartum, moderate depressive symptoms during pregnancy and minimal postpartum, severe depressive symptoms during pregnancy and postpartum (78). Another study found that depressive symptoms were significantly worse for adolescents during the second trimester compared to all other stages (89).

Pregnancy stage was also shown to play a role when it came to differences in depressive symptoms between adolescent and adult mothers. Compared to adults, it was found that during pregnancy, the younger a mother was, the more depressive symptoms she had, whereas postpartum, age was not found to play a role (94). Another study found, however, that stage of pregnancy did not play any significant role in depressive symptoms among adolescent mothers (100). There is clearly a range of findings in the literature when it comes to the role the stage of pregnancy plays in depressive symptoms for adolescent mothers. There isn't necessarily a framework, therefore, to address whether or not the lack of stratification in this study could have impacted the results or not.

Several studies also looked at depression in adolescent mothers over time. Most studies looking at this pattern found that depressive symptoms decreased over time, suggesting that the stage of pregnancy did matter (88,97,113,120). These findings suggest that the more time between delivery and interviewing the adolescent, there is a higher likelihood for them to be less depressed than they were just after delivery, potentially impacting the findings of this study. There could be a larger story in this data about change in depressive symptoms over time in adolescent mothers that was not explored.

5.3 Strengths

This study contributed to a growing body of literature on depression among adolescents in significant ways. Little is known in South Africa about what factors influence depression in adolescents. As adolescent pregnancy is relatively common in South Africa, it was hypothesised as a factor contributing to depression (44). Though it wasn't found that

adolescent pregnancy impacts incident depression, it was found to impact depressive symptoms, adding this to the literature. Given that this study used cohort data, these analyses and findings therefrom are especially robust, giving insight into how factors can contribute to a higher risk of depression in adolescents.

Further, while there is some research into how income inequality impacts the health and mental health of adults in South Africa, there is no identified research addressing how it affects adolescents' health. Adding this dimension to the literature helps contextualize this pervasive issue in South African society to the younger generations.

5.4 Limitations

As discussed in the *Manuscript* chapter, while there are clear strengths in this study, it was also subject to some additional limitations. The NIDS was not designed to be representative for the sample selected for use in this study, making it not nationally representative. Further, as mentioned in the *Manuscript* chapter, the NIDS did not measure some relevant variables to this study, thus they could not be controlled for. Not being able to control for social support, IPV, childhood trauma, pre-existing depression, and if the pregnancy was planned or not left the potential for these factors to confound the relationship between teenage pregnancy and incident depression. This list of variables is limited, however, results from previous studies suggest that these are important variables in a potential causal relationship between adolescent pregnancy and depression (102–104,106,108). Because these variables could not be controlled for, the analysis was then open to the effects of residual confounding that could have biased the results towards or away from the null.

One of such variables was HIV status, relevant to both how adolescent pregnancy and income inequality could contribute to depression. HIV remains a major challenge in sub-Saharan African countries and must be considered in the context of adolescent pregnancy as it relates to unprotected sex. One study found the effect of HIV prevalence on adolescent pregnancy to be dependent on GDP per-capita. Countries with lower GDP per-capita were found to have a positive association between HIV prevalence and rates of adolescent pregnancy, whereas countries with a high GDP per-capita were found to have the opposite association (43). This

is important within the context of sub-Saharan Africa, as these countries have some of the lowest GDPs in the world.

The way some of the data on relevant variables was collected also limited the capacity of this study to control for potential confounders. Alcohol consumption was not asked about in the fifth wave of the NIDS, therefore, this factor was not able to be controlled for at follow-up. Further, there was not a question about how long ago a woman had given birth. This limited this study's capability to look at the variable of time with regards to giving birth and symptoms of depression.

Finally, the sample size was unfortunately not robust enough to ensure accuracy in detecting differences in prevalence between those who had experienced an adolescent pregnancy and those who had not as the power for binary depression was 28.7%. Further, the distribution of the sample limited the analyses of some variables. The majority of the selected sample were Black, with very few participants in the other race categories. Because of this distribution, race was not able to be controlled for, as it showed to be an extremely unstable covariate. Further, as previously mentioned, the sample was not robust enough to analyse different stages of pregnancy, as too few participants were in the antenatal stage, also making this analysis unstable.

5.5 Recommendations

This initial investigation of depression in adolescent girls in South Africa has laid the groundwork for several further studies. First, a more extensive analysis of the factors related to depression severity would be very illuminating. There are more measures studied in the NIDS to look into what is related to depression among adolescents in South Africa. Further, to investigate factors that are not measured by the NIDS, a latent class analysis could be done to look at underlying confounders not specifically considered.

When it comes to looking at incident depression, studies into potential reasons why adolescent pregnancy did not turn out to be a significant factor could cast light on other factors related to depression in this population. In this study, it was hypothesised that adolescent pregnancy would have a negative emotional impact on adolescent girls. This,

however, could be a westernized fallacy in some communities in South Africa. It is possible that adolescent pregnancy could have a positive emotional effect, or be emotionally neutral for adolescent girls. Looking at this dynamic would require more community-based studies in a variety of communities in South Africa to capture the natural heterogeneity of the country. Further, other factors of depression among adolescent girls should be studied at this micro-level in order for more tailored programs to be developed to effectively address this issue.

In this same vain, more qualitative research should be done looking into both depression and adolescent pregnancy in this group to get a better idea of how it effects girls' lives. Further research should also be conducted in South Africa looking at the effects of income inequality and adolescent pregnancy on adolescent girls' general health.

The finding from this research of a marginally significant relationship between adolescent pregnancy and depression suggest the plausibility of causality. In light of the limitations of this research, it follows that there were no conclusive results. What this research offers is an initial exploration of the effect of adolescent pregnancy on depression as well as a study of income inequality's effect on adolescent health in South Africa for future research to build on.

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Appendix

Appendix one – Plagiarism declaration



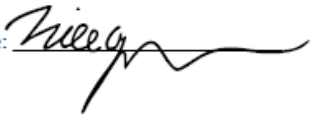
PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I Madelyn Goodman (Student number: 2071228) am a student registered for the degree of MSc Epidemiology and Biostatistics in the academic year 2019.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.
- I have included as an appendix a report from "Turnitin" (or other approved plagiarism detection) software indicating the level of plagiarism in my research document.

Signature:  Date: [redacted] 25 Feb 2021

1

Appendix two – Signed turn it in report

See attached file

Appendix three – Ethics clearance certificate

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

28/01/2019
Revised 03/06/2020

Ref: W-CBP-191108-03

TO WHOM IT MAY CONCERN:

Waiver: This certifies that the following research does not require clearance from the Human Research Ethics Committee (Medical).

Investigator: Ms M Goodman
Student No. (if appropriate): 2071228
Staff No. (if appropriate):

Supervisor: Drs S/E Mall/Chirwa

School: Public Health
Medical School
University

Project title: *Relationships between teenage pregnancy, income inequality and incident depression from a national representative panel study in South Africa from 2013 to 2017*

Reason: Review of information in the public domain.
No human participants will be involved in the study.

Dr CB Penny
Chairperson: Human Research Ethics Committee (Medical)

Research Office Secretariat:
Physical address: Phillip Tobias Building, 3rd Floor, Office 302, Corner York Road and Princess of Wales Terrace, Parktown, Johannesburg 2193.
Postal address: Private Bag 3, Wits 2050
Tel Nos. +27 (0)11-717-1234/2656/2700/1252
Office E-mail: HREC-Medical.ResearchOffice@wits.ac.za.
Website:http://www.wits.ac.za/research/about-our-research/ethics-and-research-integrity/

[i] The Apartheid system in South Africa created the racial categories, White, Black African, Indian, and Coloured. These categories are still used in the national census as well as other statistical data in the country.

Categories are used here to investigate potential health disparities in said groups, perhaps due to the lasting effects of this oppressive system.