THE ASSOCIATION BETWEEN HOUSEHOLD FOOD SECURITY AND MORTALITY IN CHILDREN UNDER-FIVE YEARS OF AGE IN AGINCOURT, LIMPOPO PROVINCE, IN 2004

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DECLARATION

I, Penny Crowther, declare that this research report is my own work. It is being submitted for the degree of Master of Science in Medicine in the Field of Epidemiology and Biostatistics at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

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ABSTRACT

Background: When children experience food insecurity, in addition to poverty, their resultant inadequate food intake and disease often leads to the development of protein-energy malnutrition and ultimately to death. In South Africa, where three out of every four children live in poverty, food insecurity and its multiple negative effects are consequently among the most urgent social issues affecting households and their children. Since household food insecurity is thought to be associated with increased child mortality, it is important to study any such associations amongst South African children to determine additional risk factors for child mortality.

Objectives: The main objective of this study was to establish the relationship between household food security and mortality in children under the age of five years in the Agincourt field site, Limpopo Province, in 2004.

Methods: An analytical cross-sectional study of secondary data obtained from the 2004 census questionnaire and food security module of the Agincourt Health and Demographic Surveillance System in rural Limpopo Province was conducted, involving a total of 7,790 black children under the age of five years. Certain exposure variables were selected for use as indicators of food security and these were analysed with respect to child mortality using univariate and multivariate logistic regression.

Results: Based on the outcome indicators of food consumption, 37% of the study population were found to have experienced household food insecurity in 2004, reporting insufficient food for the entire household in the previous month and year. The limited dietary diversity and insufficient quantities of food experienced by the majority of the population were supplemented by the local growth of food crops and the gathering of food from the bush. Of the 79 children (1%) under the age of five years who died in 2004, the

majority (24%) died of HIV-related diseases, in addition to deaths caused by diarrhoea, respiratory infections, and malnutrition. Child mortality was found to be associated with the reporting of "unknown" for several indicators of food security. Additionally, expecting the food availability of the household in the coming year to be less than that of the current year (that is, the prediction of future household food insecurity) was significantly associated with an increased risk of under-five child mortality compared to the expectation of the same amount of food the following year (adjusted odds ratio (OR) 2.0), and with a greatly increased risk of mortality compared to the prediction of more food (future household food security) (adjusted OR 4.4). The latter association was age-specific to infants under the age of one year (adjusted OR 5.6) and cause-specific to HIV deaths (adjusted OR 5.9).

Conclusions: Following a significant trend in this study in the rural north-east of South Africa, future household food security was inversely related to, and hence protective over, childhood mortality in 2004, even after controlling for confounding factors. Further research on the associations between household food security and under-five child mortality, conducted following the development of a standard nation-wide food security measurement tool specific to South African household conditions, would confirm household food insecurity as a significant risk factor for under-five child mortality and, consequently, as a target for future policies in the reduction of child mortality in this country.

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ABBREVIATIONS

AHPU	Agincourt Health and Population Unit
CI	Confidence Interval
DSS	Demographic Surveillance System
FAO	Food and Agriculture Organisation of the United Nations
HIV/AIDS	Human Immunodeficiency Virus / Acquired Immune Deficiency Syndrome
HDSS	Health and Demographic Surveillance System
HH	Household Head
HSRC	Human Sciences Research Council
INDEPTH	International Network for the Demographic Evaluation of Populations and Their Health
OR	Odds Ratio
PCA	Principal Component Analysis
PEM	Protein-Energy Malnutrition
SD	Standard Deviation
SES	Socio-Economic Status
UN	United Nations
UNICEF	United Nations Children's Fund
USDA	United States Department of Agriculture
WHO	World Health Organisation

Chapter 1: INTRODUCTION

"There is no trust more sacred than the one the world holds with children. There is no duty more important than ensuring that their rights are respected, that their welfare is protected, that their lives are free from fear and want and that they can grow up in peace."

-- KOFI ANNAN, Secretary-General of the United Nations (1997-2006)

Foreword to The State of the World's Children, 2000

"…the first essential component of social justice is adequate food for all mankind. Food is the moral right of all who are born into this world."

-- NORMAN BORLAUG, Agricultural Scientist, Humanitarian, Nobel Peace Laureate

Nobel Lecture, 1970

1.1 FOOD SECURITY

Poverty and food insecurity are inextricably linked. As a continent of extreme poverty, Africa has the highest percentage of undernourished people in the world – nearly 200 million people have chronic food insecurity, or malnutrition, and 38 million people are affected by acute food insecurity, with 24,000 dying from hunger daily [Clover, 2003]. In South Africa, where three out of every four children live in poverty [Berry & Guthrie, 2003], food insecurity and its multiple negative effects are consequently among the most urgent social issues affecting households and their children.

1.1.1 Definitions

The concept of food security can be traced back to the Universal Declaration of Human Rights in 1948, which recognised the right to food as a core element of an adequate standard of living [Maxwell & Frankenberger, 1992]. The term *food security* subsequently

originated in international development literature in the 1970s with the increased public interest in the subject following the world oil crisis and related world food crisis of 1972-74 [Cook, 2006]. The amount of academic literature on food security continued to grow in the 1980s with the African famine of 1984-85 and the resulting increase in numbers of people requiring food assistance [Maxwell & Frankenberger, 1992]. With such growth, the concept of food security has become more complex: Hoddinott (1999) reports approximately 200 definitions and 450 indicators of food security, and Maxwell and Frankenberger (1992) list 194 studies on the concept and definition of food security and a further 172 studies on its indicators.

Definitions of food security have expanded over time to integrate a wider range of food-related issues and to more completely reflect the role of food in human society, including its nutritional, social, cultural, symbolic, and political roles [Cook, 2006]. The most commonly used definition is that proposed by the Food and Agriculture Organisation (FAO) of the United Nations: "*Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food, which meets their dietary needs and food preferences for an active and healthy life"* [FAO, 2001].

As such, the opposite of this concept, food insecurity, which demonstrates a range in severity, exists in its least severe form when people experience uncertainty about the sufficiency of their household food supply and adjustments to household food management, including reductions in diet quality and variety; and in its most severe form when people, including children, are hungry and undernourished due to the physical unavailability of food, their lack of social or economic access, and/or inadequate food utilisation [FAO, 1998; Cook *et al*., 2004]. Therefore, severely food insecure people are

those individuals whose food intake falls below their minimum calorie, or energy, requirements, and those who exhibit physical symptoms caused by energy and nutrient deficiencies resulting from an inadequate or unbalanced diet, or from inability of the body to utilise food effectively due to infection or disease [FAO, 1998].

Food insecurity is therefore attributable to many factors varying in importance across regions, countries, social groups, and over time [FAO, 1998]. The full range of factors that place people at risk of becoming food insecure is referred to as vulnerability, where the degree of vulnerability for an individual, household, or social group is determined by their exposure to the risk factors and their ability to cope with or withstand stressful situations [FAO, 1998]. These factors can be grouped to represent four areas of potential vulnerability: socio-economic and political environment, performance of the food economy, care practices, and health and sanitation [FAO, 1998].

Household food security is the application of the aforementioned concept to the family level, with the focus on individuals within households [FAO, 2001]. Food insecurity at the household level can manifest itself in four dimensions: quantitative (insufficient food), qualitative (reliance on inexpensive non-nutritious food), psychological (anxiety about food supply or the stress of meeting daily food needs), and social (having to acquire food by socially unacceptable means, such as charitable assistance, buying food on credit, and in some cases, stealing) [Radimer *et al*., 1992]. Research has shown that food insecurity in households typically occurs in a series of events as resources diminish. Anxiety regarding household food supplies is generally followed by compromises in the quality and then quantity of parents' food intakes, and, at the most severe levels, in children's food intakes [Cook, 2006]. Many decisions and strategies are employed to assure food security, often at

the expense of other basic goods and services such as medical care and education [Galal, 2002]. Hunger is therefore a managed process at the household level, whereby families aim to protect children from food insecurity and its consequences.

1.1.2 Negative Effects of Food Insecurity

There is an increasing amount of scientific literature demonstrating the associations between food insecurity and adverse health and developmental outcomes in children [Brown, 2002]. There is strong evidence that household food insecurity is associated with inadequate intakes of several important nutrients, poor overall health status, a compromised ability to resist illness due to impaired immunity and wound healing, and a greater incidence of hospitalisations [Olson, 1999; Alaimo *et al*., 2001b; Cook *et al*., 2004; Cook *et al*., 2006].

Additionally, associations exist between household food insecurity and behavioural and psychosocial dysfunction in children, such as higher levels of aggression, hyperactivity, anxiety, and emotional stress [Kleinman, *et al*., 1998; Murphy *et al*., 1998]. Associations are also found between household food insecurity and academic difficulties in children, resulting from impaired cognitive functioning and diminished capacity to learn [Lynch *et al*., 1997; Alaimo *et al*., 2001a; Jyoti *et al*., 2005].

The majority of the studies provide evidence of the multiple negative effects of hunger and food insecurity on children even after controlling for confounding factors such as poverty and low income [Brown, 2002], thereby demonstrating the importance of targeting food insecurity as an urgent issue.

1.1.3 State of Food Security Worldwide

Globally, 1.1 billion people, including 325 million in sub-Saharan Africa, live on less than the internationally recognised poverty threshold of one U.S. dollar per day [von Braun *et al*., 2004]. Such widespread and severe poverty is often both a cause and a consequence of food insecurity.

The World Food Summit has estimated that, of the 854 million chronically food insecure (undernourished) people worldwide, approximately 9 million live in industrialised countries, 25 million live in transition countries, and 820 million live in developing countries, with 96% of the latter also suffering from chronic nutritional deficiencies [FAO, 2006]. In sub-Saharan Africa, the number of undernourished people has increased to 206 million over the past decade. In addition to chronic food insecurity, it is estimated that up to 2 billion people worldwide experience intermittent food insecurity due to varying degrees of poverty [FAO, 2006].

1.1.4 State of Food Security in South Africa

Food insecurity and poverty are therefore among the most urgent social issues in sub-Saharan Africa, including South Africa [Lemke, 2005]. Despite there being adequate national food supplies in South Africa to feed the entire population [Steyn *et al*., 2001], the country experiences increasing household food insecurity.

National studies have found that more than 14 million people, or 35% of the South African population, are food insecure [HSRC, 2004], and that 27% (urban areas) to 62% (rural areas) of households suffer from food poverty, whereby monthly food spending is less than the cost of a nutritionally adequate low-cost diet [Rose & Charlton, 2002a]. Additionally, it

has been found that food insecurity and the prevalence of underweight children is consistently higher in rural areas, such as those in Limpopo Province [Rose & Charlton, 2002b]. Further compounding the problem is the negative impact of the HIV/AIDS epidemic on household food security [van Liere, 2002] in a country where the HIV prevalence is relatively high at 21.5% [UNICEF, 2004].

There is a fair amount of literature on food security in South Africa, which initially focused mainly on national food supplies [Van Zyl & Kirsten, 1992] and on health-related issues regarding immediate causes of food security, nutritional status, and under- and malnutrition [Vorster *et al*., 1997]. More recently, qualitative and quantitative studies have been performed to identify the food insecure in this country, and the risk factors for undernutrition [Rose & Charlton, 2002b; Chopra, 2003; Lemke, 2005].

1.1.5 Measurement and Indicators

In order to reduce and monitor food insecurity it is necessary to determine or measure who is food insecure, why and how they became vulnerable, and where they reside [Maxwell & Frankenberger, 1992]. Food security measurement generally refers to the measurement of individual- and household-level experiences of compromised diets using a series of derived indicators in a food security index [Cook, 2006]. Currently, most methods of developing food security indexes or scores include household vulnerability approaches, experiential tools, coping strategy assessment tools, or combinations of these [Hendriks, 2005].

Since the concept of food security is complex, with multiple factors affecting food supply, access, adequacy, utilisation, safety, and cultural acceptability, the measurement of food (in)security is consequently complex, extensive, and expensive [Hendriks, 2005]. Also, the

set of variables or indicators that are used in the measurement of regional household food security is usually restricted by the data or resources available [Hendriks, 2005]. As such, there is no consensus regarding food security measurement, and new indicators and measurement scales are continually being developed and validated [Hendriks, 2005].

A number of different indicators can be used in the measurement of household food security. In their extensive report, Maxwell and Frankenberger (1992) divide these into "process indicators", which describe both food supply and food access, and "outcome indicators", which serve as proxies for food consumption. Process indicators that reflect food supply include measures of agricultural production, access to natural resources, market infrastructure, and exposure to and consequences of regional conflict [Maxwell & Frankenberger, 1992]. The indicators describing food access are the various strategies used by households to ensure their household food security needs, and vary by season, region, community, social class, ethnic group, household, and gender [Maxwell & Frankenberger, 1992]. Outcome indicators, used to characterise food security outcomes, can be direct or indirect. Direct indicators of food consumption, such as those in household consumption surveys, reflect actual food consumption rather than medical status, for example [Maxwell & Frankenberger, 1992]. Indirect indicators include nutritional status assessments and are generally only used when direct measurements are unavailable or too expensive [Maxwell & Frankenberger, 1992].

Research into the direct measurement of food insecurity was initiated in the U.S. in the late 1980s, because the phenomenon of food insecurity, as experienced by people, was not well understood [Frongillo, 1999]. Focusing on the development and validation of questionnaire-based, direct measures of people's experience with food insecurity and

hunger, a rigorous naturalistic paradigm was selected to understand, define, and measure food insecurity [Radimer *et al*., 1990 & 1992]. Such questionnaire-based measures have been validated for the identification of households with hunger and food insecurity [Frongillo *et al*., 1997]. The standard measurement tool in the United States has since become the U.S. Household Food Security Scale, consisting of a core set of 18 qualitative food security questions [Hamilton *et al*., 1997]. Many additional measures have been developed based on the scale, including the more recent U.S. Food Security Supplement [Frongillo, 1999].

However, there is no standard tool for measuring hunger and food security in South Africa. A recent food expenditure survey in South Africa successfully used objective, quantitative indicators (food poverty and low energy availability) for assessing food insecurity in this country [Rose & Charlton, 2002a & b]. A qualitative study conducted in rural and urban areas of South Africa developed a set of indicators to classify households into four categories of food security, ranging from very insecure to secure [Lemke, 2001; Lemke *et al*., 2003].

In 2004, Hunter and co-workers of the Agincourt Health and Population Unit's (AHPU) demographic surveillance system (DSS) in rural Limpopo Province, South Africa [AHPU, 2003], incorporated a food security questionnaire into the regional census, based on the existing INDEPTH [INDEPTH Network, 2007] food security questionnaire but adapted to local conditions. Additionally, questions were adapted from the U.S. Department of Agriculture (USDA) and U.S. Census Bureau modules in order to gauge food insecurity, with and without hunger. The measurement of food (in)security in South Africa is therefore possible using a variety of validated tools.

1.2 MALNUTRITION

Good nutrition is essential for the survival, health, and development of current and succeeding generations [UNICEF, 2006]. Well-nourished children perform better at school, grow into healthier adults, and are therefore able to give their children a better start in life [UNICEF, 2006]. When children experience food insecurity, however, in addition to poverty, low levels of education, inadequate care practices, and poor access to health services, they develop protein-energy malnutrition (PEM), or undernutrition [Saloojee & Pettifor, 2001; UNICEF, 2006]. The major importance of household food insecurity in the aetiology of undernutrition/malnutrition and death in developing countries is illustrated in the well-known UNICEF causal framework (*Figure 1.1*) [UNICEF, 1990].

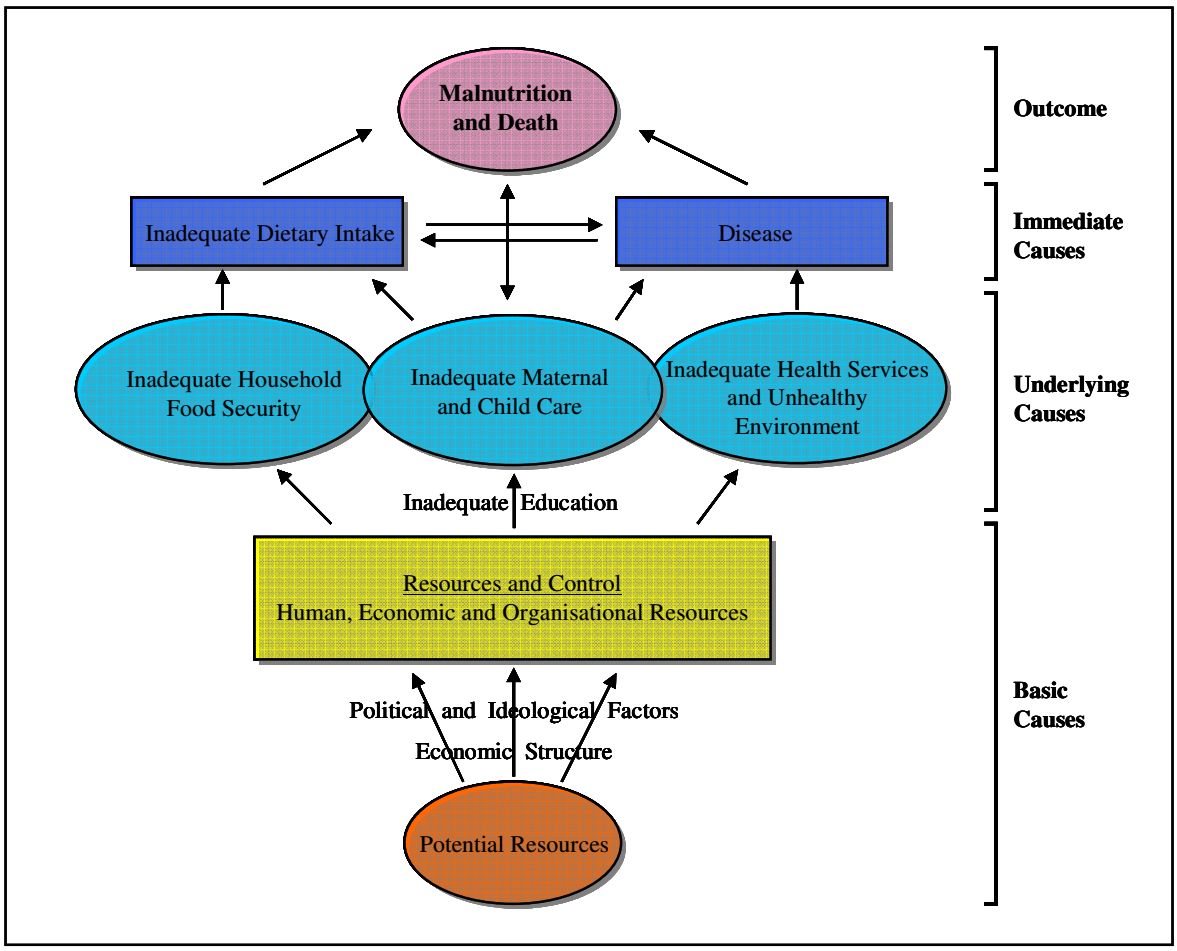

Figure 1.1 Causal framework showing the role of food insecurity in the aetiology of malnutrition and death [*Adapted from* UNICEF, 1990].

The model shows that malnutrition and death are caused by a combination and interaction of inadequate dietary intake and disease, which, in turn, are caused by a necessary combination of insufficient household food security, inadequate child care resulting from lack of education, and insufficient health services [Maxwell & Frankenberger, 1992].

Undernutrition, defined as the outcome of insufficient food intake (hunger) and repeated infectious diseases, includes the severe forms of clinical malnutrition (kwashiorkor and marasmus), the more common forms of mild or moderate malnutrition (being underweight, stunted, or wasted), and micronutrient malnutrition (being deficient in vitamins and minerals) [UNICEF, 2006]. The poor feeding of infants and young children, especially the lack of optimal breastfeeding, in addition to illnesses such as diarrhoea, pneumonia, malaria, and HIV/AIDS, are major causes of undernutrition [UNICEF, 2006]. There is considerable evidence that such undernutrition has adverse effects on children's natural bodily capacities, such as growth, resisting infections and recovering from disease, cognitive development, and physical work [Pelletier & Frongillo, 2003].

As a result of global food insecurity, childhood and maternal undernutrition is the single leading cause of the worldwide burden of disease [Ezzati *et al*., 2002]. That is, more than a third of the world's children are malnourished: approximately 146 million children under-five years of age are underweight (weight-for-age < -2 standard deviations (SD) of WHO reference values), 226 million children are stunted (height-for-age < -2 SD of WHO reference values), and 67 million are wasted (weight-for-height < -2 SD of WHO reference values) [UNICEF, 1998 & 2006]. Since the vast majority of the food insecure live in low-income developing countries, risks associated with food insecurity, hunger, and mal-nutrition still dominate the health status of the population of these countries [WHO, 2002].

In South Africa, it is estimated that about 2.3 million children suffer from undernutrition [Labadarios, 2000]. National and local surveys have shown that acute undernutrition, or wasting, occurs at low levels, whereas chronic undernutrition and malnutrition, or stunting, occurs at high levels, thereby reflecting chronic exposure to adverse conditions such as food insecurity [Labadarios, 2000; Chopra, 2003]. Findings of the National Food Consumption Survey of children aged 1-9 years indicated that 22% of all South African children in this age group were stunted, 10% were underweight, and 5% were wasted [Labadarios, 2000]. Furthermore, younger children (1-3 year olds) were the most severely affected, as were those residing in rural areas. In rural Limpopo Province, for instance, the prevalence of stunting in the 1-9 year old age group was 23%, that of underweight was 15%, and wasting was 7.5% [Labadarios, 2000]. Childhood malnutrition is consequently of great concern in this country.

1.3 CHILD MORTALITY AND MALNUTRITION

Globally, nearly 11 million children under the age of five die each year, of which 40% are neonatal deaths [FAO, 2005]. It has been found that changes in child survival are strongly associated with changes in malnutrition in developing countries [Pelletier & Frongillo, 2003]. Malnutrition is thus a primary contributor to morbidity and mortality in children, exacerbating the progression of disease, and, although it is seldom reported as a cause of death, it is estimated to contribute to 6 million, or over half, of all child deaths each year [FAO, 2005]. Mildly underweight children are twice as likely to die of infectious diseases as children who are better nourished. The risk of death increases five- to eight-fold for children who are moderately to severely underweight [FAO, 2005]. Although the risk of mortality clearly increases with the severity of malnutrition, the largest numbers of deaths

occur amongst those with mild to moderate malnutrition [Pelletier *et al*., 1995; UNICEF, 2006]. As such, relatively few of these children die of starvation. The majority are killed by neonatal disorders and treatable infectious diseases, such as diarrhoea, pneumonia, malaria, and measles, as a consequence of malnutrition and hunger having weakened their immune systems [FAO, 2005].

In a study conducted at the rural Agincourt field site, Limpopo Province, detailed analysis of the mortality profile, based on 1,001 deaths between 1992 and 1995, showed an increasing trend in overall mortality relative to general population growth [Tollman *et al*., 1999b]. Of note was the continuing high level of deaths from infectious and nutritional causes (diarrhoea and kwashiorkor) among children [Tollman *et al*., 1999b].

1.4 RATIONALE OF THE STUDY

One of the Millennium Development Goals (MDG 4) established by 189 nations, including South Africa, at the United Nations Millennium Summit in 2000, was a reduction of the under-five mortality rate by two-thirds between 1990 and 2015 [UN, 2005]. In 2004, the under-five mortality rate (the probability of dying between birth and exactly five years of age) in South Africa was 67 per 1,000 live births [UNICEF, 2004]. Since the level of child mortality is a fundamental indicator of child health, understanding the causes of child deaths provides insight into how they can be reduced.

The food insecurity existing in many rural South African households may be associated with increased child mortality. As studies on this concept have not been previously conducted in this country, it is important to study any such associations amongst South

African children to determine additional risk factors for child mortality, which would increase the knowledge of the topic both in this area and nationally, and which may be targeted by future policies for the reduction of child mortality.

1.5 STUDY OBJECTIVES

1.5.1 Primary Objectives

The main objective was to establish the relationship between household food security and mortality in children under the age of five years in the Agincourt field site, Limpopo Province, in 2004.

1.5.2 Hypothesis

Mortality in children under the age of five years is negatively correlated with food security in Agincourt, in 2004.

1.5.3 Secondary Objectives

- To determine the relationship between food security and age group-specific mortality (0-1 years (breastfeeding), and 1-5 years (family food)).
- To determine the relationship between food security and socio-economic-specific mortality (poor and wealthy).
- To assess the relationship between food security and selective cause-specific mortality (malnutrition, HIV, and diarrhoea).

Chapter 2: MATERIALS AND METHODS

2.1 STUDY SITE

Fieldwork for the study was conducted at the field site of the Agincourt Health and Population Unit (AHPU) of the School of Public Health, University of the Witwatersrand. Situated 500 km northeast of Johannesburg, Agincourt is a rural subdistrict of Bushbuckridge in the Bohlabela District of Limpopo Province, adjacent to the border with Mozambique (*Figure 2.1*) [Tollman, 1999]. The area lies in the former Gazankulu and Lebowa 'homelands' of the semi-arid (annual rainfall 550-700 mm) central lowveld, and is bounded by the Drakensberg escarpment and commercial forestry plantations to the west, the Kruger National Park to the east, the Hoedspruit farming area to the north, and Hazyview to the south [Tollman *et al.*,1999a].

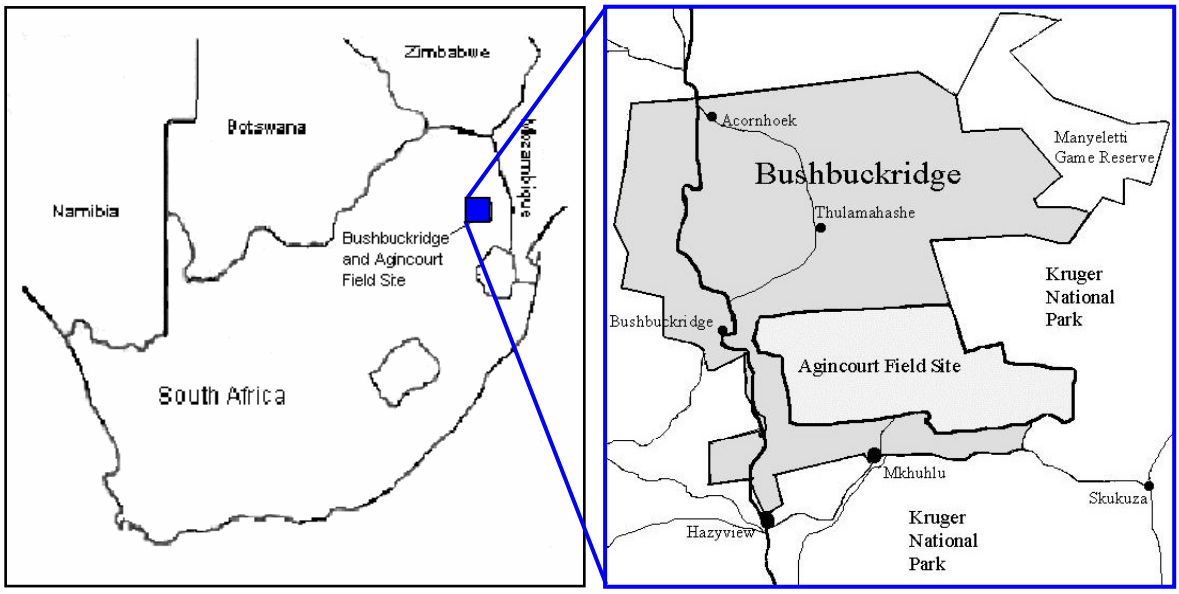

Figure 2.1 Map of South Africa showing the highlighted Bushbuckridge area (Bohlabela District) and Agincourt field site [Adapted from Collinson *et al.*, 2006].

The Agincourt field site covers 400 km^2 and includes 70,000 people in 11,000 households across 21 villages [AHPU, 2003]. As such, the area, which is mainly settled by black Shangane people, is heavily populated with an average of 175 people per km^2. Typical of rural communities across South Africa, the settlement pattern of the field site is characterised by the presence of large villages, each surrounded by cultivated fields and communal land used for livestock grazing and the harvesting of natural resources [Hunter *et al*., 2007]. Homestead yards (*Figure 2.2*) are generally large (30 m x 40 m) and comprise dwellings, animal pens, and garden plots used for small-scale cultivation of maize – the staple crop – and sometimes fruit and vegetables [Hunter *et al*., 2007]. Subsistence agriculture is not supported by the small size of the household garden plots and the serious water shortage problem [AHPU, 2003]. Migrant labour is the main form of employment in Agincourt, with remittances being critical to local livelihoods [AHPU, 2003].

Figure 2.2 Terrain and homesteads typical of the Agincourt field site [Schatz, 2003].

2.2 STUDY POPULATION

The study population consisted of all children under the age of five years that were residing in Agincourt in 2004.

2.3 STUDY DESIGN

The study was an analytical cross-sectional study of secondary data, in which exposures and outcomes were assessed simultaneously among individual children in the population over the one-year period.

2.4 DATA COLLECTION

2.4.1 Agincourt Health and Demographic Surveillance System

In order to provide population-based information to support health planning and practice with regard to rural subdistrict populations, a health and demographic surveillance system (HDSS) was initiated in Agincourt in 1992 [Tollman *et al*., 1999b]. The primary tool of the HDSS is an annual census of the demographic status of every member of the population in the 21 defined villages, as well as the systematic recording of all births, deaths, in-migrations, and out-migrations that have occurred since the preceding year's update [Collinson *et al*., 2006].

In addition to demographic and socio-economic information, the census data include one or two detailed modules each year that provide information on socially relevant topics. In 2004, the census included a module detailing information on the factors determining food security. Before data collection began, these data collection modules were workshopped and piloted with community members and Agincourt staff, and data quality procedures were interwoven into the process of the field operation [Collinson *et al*., 2006].

2.4.2 Questionnaires

The field team that administered the census and module questionnaires comprised local youth, recruited from villages of the field site, who had completed secondary school and undergone the relevant training [Tollman *et al*., 1999b]. Working in couples under fieldworker guidelines (*Appendix B*), the fieldworkers visited each household in every village, interviewed in the local language (Shangaan) the most senior adult present, and systematically recorded each household member according to age, gender, education level, union status, refugee status, socio-economic status, birth characteristics, mortality, and food security status. All recorded deaths were the subject of a verbal autopsy, during which a separate questionnaire was administered by a trained, lay fieldworker to the closest caregiver of the deceased, and subsequently assessed for causation by three independent medical practitioners [Tollman *et al*., 1999b; Byass *et al*., 2006]. Quality control of the census was ensured by field supervisors who revisited a 2% random sample of households to complete duplicate census forms, which were then compared with the original questionnaire to assess discrepancies [Tollman *et al*., 1999a].

The secondary data used in the current study were obtained from the completed Agincourt annual census questionnaire of 2004, the household food security module questionnaire of 2004 (*Appendix A*), and, where necessary, from verbal autopsies of the deaths.

2.4.3 Community Participation

A partnership between the Agincourt HDSS, the study communities, and the local health services was a priority from the outset of the establishment of the HDSS [Collinson *et al*., 2006]. Prior to the start of the study, a series of meetings was held in each village with

community members and their leadership in order to disseminate information regarding the study for their approval and acceptance.

2.5 SAMPLE SIZE

Of the total 9,736 children under the age of five years that were recorded in the 2004 census questionnaire, 1,942 children were excluded from the study due to missing household data entries and a further 4 children were excluded because of unknown gender. The final sample size of the study was therefore 7,790 children.

2.6 MEASUREMENTS

2.6.1 Household Food Security

An initial intention of the study was to develop a household food security index using, as indicators, the 19 variables created from the 2004 household food security module questionnaire (*Appendix A*). These food security variables represent both "process indicators", which describe food supply and food access, and "outcome indicators", which serve as proxies for food consumption, as described by Maxwell and Frankenberger (1992). Such an index would classify households into various categories of food security, ranging from very insecure to secure.

Due to the large amount of missing data and "unknown" responses regarding the food security questionnaire, however, it was not possible to construct a reliable and valid household food security index for this study. Instead, certain exposure variables were

selected for use as predictors or indicators of food security: whether the household had not had enough food to eat in the last month, and year; the number of meals taken by the child per day; and how the amount of food available to the household was expected to change in the coming year. Each of the selected variables was subsequently analysed with respect to mortality that occurred only in 2004 in children under the age of five years (hereafter referred to as under-five mortality, which is *not* intended to be synonymous with under-five mortality rate, as this would be under-estimated in this study).

2.6.2 Socio-Economic Status

The socio-economic status (SES) of each child's household was discerned from the 2003 census data by construction of an SES index. The basis of the index is that housing characteristics, such as sources of water, type of toilet facilities, and housing construction materials; and household possessions, including electricity, radio, television, and animals, often reflect the SES of households [Bawah & Zuberi, 2004]. It is presumed, firstly, that wealthier households are more likely to own any given set of assets and, secondly, that certain assets are more likely to be owned at relatively low levels of SES (such as radio or bicycle), while others are owned only at higher levels (television or car) [Pongou *et al*., 2006]. As such, it is possible to use these variables together as a proxy for household wealth or SES in the creation of a poverty index.

In this study, the SES index was constructed using principal component analysis (PCA), a statistical procedure that linearly transforms a large set of variables into a smaller number of uncorrelated variables that retain most of the information contained in the original set [Bawah & Zuberi, 2004]. Such a method is used as it is able to mathematically determine the weights that will maximize the variation in the linear composite or principal

components, which are ordered such that the first few tend to explain most of the variation in the original set of variables [Bawah & Zuberi, 2004]. PCA was performed on 26 variables relating to household SES, including number of rooms; wall, roof, and floor type; toilet facility and type; water supply and availability; power used for light and cooking; and ownership of stove, fridge, television, video, satellite dish, radio, cellular and fixed phone, car, motorbike, bicycle, cart, cattle, pigs, goats, and poultry. Using an Eigenvalue of 1.0 or more, the first principal component, representing the greatest variation (16.96%), was selected and divided into tertiles to create a continuous SES index ranging from 1 (lowest SES) to 3 (highest SES).

2.7 DATA ANALYSIS

Data were entered, cleaned, and analysed using the statistical computer software program STATA version 9.0 (STATA Corporation, College Station, TX, USA).

2.7.1 Descriptive Analysis

Descriptive analysis was first performed on all of the data. Frequencies and percentages were calculated for categorical variables, such as gender, child mortality, parent education status, SES, and the various food security variables. Means and their corresponding standard deviations were calculated for continuous variables, such as child age and age at death. Additionally, the frequency distributions of certain variables were represented graphically by histograms, for continuous data, and bar charts for discrete data.

2.7.2 Logistic Regression Analysis

Logistic regression is a statistical regression model for Bernoulli-distributed dependent variables. It is used to determine associations and to control for confounders when the outcome variable is binary (0 or 1 / lived or died) and the explanatory variable(s) are categorical or continuous, such that the relationship between the two is non-linear, or s-shaped. Logistic modelling is thus used to create a generalised linear model, whereby the logarithm of the odds (the probability divided by one minus the probability) of the outcome is modelled as a linear function of the explanatory variables, x_i. Data are fitted to the logistic model of the form:

$$\text{logit}(p_i) = \ln(p_i/1 - p_i) = \alpha + \beta_1 x_{1,i} + \beta_2 x_{2,i} + \ldots + \beta_k x_{k,i}$$

where $i = 1, \ldots, n$; α is the intercept; β is a parameter estimated using maximum likelihood; there are n units with covariates x; and $p_i = \Pr(Y_i = 1)$. Thus, the model provides the log of the odds that the outcome variable is equal to 1. Logistic regression ultimately expresses both the magnitude and direction of the association between the outcome and explanatory variable(s) by calculating the odds ratio (OR) and corresponding 95% confidence interval (CI) of the association. When one dichotomous explanatory variable is included in the model, the OR obtained from the logistic regression is equivalent to that obtained from the Chi-squared test of the explanatory and outcome categorical variables.

2.7.2.1 Univariate Analysis

Univariate logistic regression was performed to determine which individual explanatory variables were significantly associated with the outcome variable, under-five child mortality in 2004, by calculation of unadjusted ORs and 95% CIs. As such, each of the 19 food security variables (*Appendix A*) was individually included in a logistic regression model as an explanatory variable. Additionally, the explanatory variables investigated as

possible confounders included gender, age, birth weight, ever been breastfed, mother and father education, parent union status, refugee status, age and gender of the household head (HH), household dependency- and sex-ratio, and SES (continuous and categorical). In order to control for age group, each of the latter logistic regressions was performed a second time stratified by age group (0-1 years and 1-5 years) and results were subsequently compared to the initial logistic regression results.

2.7.2.2 Multivariate Analysis

Following univariate analysis, multivariate analysis of the data was performed in order to calculate adjusted ORs and 95% CIs and thus determine the magnitude and direction of the association between each of the significant food security variables and the outcome (under-five mortality in 2004), whilst adjusting for the effects of confounding. Separate multivariate logistic regression models were constructed for each of the food security variables found by univariate logistic regression analysis to be significantly associated with the outcome. Other than those regarding food security, all other explanatory variables found to be significantly associated with the outcome were included in each multivariate logistic regression model. Subsequently, only explanatory variables that improved the final models were retained. By including, and thereby controlling for, many such significant confounding variables, the possibility of spurious associations between the outcome and food security variables was reduced. Finally, stratified multivariate analysis was conducted on the food security variables by age groups and by cause of death.

2.8 ETHICAL CONSIDERATIONS

- The University of the Witwatersrand Committee for Research on Human Subjects (Medical) provided ethical approval for the current secondary data analytical study: Clearance number M070239 (*Appendix C*).
- The University of the Witwatersrand Committee for Research on Human Subjects (Medical) provided ethical "blanket approval" for a generic protocol concerning a study at the Agincourt field site entitled "Investigating and responding to changes in the health and population dynamics of rural South Africans": Clearance number M960720 (*Appendix C*).
- Informed consent was obtained from participants at the community, household, and individual levels prior to their inclusion in the study.

Chapter 3: RESULTS

3.1 DESCRIPTIVE ANALYSIS

3.1.1 Overall Population

A total of 7,790 children under the age of five years (mean = 2.46 years; SD = 1.48 years) were analysed in the study, of which 50.30% were female (*Figure 3.1*).

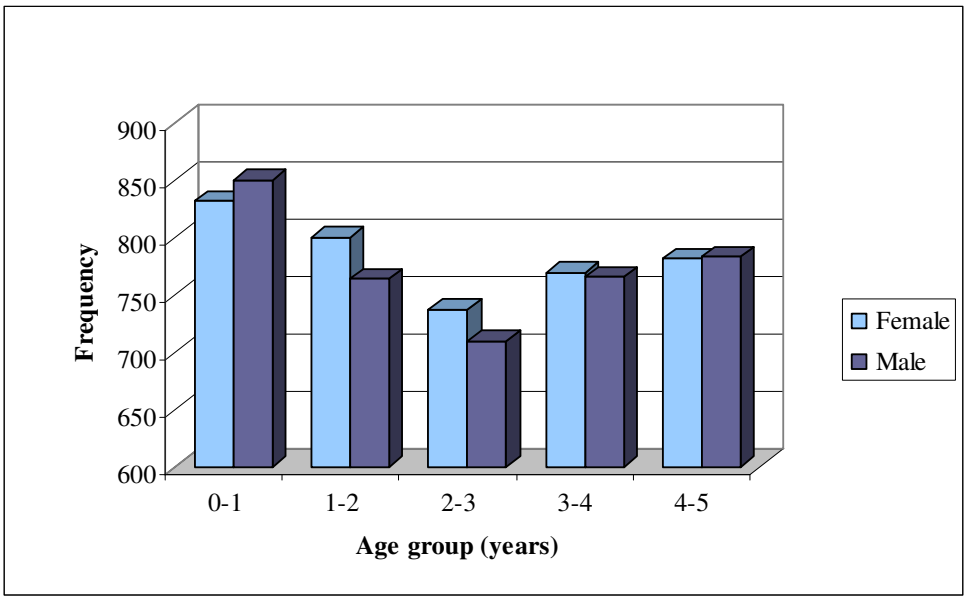

Figure 3.1 Age and sex distribution of all children under the age of five years included in the study in 2004 (N=7,790).

The distribution of all of the children by their socio-demographic characteristics is shown in *Table 3.1*. The majority of the children (89.75%) had a normal birth weight of greater than 2.5 kilograms, whereas only 10.25% of the children displayed a low weight at birth. Nearly all (96.64%) of the children were breastfed for varying periods of time.

Table 3.1 Distribution of socio-demographic characteristics among all respondents in 2004.

Characteristic	Total Number of Respondents (n=7,790)	
	Number[a]	%
Gender		
Female	3,918	50.30
Male	3,872	49.70
Age group (years)		
0-1	1,681	21.58
1-2	1,564	20.08
2-3	1,447	18.58
3-4	1,534	19.69
4-5 (<5)	1,564	20.08
Birth weight (kg)		
<2.5	518	10.25
≥2.5	4,535	89.75
Parents union status at birth		
Not in union	728	20.48
Union	771	21.69
Formal married	2,055	57.82
Refugee		
South Africa	5,027	64.57
Mozambique, prior 1993	399	5.13
Mozambique, after 1992	2,359	30.30
Household head age at birth (years)		
0-30	435	5.69
30-60	5,413	70.83
>60	1,794	23.48
Household head gender at birth		
Female	2,491	32.59
Male	5,152	67.41
Household dependency ratio at birth (children:adults)		
0-2	6,686	85.83
>2	1,104	14.17
Household adult sex ratio at birth		
0-2	7,138	91.63
>2	652	8.37
Socio-economic status		
1st tertile	2,538	33.33
2nd tertile	2,538	33.33
3rd tertile	2,539	33.34

[a] Totals exclude missing and unknown values.

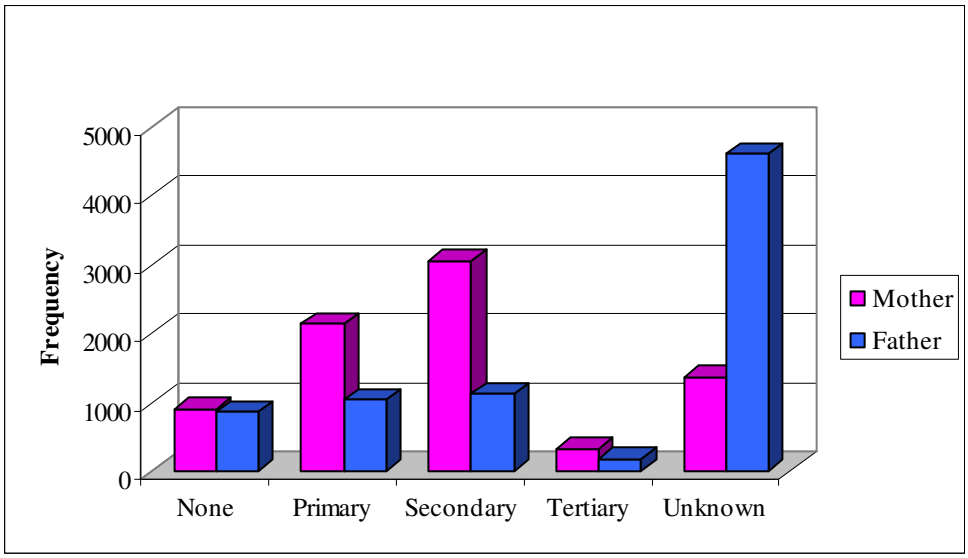

Figure 3.2 Highest education levels attained by mothers and fathers in the study population at the time of their children's births (N=7,790).

The highest education level attained by the majority of parents at the time of their children's birth was some level of secondary education (grades 8 to 12) (*Figure 3.2*). At the time of their birth, 57.82% of the children's parents were in a formal marriage (married or remarried), whereas 21.69% were in an informal union (co-habiting), and 20.48% were not in any union (separated, divorced, or widowed). Almost two thirds (64.57%) of the children in the study were South African, with the rest being refugees – 5.13% of the children's families moved to the area from Mozambique prior to the establishment of the Agincourt field site in 1992, and the remaining 30.30% migrated to Agincourt from Mozambique after the end of 1992 (*Table 3.1*).

Comprising 70.83%, the most common age of the household heads at the time of the children's births was between 30 and 60 years old (mean = 49.40 years; SD = 14.11 years). Greater than two thirds (67.41%) of the children's household heads were male. The vast majority (85.83%) of households displayed a low dependency ratio of between 0 and 2

children to adults at the time of birth, with only 14.17% having a greater dependency ratio (mean = 1.14; SD = 0.74). Similarly, 91.63% of households had an adult sex ratio (male:female) of 0 to 2, while 8.37% had a higher ratio (mean = 0.86; SD = 0.64) (*Table 3.1*).

The socio-economic status of each child in the study was calculated according to the method described in *Section 2.6.2*, such that 33.33% of individuals were distributed into each respective tertile ranging from 1 (representing the lowest SES) to 3 (highest SES). The socio-economic characteristics of the children and their households are summarised in *Table D.1* (*Appendix D*).

The majority of households consisted of one to five rooms (92.76%), cement walls (79.38%) and floors (91.51%), and corrugated iron roofs (90.35%); 62.88% had a toilet facility in the yard, with the majority using pit toilets (62.57%); water was supplied by a tap in the street for 73.89% of individuals, and 62.90% stated that water was not available every day; electricity was the main power used for light (74.36%), whereas 78.61% used wood as the fuel source for cooking. Certain household appliances were owned by the majority of people: television (60.31%), cellular phone (59.47%), and fridge (50.62%); whereas other appliances were scarcer: stove (40.06%), radio (26.59%), video cassette recorder (8.45%), fixed telephone (2.17%), and satellite dish (0.30%). Additionally, few people possessed their own transport: motor car (16.20%), bicycle (13.09%), cart (2.92%), and motorcycle (0.56%). Finally, poultry was the most commonly owned livestock (62.48%), followed by cattle (15.14%), goats (14.58%), and pigs (2.92%).

3.1.2 Household Food Security

The food security questionnaire completed within the 2004 population census provided a description of the study population with respect to its household food security characteristics of food supply and access (*Table 3.2*), and food consumption (*Table 3.3*).

Table 3.2 Distribution among all respondents in 2004 of food security characteristics representing "process indicators" of food supply and food access.

Characteristic	Total Number of Respondents (N=7,790)	
	Number	%
How household obtained maize[a]		
Grown in own garden	2,401	30.82
Grown outside of own garden	225	2.89
Purchased	7,290	93.58
Borrowed	62	0.80
Received it free	279	3.58
Other	157	2.02
Unknown	255	3.27
Staple foods (other than maize)[a]		
Rice	4,887	62.73
Bread	6,565	84.27
Potatoes	1,182	15.17
Other	742	9.52
Unknown	278	3.57
Food crops (other than maize) grown in own garden[a]		
Fruit	2,641	33.90
Vegetables	3,628	46.57
Other	796	10.22
None	2,464	31.63
Unknown	257	3.30
Food crops (other than maize) grown in field[a]		
Fruit	95	1.22
Vegetables	817	10.49
Other	803	10.31
None	6,024	77.33
Unknown	261	3.35
Gardens/fields produced enough to feed all household last year		
Yes	1,525	19.58
No	5,744	73.74
Unknown	521	6.69

Reasons for not enough food to feed all household last year[a] (N=6,265)		
Gardens/fields too small	1,659	26.48
Not enough fertiliser	679	10.84
Not enough water	3,813	60.86
Not enough labour	516	8.24
Other	476	7.60
Unknown	2,197	35.07
How food requirements were supplemented when not enough food last year[a] (N=6,265)		
Buy food from market	5,084	81.15
Relatives, friends donate	357	5.70
Government food aid	107	1.71
Gather from bush	4,354	69.50
Sell household goods	4	0.06
Borrow money	64	1.02
Manage on food available	147	2.35
Other	26	0.42
Unknown	2,109	33.66

[a] More than one option was possible, eg. Maize was grown in own garden *and* was purchased.

As shown in *Table 3.2*, the staple food of the study population of 7,790 people was maize (mealies or mealie meal), which was obtained by the majority (93.58%) of the population by its purchase. Additionally, 30.82% of households grew maize in their own gardens or homestead plots. Staple foods other than maize that were often consumed by household members included bread (84.27%), rice (62.73%), and potatoes (15.17%). In addition to maize, other food crops were grown in homestead gardens by 65.07% of the population. As such, 46.57% of the population grew their own vegetables, 33.90% grew fruit, and 10.22% grew other crops including peanuts, groundnuts, and cassava. In contrast, only 19.32% of the population grew food crops other than maize in a field outside of their homestead plots: vegetables were grown by 10.49% of the population, while other crops such as peanuts and groundnuts were grown by 10.31%.

The majority (73.74%) of the population's gardens and fields did not produce enough food crops to feed all household members in 2004 (*Table 3.2*). The main reasons cited for such under-production were insufficient water (60.86%), insufficient space for crop growth in gardens and fields (26.48%), and insufficient amounts of fertiliser (10.84%). In order to supplement their food requirements, these particular households bought additional food from markets (81.15%) and gathered various foods from the surrounding bush (69.50%). Of these latter households, the most commonly gathered bush food was wild herbs (99.36%), such as Guxe, which was also the most frequently gathered: 37.12% of households harvested wild herbs more than ten times per month. Wild fruit, such as Marula, was gathered by 36.91% of the households, with the majority (27.40%) harvesting fruit one to five times per month. Only 29.44% of households reported harvesting wild insects, such as locusts, flying ants, and mopani worms, which were mainly gathered one to five times per month (26.44%). Bush meat, such as small mammals and birds, and other wild food, such as rain frogs, were rarely gathered to supplement household food requirements (0.83% and 0.11%, respectively) (*Figure 3.3*).

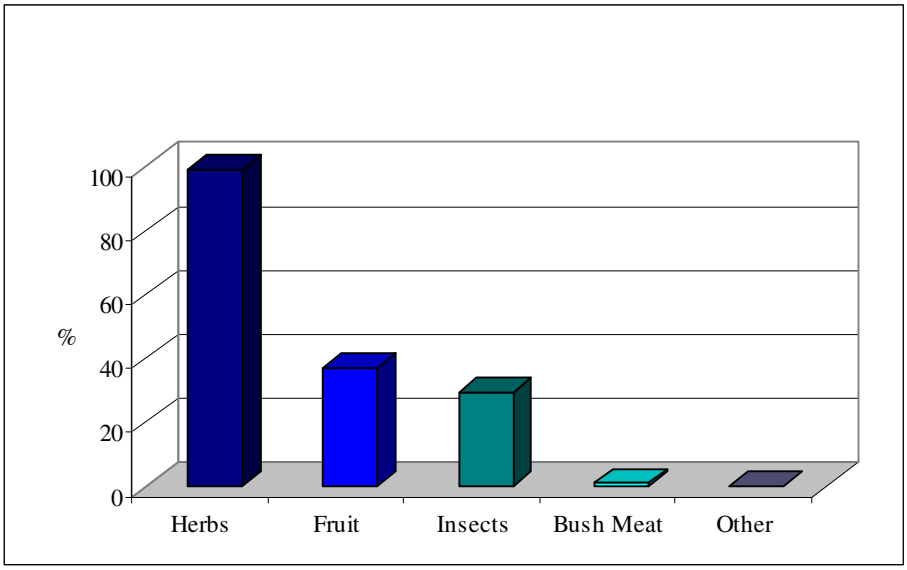

Figure 3.3 Percentage of the population that supplemented their food requirements in 2004 by harvesting foods from the bush (N=4,354), according to food type.

Table 3.3 Distribution among all respondents in 2004 of food security characteristics representing "outcome indicators" of food consumption.

Characteristic	Total Number of Respondents (N=7,790)	
	Number	%
Not enough food last year		
No	4,506	57.84
Yes	2,947	37.83
Unknown	337	4.33
Reasons for not enough food last year (N=3,286)		
Not enough money	2,701	82.20
Food did not grow	27	0.82
Not enough money / food growth	118	3.59
New household members	3	0.09
Other	65	1.98
Unknown	372	11.32
Season of not enough food last year (N=3,284)		
Summer only	890	27.10
Winter only	685	20.86
Both	1,350	41.11
Unknown	359	10.93
Not enough food last month		
No	4,641	59.58
Yes	2,832	36.35
Unknown	317	4.07
Period of not enough food last month (days) (N=3,082)		
1-7	1,815	58.89
8-30	1,012	32.84
Unknown	255	8.27
No. of meals eaten / day		
0-2	822	10.55
3	5,207	66.84
≥4	1,060	13.61
Unknown	701	9.00

As shown in *Table 3.3*, food consumption by the study population in 2004 could be represented by a number of outcome indicators. Over a third (36.35%) of the population's households reported not having enough food to eat in the past month, compared to 59.58% reporting food security in that respect. Of the food insecure, 58.89% did not have sufficient

food for one to seven days of the month, whereas 32.84% did not have enough food to eat for eight to thirty days and were thus the most food insecure.

Similarly, 37.83% of households reported not having sufficient food to eat in the past year, while 57.84% reported being food secure. Of the former households, 41.11% did not have enough food in summer and winter, whereas 27.10% were food insecure in summer only and 20.86% in winter only. The main reason cited for such lack of food that year was too little money (82.20%), sometimes in combination with a poor homestead harvest (3.59%) (*Table 3.3*).

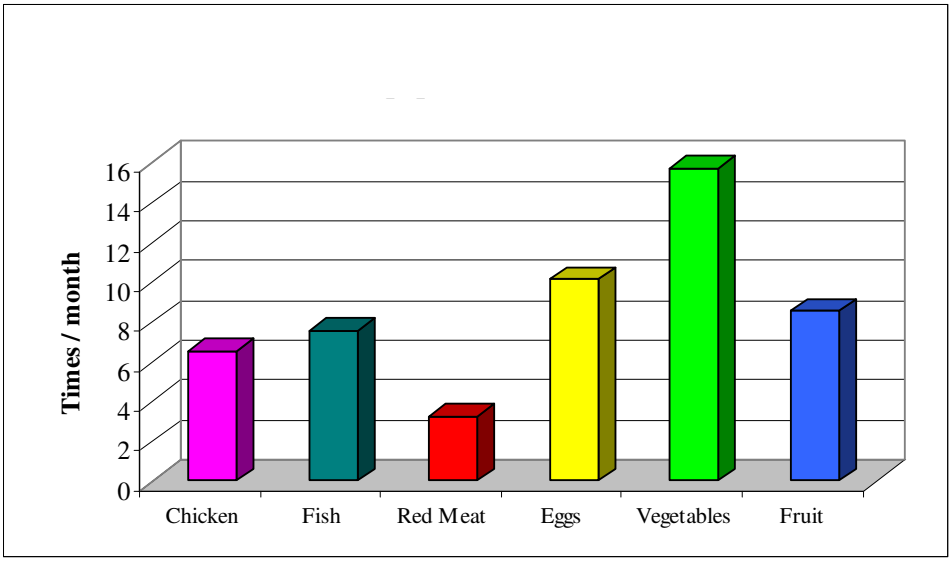

Figure 3.4 Mean number of times per month foods were consumed by the study population in 2004.

Certain food types were consumed more regularly than others by the population (*Figure 3.4*). The vast majority (94.03%) of the study population reported eating vegetables, with 35.21% consuming them more than twenty times a month (median = 12 times per month). Eggs were the second most commonly and frequently consumed food: 66.15% of

individuals reported eating eggs, 13.93% of which did so over twenty times per month (median = 8 times per month). Fruit was known to be consumed by 82.95% of the population, mostly one to ten times per month (median = 4 times). All types of meat were the least frequently consumed foods: 58.46% of the population ate fish one to ten times per month (median = 8 times), 72.71% ate chicken one to ten times per month (median = 4 times), and 70.71% consumed red meat one to ten times per month (median = 2 times).

Two-thirds (66.84%) of the population's children consumed three meals per day (mean = 3.04 meals per day; SD = 0.56) in 2004 (*Table 3.3*). Similarly, 66.15% of households reported that their children had consumed three meals the previous day (mean = 3.04 meals yesterday; SD = 0.57). When asked to predict their future expected food availability, and hence food security, in the coming year, 8.46% of the population reported less food, 27.42% reported the same amount of food, and 10.05% predicted that they would have more food (*Figure 3.5*).

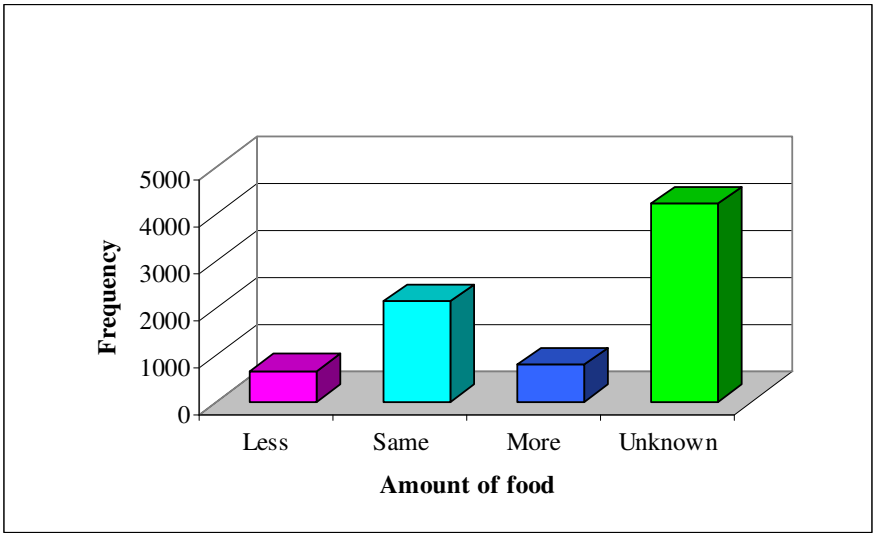

Figure 3.5 Future expected food availability, and hence food security, of the study population for 2005 (N=7,790).

3.1.3 Child Mortality and Causes of Death

Of the 7,790 children constituting the study population, 79 children (1.01%) died from a range of causes in 2004, 51.90% of which were male (*Figure 3.6*). The majority (59.49%) of the children died before the age of one year (mean age = 0.98 years; SD = 0.96 years; median age = 0.54 years), with the number of deaths decreasing as child age increased (*Figure 3.6*). The mean age of the 7,711 surviving children was higher at 2.55 years (SD = 1.46 years).

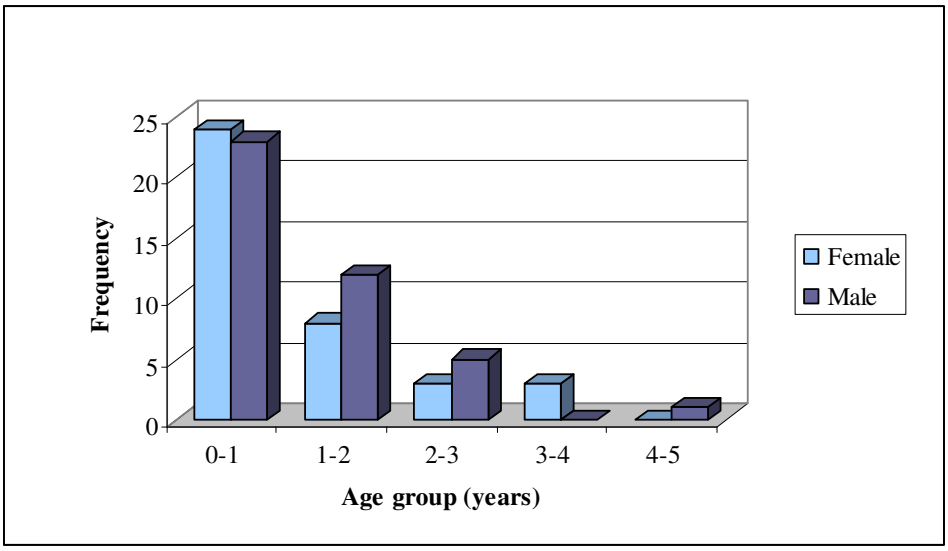

Figure 3.6 Age and sex distribution of all children under the age of five years included in the study who died in 2004 (N=79).

The distribution of all of the children by their socio-demographic characteristics compared to those children who died in 2004 is shown in *Table 3.4*. The majority (80.56%) of the children who died had a normal birth weight of greater than 2.5 kilograms, although these children were more likely to have a lower birth weight than the surviving children. Compared to the 96.64% of surviving children who had been breastfed, slightly fewer (92.41%) of the deceased children received breastfeeding. The highest education level attained by the majority of parents at the time of these children's birth was secondary education: 59.38% of mothers and 42.86% of fathers had some level of high school education, compared to lower proportions of the surviving children's parents.

Table 3.4 Distribution of socio-demographic characteristics among all respondents and among the children who died in 2004.

Characteristic	Total Number of Respondents (%) (N=7,790)	Number of Children Died in 2004 (%) (N=79)
Gender		
Female	3,918 (50.30)	38 (48.10)
Male	3,872 (49.70)	41 (51.90)
Age group (years)		
0-1	1,681 (21.58)	47 (59.49)
1-2	1,564 (20.08)	20 (25.32)
2-3	1,447 (18.58)	8 (10.13)
3-4	1,534 (19.69)	3 (3.80)
4-5 (<5)	1,564 (20.08)	1 (1.27)
Birth weight (kg)		
< 2.5	518 (10.25)	7 (19.44)
≥ 2.5	4,535 (89.75)	29 (80.56)
Mother education level		
None	904 (14.09)	6 (9.38)
Primary	2,140 (33.34)	17 (26.56)
Secondary	3,045 (47.44)	38 (59.38)
Tertiary	328 (5.11)	3 (4.69)
Father education level		
None	853 (26.83)	9 (32.14)
Primary	1,030 (32.40)	5 (17.86)
Secondary	1,121 (35.26)	12 (42.86)
Tertiary	174 (5.47)	2 (7.14)
Parents union status at birth		
Not in union	728 (20.48)	5 (16.67)
Union	771 (21.69)	13 (43.33)
Formal married	2,055 (57.82)	12 (40.00)
Refugee		
South Africa	5,027 (64.57)	46 (58.23)
Mozambique, prior 1993	399 (5.13)	10 (12.66)
Mozambique, after 1992	2,359 (30.30)	23 (29.11)
Household head age at birth (years)		
0-30	435 (5.69)	6 (7.79)
30-60	5,413 (70.83)	53 (68.83)
>60	1,794 (23.48)	18 (23.38)
Household head gender at birth		
Female	2,491 (32.59)	36 (46.75)
Male	5,152 (67.41)	41 (53.25)
Household dependency ratio at birth (children:adults)		
0-2	6,686 (85.83)	68 (86.08)
>2	1,104 (14.17)	11 (13.92)

Household adult sex ratio at birth		
0-2	7,138 (91.63)	74 (93.67)
>2	652 (8.37)	5 (6.33)
Socio-economic status		
1st tertile	2,538 (33.33)	39 (50.00)
2nd tertile	2,538 (33.33)	21 (26.92)
3rd tertile	2,539 (33.34)	18 (23.08)

At the time of their birth, in comparison to the parents of the total population of children, the majority of the parents of the children who died were in a union (43.33%) or were formally married (40.00%). Of the children who died, 58.23% were South African and 41.77% were refugees, compared to the smaller 35.43% of the total population being refugees. The majority (68.83%) of the household heads of the children who died were between thirty and sixty years of age (mean = 49.25 years; SD = 14.02) and 53.25% were male. That is, the household heads of the children who died were more likely than the household heads of the surviving children to be female. The household dependency ratio and adult sex ratio at birth were similar for the total population and for those children who died. The greatest percentage (50.00%) of deceased children were classified in the lowest tertile of household socio-economic status, while 26.92% were classified as SES 2, and 23.08% were in the highest tertile, SES 3. The SES characteristics of the children's households are summarised in *Table D.1* (*Appendix D*).

Of the children who died in 2004, 59.49% were reported to have died locally, with 60.76% dying at home. As shown in *Figure 3.7*, nearly a quarter (24.05%) of the 79 children's deaths were caused by diseases resulting from HIV infections (mean age = 1.09 years). The remaining main causes of death included gastrointestinal diseases (8.86%) (mean age = 1.57 years), respiratory infections (7.59%) (mean age = 0.40 years), malnutrition (5.06%) (mean age = 2.09 years), complications associated with labour and delivery (3.80%), and

diseases of the central nervous system (2.53%) (mean age = 0.96 years). Constituting a third (32.91%) of deaths (mean age = 0.96 years), other ill-defined and unspecified causes were the most commonly recorded causes of under-five deaths. The twelve remaining deaths (15.19%) had missing or unknown causes (mean age = 0.69 years) (*Figure 3.7*).

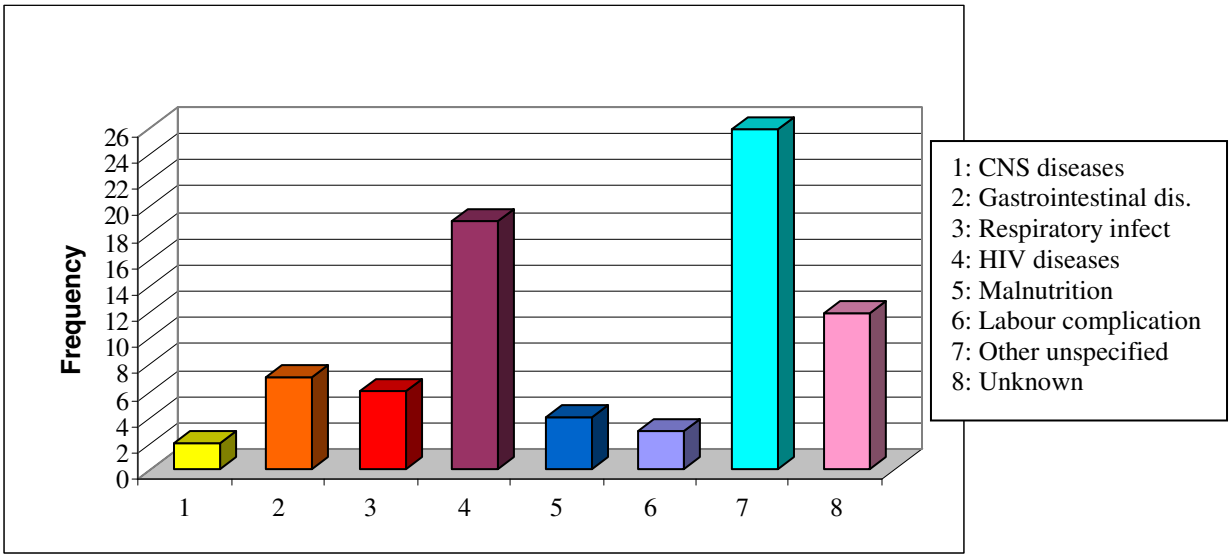

Figure 3.7 Main causes of mortality in 2004 in children under-five years of age (N=79).

A description of the study population with respect to its household food security characteristics of food supply and food access compared to those of the children who died in 2004 is shown in *Table D.2* (*Appendix D*). The household food security characteristics of the children who died were similar to those of the total study population, as described in *Section 3.1.2*. A notable difference, however, was that the majority of the households of deceased children reported a greater percentage of "unknowns" regarding the various characteristics. Also, a greater percentage of these households reported that: they grew maize in their own gardens (35.44%); their gardens or fields did not produce enough crops to feed all household members that year (78.48%); and they gathered food from the bush to supplement their food requirements (72.46%).

The household food security characteristics representing the food consumption of the study population compared to those of the children who died in 2004 are tabulated in *Table D.3* (*Appendix D*). The characteristics of the latter children were again similar to those of the total population, as described in *Section 3.1.2*. However, the main difference between the two was that all of the households of deceased children reported a far greater percentage of "unknowns" regarding the various food security characteristics. Additionally, compared to the total population, a greater percentage of the households of deceased children reported that: they did not have sufficient food to feed all household members in both summer and winter of the previous year (50.00%); and they did not have enough food for the household in the previous month (41.77%). Similarly, these households reported consuming chicken (mean = 6.32), red meat (mean = 2.44), eggs (mean = 8.82), vegetables (mean = 14.91), and fruit (mean = 6.76) fewer times per month on average. Only fish was consumed more frequently per month by these households (mean = 8.1 times). Finally, when asked to report their expected food availability, and hence food security, for the coming year, a greater percentage of the households of deceased children than total households anticipated less food (food insecurity) (13.92%), and fewer reported the same amount (22.78%) or more food (food security) (3.80%). The majority (59.49%) of these households, however, reported that their future expected food availability was "unknown".

3.2 UNIVARIATE ANALYSIS

As described in *Section 2.7.2.1*, univariate logistic regression was performed to determine which individual explanatory variables were significantly associated with the outcome variable, under-five child mortality in 2004, by calculation of crude ORs and 95% CIs. These results are shown in *Table 3.5*.

Table 3.5 Variables significantly associated with under-five child mortality in 2004, following univariate analysis.

Variable	Crude Odds Ratio	P-value	95% Confidence Intervals
Age (years) **	0.39	0.000	0.31 - 0.50
Age group (years)			
0-1 (<1)	1		
1-5 (<5)**	0.18	0.000	0.12 - 0.29
Ever been breastfed			
No	1		
Yes **	0.26	0.002	0.11 - 0.60
Parents union status at birth			
Not in union	1		
Union *	2.48	0.086	0.88 - 6.99
Formal married	0.85	0.760	0.30 - 2.42
Refugee			
South Africa	1		
Mozambique, prior 1993 **	2.78	0.004	1.39 - 5.56
Mozambique, after 1992	1.07	0.803	0.64 - 1.76
Gender of household head at birth			
Female	1		
Male **	0.55	0.009	0.35 - 0.86
Socio-economic status			
1st tertile	1		
2nd tertile **	0.53	0.021	0.31 - 0.91
3rd tertile **	0.46	0.006	0.26 - 0.80
Not enough food last month			
No	1		
Yes	1.36	0.197	0.85 - 2.16
Unknown *	2.22	0.071	0.93 - 5.27
Period of not enough food last month (days)			
0	1		
1-7	1.43	0.179	0.85 - 2.42
8-30	1.28	0.467	0.66 - 2.51
Unknown **	2.81	0.019	1.18 - 6.70
Season of not enough food last year			
Neither	1		
Summer only	0.79	0.555	0.35 - 1.75
Winter only	0.44	0.165	0.14 - 1.41
Both	1.26	0.413	0.72 - 2.22
Unknown *	1.97	0.098	0.88 - 4.40
No. of meals eaten / day			
0-2	1		
3	2.22	0.124	0.80 - 6.15
≥4	1.56	0.472	0.47 - 5.18
Unknown **	3.26	0.044	1.03 - 10.28

No. of meals eaten yesterday			
0-2	1		
3	2.36	0.098	0.85 - 6.51
≥4	1.37	0.612	0.40 - 4.71
Unknown **	3.32	0.041	1.05 - 10.46
Future expected food availability			
Less food	1		
Same food *	0.50	0.073	0.24 - 1.07
More food **	0.23	0.023	0.06 - 0.82
Unknown	0.66	0.226	0.34 - 1.29

* Statistically significant at the 10% level.
** Statistically significant at the 5% level.

3.2.1 Socio-Demographic Characteristics

Gender was not a significant risk factor for under-five mortality in 2004. However, as shown in *Table 3.5*, child age was found to be a highly significant risk factor (P<0.001): with age as a continuous variable, the odds of under-five mortality increased 0.39 times for each one year increase in age, that is, the odds of under-five mortality increased 2.56 times for each one year decrease in age; and when stratified into age groups, the odds of under-five mortality were 5.56 times higher for children aged 0-1 years than for children in the 1-5 year age group. Breastfeeding was a highly significant protective factor, as children under-five who were breastfed were 3.85 times less likely to die in 2004 than children who were not breastfed.

The odds of under-five child mortality were 2.48 times greater for those children whose parents were in a union at the time of birth than for those whose parents were not in any union. Additionally, children whose families had migrated to Agincourt prior to 1993 were 2.78 times more likely to die in 2004 than children of South African families. A male household head at the time of birth was protective over under-five mortality, as children from these households were 1.82 times less likely to die than children from households

with female heads. Also, a higher household socio-economic status was protective: the odds of under-five mortality were 1.89 and 2.17 times lower for children in SES 2 and SES 3, respectively, than for children in the lowest SES group. All of these socio-demographic variables displaying statistically significant associations with under-five mortality in 2004 were therefore confounders of the association between the outcome and the various food security variables.

3.2.2 Household Food Security Characteristics

As shown in *Table 3.5*, there were multiple food security variables that were significantly associated with under-five mortality in 2004, prior to adjusting for possible confounding variables. The odds of such mortality were found to be 2.30 times greater for children of households who reported that it was "unknown" whether they grew food crops other than maize in a field outside their homestead, than for those who did not grow any such crops ($P<0.1$). Similarly, the odds of under-five mortality were 2.22 times greater for those households reporting that it was "unknown" whether they had enough food the previous month, compared to households with enough food; and 2.81 times greater when the period of insufficient food the previous month was "unknown", compared to households with enough food.

Additional risk factors for under-five mortality included the number of times fish, eggs, and vegetables were eaten per month, as well as the number of meals consumed per day and the previous day (*Table 3.5*). The odds of mortality increased 3.26 and 3.32 times, respectively, when the latter two food security variables were "unknown", compared to when between zero and two meals were eaten per day. Finally, expecting the future food

availability of the household to be the same or more than that of the household in 2004 (that is, future household food security) was protective over under-five mortality. The children of those households predicting the same amount of food the following year were twice less likely to die than those expecting less food (food insecure), while the children of households expecting more food (the most food secure) were 4.35 times less likely to die than children from food insecure households.

3.2.3 Characteristics of "Unknowns"

To determine whether the children with "unknown" or missing food security variables differed in any way from the other children, a binary variable distinguishing the two types was created for each significant food security variable, which was then logistically regressed upon all socio-demographic variables. Any variables identified as predicting the probability of "unknown" food security data were then noted.

As shown in *Table D.4* (*Appendix D*), several socio-demographic characteristics were significantly associated with the reporting of "unknown" food security variables. An increase in child age was associated with a slightly increased risk of "unknown" food security. Also, single parents that were not in any union were far more likely than parents in unions or marriages to report "unknowns". Other risk factors for reporting "unknown" food security included being a Mozambican refugee, having a household head aged less than thirty years, a household dependency ratio of less or greater than two, and a low socio-economic status. Additionally, the higher the education levels of the mother and father, the greater the probability of "unknown" food security variables being reported. However, this latter trend was reversed regarding "unknown" future food security.

3.3 MULTIVARIATE ANALYSIS

As described in *Section 2.7.2.2*, following univariate analysis, multivariate analysis of the data was performed in order to calculate adjusted ORs and 95% CIs and thus determine the magnitude and direction of the association between each of the significant food security variables and the outcome (under-five mortality in 2004), whilst adjusting for the effects of confounding. The four explanatory variables found to be significant confounders and therefore included in the analyses were age in years (continuous), whether the children had ever been breastfed, socio-economic status (stratified into SES 1, 2, and 3), and gender of the household head at the time of birth.

3.3.1 Overall Analysis

The household food security variables that were significantly associated with mortality in 2004 in children under the age of five years following multivariate logistic regression are shown in *Table 3.6*. The inclusion of confounding factors in these analyses increased the strength of the association between child mortality and each of the food security variables, except future expected food availability, which remained unchanged. As such, the odds of under-five mortality were 2.55 times greater and 2.87 times greater for children of households reporting that it was "unknown" whether they grew food crops other than maize in their own gardens and in fields outside their homesteads, respectively, relative to those who did not grow other food crops. Although not statistically significant, growth of food crops other than maize in both gardens and fields appeared to be protective over child mortality. Children of households that stated it was "unknown" whether they had sufficient food to feed the entire household the previous month, and an "unknown" number of days that this occurred, were 2.62 times and 3.41 times likelier, respectively, to die in 2004 than those children who had enough food. Additionally, the odds of mortality were 2.19 times

greater for children in households that did not know the season in which there was insufficient food the previous year, compared to those having sufficient food that year.

Table 3.6 Household food security variables significantly associated with under-five mortality in 2004, following multivariate logistic regression.

Variable	Crude Odds Ratio (95% CI)	Adjusted Odds Ratio[a] (95% CI)
Not enough food last month		
No	1	1
Yes	1.36 (0.85 - 2.16)	1.33 (0.83 - 2.13)
Unknown	2.22 (0.93 - 5.27) *	2.62 (1.06 - 6.44) **
Period of not enough food last month (days)		
0	1	1
1-7	1.43 (0.85 - 2.42)	1.41 (0.83 - 2.39)
8-30	1.28 (0.66 - 2.51)	1.25 (0.63 - 2.47)
Unknown	2.81 (1.18 - 6.70) **	3.41 (1.38 - 8.41) **
Season of not enough food last year		
Neither	1	1
Summer only	0.79 (0.35 - 1.75)	0.76 (0.34 - 1.70)
Winter only	0.44 (0.14 - 1.41)	0.43 (0.13 - 1.39)
Both	1.26 (0.72 - 2.22)	1.12 (0.63 - 1.98)
Unknown	1.97 (0.88 - 4.40) *	2.19 (0.95 - 5.04) *
No. of meals eaten / day		
0-2	1	1
3	2.22 (0.80 - 6.15)	2.32 (0.83 - 6.45)
≥4	1.56 (0.47 - 5.18)	1.69 (0.50 - 5.70)
Unknown	3.26 (1.03 - 10.28) **	3.41 (1.07 - 10.91) **
No. of meals eaten yesterday		
0-2	1	1
3	2.36 (0.85 - 6.51) *	2.51 (0.90 - 6.98) *
≥4	1.37 (0.40 - 4.71)	1.52 (0.44 - 5.26)
Unknown	3.32 (1.05 - 10.46) **	3.55 (1.11 - 11.34) **
Future expected food availability		
Less food	1	1
Same food	0.50 (0.24 - 1.07) *	0.50 (0.23 - 1.07) *
More food	0.23 (0.06 - 0.82) **	0.23 (0.06 - 0.85) **
Unknown	0.66 (0.34 - 1.29)	0.63 (0.32 - 1.23)

[a] Adjusted for age, ever been breastfed, socio-economic status, and gender of household head at birth.
* Statistically significant at the 10% level.
** Statistically significant at the 5% level.

Surprisingly, children who consumed chicken eleven to twenty times per month were 1.65 times more likely to die in 2004 than those who consumed it less than ten times a month. Also, when the frequency of consumption of eggs and vegetables was "unknown", the risk of mortality was higher than when these foods were consumed less than ten times a month. Similarly, compared to children who ate zero to two meals per day, an "unknown" number of meals consumed per day, as well as the previous day, related to a three-fold increase in the risk of mortality.

Finally, expecting the future food availability of the household to be the same or more than that of the household in 2004 (that is, future household food security) was protective over under-five mortality. The children of those households predicting the same amount of food the following year were twice less likely to die than those expecting less food (food insecure), while the children of households expecting more food (the most food secure) were 4.35 times less likely to die than children from food insecure households (*Table 3.6*).

3.3.2 Food Security and Age-Specific Mortality

As shown in *Table 3.7*, household food insecurity was significantly associated with mortality in children under the age of one year, but not with children aged between one and five years. As such, children in the younger age group in households that reported "unknown" as to whether their households grew food crops other than maize in a garden or field, whether they had sufficient food the previous month, the period of insufficient food that month, and the season of insufficient food the previous year, were at a far greater risk of mortality in 2004 than those children residing in households that reported "no". Importantly, children under the age of one year who resided in households that expected

the same or a greater amount of food availability the following year were protected from mortality: they had a 2.86- and 5.56-fold reduced risk of mortality in 2004, respectively, relative to food insecure children.

Table 3.7 Household food security variables significantly associated with under-five mortality in 2004, following multivariate logistic regression by age group.

Variable	Adjusted Odds Ratio (95% CI)[a]	
	Mortality in Age Group 0-1 years	**Mortality in Age Group 1-5 years**
Food crops (other than maize) grown in own garden		
No	1	1
Yes	0.78 (0.41 - 1.46)	0.81 (0.38 -1.71)
Unknown	3.13 (0.83 - 11.86) *	1.68 (0.47 - 6.06)
Food crops (other than maize) grown in field		
No	1	1
Yes	1.11 (0.53 - 2.35)	0.54 (0.16 - 1.81)
Unknown	3.65 (1.02 - 13.08) **	1.76 (0.52 - 5.96)
Not enough food last month		
No	1	1
Yes	1.60 (0.87 - 2.94)	0.97 (0.46 - 2.05)
Unknown	3.15 (0.86 - 11.50) *	1.61 (0.46 - 5.62)
Period of not enough food last month (days)		
0	1	1
1-7	1.53 (0.76 - 3.09)	1.21 (0.54 - 2.74)
8-30	1.79 (0.78 - 4.12)	0.64 (0.19 - 2.20)
Unknown	4.55 (1.23 - 16.83) **	1.93 (0.55 - 6.73)
Season of not enough food last year		
Neither	1	1
Summer only	0.59 (0.18 - 1.98)	0.98 (0.33 - 2.92)
Winter only	0.50 (0.12 - 2.13)	0.35 (0.05 - 2.61)
Both	1.39 (0.67 - 2.90)	0.87 (0.34 - 2.21)
Unknown	2.79 (0.90 - 8.64) *	1.34 (0.39 - 4.64)
Future expected food availability		
Less food	1	1
Same food	0.35 (0.13 - 0.92) **	0.94 (0.25 - 3.51)
More food	0.18 (0.01 - 0.96) **	0.58 (0.10 - 3.51)
Unknown	0.56 (0.25 - 1.25)	0.88 (0.26 - 3.00)

[a] Adjusted for ever been breastfed, socio-economic status, and gender of household head at birth.
* Statistically significant at the 10% level.
** Statistically significant at the 5% level.

3.3.3 Food Security and Socio-Economic-Specific Mortality

It was not possible to use multivariate logistic regression to determine which household food security variables were significantly associated with SES-specific under-five mortality in 2004, due to the small number of deceased children in each SES group.

3.3.4 Food Security and Cause-Specific Mortality

Similarly, due to the small number of children whose deaths resulted from malnutrition (kwashiorkor, nutritional marasmus, and unspecified protein-energy malnutrition) (four children / 5.06%) or from diarrhoea and gastrointestinal diseases (seven children / 8.86%), it was not possible to use multivariate logistic regression to determine which household food security variables were significantly associated with malnutrition- and diarrhoea-specific under-five mortality in 2004.

However, it was possible to determine that under-five child mortality resulting from diseases caused by HIV infections in 2004 (24.05%) was significantly associated with future expected food insecurity, following multivariate logistic regression. That is, children of families expecting the same amount of food availability the following year were 14.29 ($P<0.05$) times less likely to die of HIV infections than children of families expecting less food (food insecurity). Also, children in food secure households expecting more food the following year were 5.88 ($P<0.05$) times less likely to die of HIV-related diseases than those experiencing food insecurity and expecting less food. Food security relating to this household food security variable was thus protective over HIV-specific mortality in 2004. No other food security variables were found to be significantly associated with HIV-specific mortality, however.

Chapter 4: DISCUSSION

Household food insecurity exists in its least severe form when people experience uncertainty about the sufficiency of their household food supply and adjustments to household food management; and in its most severe form when household members, including children, are hungry and exhibit physical symptoms caused by nutrient deficiencies resulting from the physical unavailability of food, their lack of social or economic access, and/or from the inability of the body to utilise food effectively due to infection or disease [FAO, 1998]. When children experience food insecurity, in addition to poverty, low levels of education, inadequate care practices, and poor access to health services, their resultant inadequate food intake and disease often leads to the development of protein-energy malnutrition, or undernutrition, and ultimately to death [UNICEF, 1990]. In South Africa, where three out of every four children live in poverty, food insecurity and its multiple negative effects are consequently among the most urgent social issues affecting households and their children.

Since household food insecurity is thought to be associated with increased child mortality, it is important to study any such associations amongst South African children to determine additional risk factors for child mortality, which would increase the knowledge of the topic both in this area and nationally, and which may be targeted by future policies for the reduction of child mortality.

In this study, using secondary data obtained from the 2004 census questionnaire and food security module of the Agincourt Health and Demographic Surveillance System, the main objective was to establish the relationship between household food security and mortality

in children under the age of five years in the Agincourt field site, Limpopo Province, South Africa, in 2004. In particular, the secondary objectives were to determine the relationships between household food security and each of age-, socio-economic-, and selective cause-specific mortality in these children. A total of 7,790 black children from this population were studied using qualitative and quantitative methods.

The measurement of household food security generally refers to the measurement of household-level experiences of compromised diets using a series of derived indicators in a food security index [Cook, 2006]. In this study, however, due to the large amount of missing data and "unknown" responses regarding the food security questionnaire, it was not possible to construct a reliable and valid household food security index. As such, it was not possible to determine the household food security status of individuals as stipulated in the study objectives. Instead, certain exposure variables were selected for use as predictors or indicators of food security and these were analysed with respect to child mortality.

The results of this study reflect the characteristics typical of a rural South African population living in poverty. Migrant labour is the main form of employment amongst this population with remittances being critical to local livelihoods, resulting in a high number of fathers being absent from the households, and leaving women, children, and the elderly to form the permanent population. Also, the Agincourt area in which the population resides is overcrowded and prone to drought, providing little opportunity for subsistence agriculture to alleviate the poverty. Such poverty is accentuated by the lack of access to clean water, toilet facilities, and adequate cooking and food storage facilities within the mostly informal houses. Such factors are additionally indicative of poor household food security.

As both a cause and consequence of such poverty, and based on the outcome indicators of food consumption used in this study, 37% of the study population were found to have experienced household food insecurity in 2004, reporting insufficient food for the entire household in the previous month and year due to a lack of money. This is congruent with the level of national food insecurity reported in other South African studies, at 35% [HSRC, 2004] and 39% [Rose & Charlton, 2002b], but is much lower than the percentage of other rural South African households reported to be food insecure – 62% [Rose & Charlton, 2002a] and 75% [Labadarios, 2000; Lemke, 2001]. Such discrepancies may be a consequence of the differences in measurement of household food security and the lack of a measurement index in this study.

Regarding their future expected household food security for the coming year, in comparison to that experienced in 2004, only 8.5% of the population predicted a lower food availability, while 27.4% expected no change, and 10% anticipated better food security. The majority (54%), however, were unsure as to their future food availability and food security status, thereby reflecting the general trend in the Agincourt area of a population in transition experiencing an uncertain future. Those people expecting a lower household food security may represent HIV-positive individuals, who would anticipate decreased productivity, labour, and income due to the effects of the disease, and who would necessitate the spending of part of the household budget initially intended for food on medication. All such factors would contribute to decreased food security in the vicious cycle linking poverty, food insecurity, and HIV/AIDS.

Results reflecting the process indicators of household food security – access to and availability of food – revealed the limited dietary diversity and insufficient quantities of

food experienced by the majority of the population. In addition to the staple diet of purchased maize and bread, many households consumed eggs, vegetables, and fruit a few times per month, whereas chicken, fish, and red meat were often limited or missing from the diet. In order to supplement their food requirements, over two thirds of the population grew fruit and vegetables in their homestead gardens, the majority of which failed to produce enough crops to feed the entire household due to the serious water shortage in the area. Additionally, 70% of households relied upon food gathered from the surrounding bush (mainly wild herbs) to supplement their diets, confirming results reported by another study involving the Agincourt population in which these resources were critical to household food security [Hunter *et al*., 2007].

Of the 79 children (1%) of the study population who died in 2004, 50% died before the age of six months, with an additional 10% dying within one year, followed by a decrease in the number of deaths as child age increased. Such a high infant mortality rate relative to the child mortality rate is characteristic of a rural population living in poverty. In line with reports of rapidly increasing HIV-related mortality among infants and young children in parts of rural north-eastern South Africa [Tollman *et al*., 1999b] and in the country as a whole [Adjuik *et al*., 2006], the majority (24%) of the deaths in this study were caused by diseases resulting from HIV infections. Also, the high number of deaths resulting from undetermined causes may include additional HIV-related deaths that were difficult to diagnose in the verbal autopsies. Additional deaths were caused by what is known to be the major burden of illness amongst children in Agincourt [Tollman *et al*., 1999b; Garenne *et al*., 2000]: diarrhoea, respiratory infections (including tuberculosis), and malnutrition (kwashiorkor, marasmus, and unspecified protein-energy malnutrition).

Although defined separately, all such causes of death can be related to a combination of HIV/AIDS and malnutrition. Household food insecurity and the resultant poor feeding of infants and young children, especially the lack of optimal breastfeeding, in addition to illnesses such as diarrhoea, pneumonia, and HIV/AIDS, are major causes of malnutrition [UNICEF, 2006]. In turn, malnutrition and hunger weaken the children's immune systems, greatly increasing their vulnerability to HIV/AIDS. Among those already infected with HIV, who require up to 50% more protein and 15% more calories than healthy individuals, malnutrition increases their susceptibility to opportunistic infections, accelerating the progression of the disease to full-blown AIDS and death [FAO, 2005]. This study correlates with reports that one-third of infants infected with HIV through mother-to-child-transmission die before their first birthdays and two-thirds die by the age of five years [Piwoz & Preble, 2000].

The results revealed several significant socio-demographic risk factors for under-five mortality in this population, with child age being the strongest. The odds of under-five mortality were 5.6 times higher for children aged 0-1 years than for children in the 1-5 year age group. It is known that a high proportion of infant deaths usually occur in the neonatal period (before one month of age), accounting for 6% of deaths in this study, and are unrelated to the infant's postnatal nutritional experience. However, the remaining infant deaths may be a reflection of household food insecurity combined with the consequences of HIV infections.

Consistent with all other research in developing countries, breastfeeding was found to be a highly significant protective factor over under-five mortality, as children under-five who were breastfed were 3.9 times less likely to die in 2004 than children who were not

breastfed. This is due to the protection against infectious diseases afforded to the infants by the maternal antibodies within breast milk, and because of the protection exclusive breastfeeding provides against household food insecurity. Despite the fact that about 10% of babies born to HIV-infected mothers become infected with the virus following its transmission in breast milk, the rate of transmission decreases significantly if breastfeeding is exclusive in the first three months [Coutsoudis *et al*., 1999]. Exclusive breastfeeding of infants is therefore the best protection against malnutrition, infection, and ultimately death.

Children whose parents were in a union at the time of birth were at 2.5 times greater risk of death than those whose parents were not in any union. A single mother would be more committed to caring for her children's nutritional needs without the financial burden of an unwilling partner, meeting their food security needs more effectively and thus decreasing the risk of mortality. In comparison, an unmarried mother living in union with a man other than the children's father or with an unwilling father could receive less physical and financial support from the partner (who is an additional mouth to feed), resulting in poorer household food security and a greater risk of child morbidity and mortality.

On the other hand, it was found that households headed by females placed children at 1.8 times greater risk of mortality than those headed by males. This is in line with studies reporting greater income poverty [Leibbrandt & Woolard, 1999], higher food insecurity [Rose & Charlton, 2002b], and higher food poverty rates [Rose & Charlton, 2002a] in female-headed households, but is despite the fact that households where women have greater control of the income spend a greater proportion of their money on child welfare [Chopra, 2003]. Such disparate findings could possibly be explained by the fact that there are multiple types of female-headed households that encounter very different conditions.

Single mothers with no support network, for example, struggle immensely to provide their children with adequate food security, while households headed by women with strong kinship links or social networks manage well due to mutual support and the sharing of resources. Although the complexity and diverse nature of such household dynamics greatly influences the nutrition status of household members, especially children, it is usually not detected in censuses, thereby limiting the interpretation of the associated results [Lemke *et al*., 2003].

An additional risk factor for under-five mortality was refugee status of the parents: children whose families had migrated to Agincourt from Mozambique prior to the establishment of the Agincourt HDSS in 1993 were 2.8 times more likely to die in 2004 than children of South African families. The civil war in Mozambique in the 1980s resulted in many Mozambican refugees migrating into South Africa. The significantly lower socio-economic status of these refugees in Agincourt would translate to poorer household food security and a reduced financial capacity for child health care, resulting in increased under-five mortality amongst these children.

Higher socio-economic status of a household was therefore protective over child mortality. Using an index of household socio-economic status, the odds of under-five mortality were found to be 1.9 and 2.2 times lower for children in the middle and upper SES tertiles, respectively, than for children with the lowest household SES. Such a trend in results is consistent with expectation and with other studies [Bawah & Zuberi, 2004].

About 300 individuals in this study reported “unknown” or were missing when questioned on various aspects of their food security. The results revealed that several socio-

demographic characteristics were significantly associated with the reporting of "unknown" household food security variables. These individuals were more likely to be poorer, Mozambican, single parents from households with young heads and, unexpectedly, were more likely to be educated. People under such circumstances may be ashamed of their poor financial and food security status in the community, and be less willing to disclose negative aspects of their household food security, preferring to answer "unknown". When asked to predict their future food availability and, hence, household food security, an additional 4,000 individuals reported "unknown" – a legitimate answer for a population in transition that is unsure of the future. These latter individuals were more likely to have lower education levels, possibly reflecting their uncertainty over future job and income attainment for the maintenance of food security.

In line with the main objective of this study, following multivariate logistic regression which controlled for child age, ever been breastfed, socio-economic status, and gender of the household head at birth, it was found that the reporting of "unknown" for several food security indicators was significantly associated with increased mortality in 2004 in children under-five years old.

Children of households that stated it was "unknown" whether they had sufficient food to feed the entire household the previous month, and an "unknown" number of days that this occurred, had far greater odds of dying in 2004 than those children who had enough food. Additionally, although not statistically significant, those children who did not have enough food the previous month were at a greater risk of dying than those who had sufficient food. Similarly, the odds of mortality were greater for children in households that did not know the season in which there was insufficient food the previous year, compared to those

reporting sufficient food that year. As another useful indicator of food security [Maxwell & Frankenberger, 1992], the number of meals consumed by children per day, as well as the previous day, was associated with a three-fold increase in under-five mortality when the number of meals was "unknown". Such results suggest that known household food security in all of these respects may have been protective over under-five mortality in 2004, but no definitive conclusions on the associations can be drawn. It is possible that the food security results other than the "unknowns" showed no significant associations with child mortality because of the very close relationship between food security and poverty, or socio-economic status, the effects of which were controlled for, and thus eliminated, during analysis.

Importantly, the results additionally showed that expecting the food availability of the household in the coming year to be less than that of the current year (that is, the prediction of future household food insecurity) was significantly associated with a two-fold increased risk of under-five mortality compared to the expectation of the same amount of food the following year, and with a greater 4.4 times increased risk of mortality compared to the prediction of more food (future household food security). Following a significant trend, future household food security was therefore inversely related to, and hence protective over, under-five child mortality in 2004, even after controlling for confounding factors.

Although not considered an indicator of household food security in this study, it is interesting to note that children of households reporting that it was "unknown" whether they grew food crops other than maize in their own gardens and in fields outside their homesteads, respectively, had a significantly greater risk of death relative to those who did not grow other food crops, and that growth of food crops other than maize in both gardens

and fields appeared to be protective over child mortality (not significant). Considering that another study in the area concluded that the local vegetation was critical to household food security through both direct provisioning and as a source of household income [Hunter *et al*., 2007], the growth of local food crops in the current study may have provided food security that appeared to have an effect on child mortality.

The relationship between household food security and under-five mortality was found to be age-specific. The results showed significant associations between food security and mortality in children under the age of one year, but not in children aged between one and five years. Future expected household food security, for example, was highly protective over mortality in infants younger than one year, but had no significant effect on older children. Since exclusive breastfeeding would be expected to protect infants from the effects of household food insecurity and therefore eliminate any relationships between infant mortality and food security, such results may be a reflection of the widespread non-exclusive breastfeeding of infants under-one year, whose diets were supplemented with household food. The mixing of breastfeeding and other foods, or the feeding of household food exclusively, would be common in infants with HIV-positive mothers. In such cases, household food insecurity would place all children at a greater risk of mortality, but would have a more profound effect on infants than on older children. Additionally, the dual responsibility of childcare and trying to attain food security that local women face, especially in households where fathers are absent, has been well documented [Chopra, 2003]. Any nutritional stress placed on such women would therefore detrimentally affect the nutritional status of their children, particularly those under-one year of age, due to their increased vulnerability.

The relationship between household food security and under-five mortality was found to be cause-specific to HIV-related deaths. Children in households experiencing food insecurity and therefore expecting less food the following year were 14.3 and 5.9 times more likely to die of HIV-related diseases in 2004 than those expecting the same amount or more food (food security), respectively. Food security relating to this household food security indicator was thus protective over HIV-specific mortality in 2004. As already detailed, malnutrition and hunger resulting from food insecurity weaken children's immune systems, greatly increasing their vulnerability to HIV/AIDS. Among those already infected with HIV, who have greater nutritional needs than healthy individuals, malnutrition increases their susceptibility to opportunistic infections, accelerating the progression of the disease to full-blown AIDS and death. Food security would therefore decrease this risk of mortality in children.

The inverse relationship between household food security and under-five mortality in Agincourt in 2004, correlates well with the UNICEF causal framework's explanation of malnutrition and death causation in developing countries [UNICEF, 1990], as already discussed. As stated by Labadarios (2000), it is insufficiently appreciated that most of the excess infant mortality is due to hunger. Even when the immediate cause of death is due to diarrhoea, pneumonia, or other infectious diseases, death would rarely have occurred in a well nourished child.

The dataset and methodology of this study had several limitations that should be taken into account. As with the vast majority of associations studied in cross-sectional surveys, the temporal relationship between the exposures (household food security) and outcome (mortality) could not be clearly determined. The use of longitudinal data would therefore

be recommended in future studies. Another limitation was that the household food security questionnaire was pre-tested but not formally evaluated. Such an evaluation could have detected the ambiguous nature of some of the questions, which may have been perceived as confusing by the interviewees. Additionally, the reason for the large number of "unknown" answers and missing data may have been discovered and rectified.

Since various different fieldworkers conducted the census interviews, there may have been systematic differences in their interpretation of questions and in the soliciting and recording of information, resulting in interviewer bias. Recall bias may also have arisen in the study, as respondents experiencing food insecurity may have been more likely to recall past exposures to adverse food and poverty conditions than food secure respondents. Adversely, food insecure people may have been less willing to provide sensitive information regarding their situation.

Another limitation was that the HIV status of individuals within each household was unknown. Such a factor could impact on the household food security if money was preferentially spent on medication rather than food. Thus, although many relevant potential confounding factors were statistically controlled for in the analyses, other unmeasured confounders, such as HIV status, may have influenced the outcomes. A final important limitation was the inability in the study to construct a household food security index for the measurement of food security, due to limits of the questionnaire and the data. Fortunately, several indicators could be used to estimate food security. Nonetheless, the results of this study require cautious interpretation.

The strengths of this study include the use of data from a Health and Demographic Surveillance System, which provides relatively comprehensive, large population-based, demographic and health information over an extended period of time. Data generated through such Systems are generally high quality, intensely prospectively collected, and fully linked data that describe the histories of well-defined populations. An additional strength is the use of verbal autopsies on all recorded deaths, which were assessed for causation by three independent medical practitioners, and which provide reasonable population-level distributions of cause of death.

Considering the results of this study, several recommendations can be made. The study confirmed that one way to reduce child mortality would be to make improvements in household nutrition. Food and nutrient interventions that have been proven to work in several other studies are exclusive breastfeeding in the first six months of life, breastfeeding with complementary feeding after six months, vitamin A and zinc supplementation, the iodisation of salt, and the fortification of staple foods, such as maize meal and bread [UNICEF, 2006]. As shown in this study, the priority of such nutrition interventions should be children under the age of one year. In addition to food, improving the quality of health care to women and children remains an important task, as does recognising that water, sanitation, and HIV/AIDS are inextricably linked to child nutrition and health. The Agincourt population therefore needs future monitoring of its HIV/AIDS statistics. Additionally, as suggested by Labadarios (2000), food and micronutrient insecurity should be addressed within the current framework of the Integrated Nutrition Programme, which is based on an integrated nutrition strategy for South Africa.

Regarding the measurement of food security in Agincourt, the present questionnaire should be evolved to enable the construction of a reliable household food security index, involving both food supply/access data and food consumption data as part of the indicator set, in order to classify households as food secure or insecure, with or without hunger. Questions should be stated unambiguously to avoid potential errors, and should provide options that allow the differentiation between genuine "unknown" answers and those wishing not to answer questions. More detailed questionnaires would allow the identification of those at highest risk of food insecurity. Finally, the development of nation-wide monitoring tools for food security, incorporating both qualitative and quantitative measures, and in line with the excellent validity and specificity of the U.S. questionnaire-based methods but adapted to South African household experiences, could become an important component of efforts to improve nutrition, and thus decrease child mortality, in South Africa.

Chapter 5: CONCLUSION

The study population of 7,790 individuals residing in Agincourt, Limpopo Province, in 2004 reflects the characteristics typical of a rural population living in poverty. Demonstrating the close relationship between poverty and household food insecurity, 37% of the population were found to have experienced the latter in 2004. The limited dietary diversity and insufficient quantities of food experienced by the majority of the population were supplemented by the local growth of food crops and the gathering of food from the bush. Of the 79 children (1%) under the age of five years who died in 2004, the majority (24%) died of HIV-related diseases, in addition to deaths caused by diarrhoea, respiratory infections, and malnutrition. However, all deaths were probably related to a combination of HIV/AIDS and malnutrition – a further reflection of poor food security.

Due to the large amount of missing data and "unknown" responses regarding the food security questionnaire, it was not possible to construct a reliable and valid household food security index with which to classify the population. Instead, under-five child mortality was found to be associated with the reporting of "unknown" for several indicators of food security: whether the household had not had enough food to eat in the last month; and year; and the number of meals taken by the child per day; and yesterday. The only association found between food insecurity and an increased risk of mortality was the prediction of future household food insecurity relative to food security, an association which was age-specific to infants and cause-specific to HIV deaths. The combination of insufficient household food security, inadequate child care resulting from lack of education, and insufficient health services, which results in inadequate dietary intake and disease, and

ultimately leads to malnutrition and death, indicates that child mortality may be reduced by policies involving childhood nutritional interventions aimed at improving food security.

Further research on the associations between household food security and under-five mortality, conducted following the development of a standard nation-wide food security measurement tool specific to South African household conditions, would confirm the inverse relationship between household food security and mortality in children under the age of five years found in this study in the rural north-east of South Africa.

Chapter 6: REFERENCES

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Appendix A: AHPU CENSUS 2004, V2.0 – HOUSEHOLD FOOD SECURITY QUESTIONNAIRE

Village	Dwelling	Household ID	Fieldworker	Date of Visit

1) How has your household obtained maize (mealies/mealie meal) over the last year? (You may select more than one option, write all numbers in the box.)		1 – Grown in own garden or homestead plot 2 – Grown by household members outside of own garden or homestead plot	3 – Purchased 4 – Borrowed 5 – Get it free (food aid/food parcel) 6 – Other
If other, specify:			
2) What staple foods other than maize (mealies/mealie meal) does your household often consume?		1 – Rice 2 – Bread	3 – Potatoes 4 – Other
If other, specify:			
3) Has your household grown food crops other than mealies in a garden on your homestead plot over the last year?		Y – Yes N – No	X – Don't know Q – Query
4) If (3) = Yes, which crops? (You may select more than one option)		1 – Fruit 2 – Vegetables	3 – Other
If other, specify:			
5) Has your household grown food crops other than mealies in a field outside of your homestead plot over the last year?		Y – Yes N – No	X – Don't know Q – Query
6) If (5) = Yes, which crops? (You may select more than one option)		1 – Fruit 2 – Vegetables	3 – Other
If other, specify:			
7) Have your fields/gardens produced enough crops to feed all the members of your household over the whole of the last year?		Y – Yes N – No	X – Don't know Q – Query
If other, specify:			
8) If (7) = No, why do your fields/gardens not produce enough crops to feed all the members of your household?		1 – Our fields/gardens are not large enough to produce enough food 2 – We do not have enough fertilizer 3 – We do not have enough water 4 – No-one available to work on the field/garden 5 – Other	
If other, specify:			
9) If (7) = No, how do you supplement your food requirements? (You may select more than one option. Write all numbers in the box)		1 – Buy food from the market 2 – Relatives, friends or neighbours bring food 3 – Food aid from the government 4 – Gather food from the bush 5 – We manage with the food we have	6 – We sell household goods, eg. furniture to buy food 7 – We sell livestock to but food 8 – Borrow money to buy food 9 – Other
If other, specify:			

		Number of times (1,2,3 etc)	Per week (W) Per month (M) Per year (Y)
10) If (9) = 4 'Gather food from the bush', what	1 – Wild herbs (eg. Guxe)		

do you gather and how regularly?	2 – Wild fruit (eg. Marula) 3 – Wild insects (eg. locust, flying ant, mopani worm)				
	4 – Bush meat (eg. small mammals, birds, etc)				
	5 – Other				
If other, specify:					
11) Has your household not had enough food to eat in the last month?		Y – Yes N – No		X – Don't know Q – Query	
12) If (11) = Yes, how often in the last month did your household not have enough to eat?	Very often (15-30 days)	Often (8-14 days)	Sometimes (2-7 days)	Rarely (1 day)	Never
13) Has your household not had enough food to eat in the last year?		Y – Yes N – No		X – Don't know Q – Query	
14) If (13) =Yes, in which season? (You may select more than one option)		1 – Summer 2 – Winter			
15) If (13) = Yes, for what reasons? (You may select more than one option)		1 – No money available at home 2 – Did not receive pension/ grant/ food aid on time 3 – Did not receive expected money from other family members 4 – Food did not grow in homestead / poor harvest 5 – Unexpected new household members 6 – Other			
If other, specify:					
		Number of times (1,2,3 etc)		Per day (D) Per week (W) Per month (M) Per year (Y)	
16) How regularly does your household eat the following?	1 – Chicken				
	2 – Fish				
	3 – Red meat				
	4 – Eggs				
	5 – Vegetables				
	6 – Fruit				
17) How many meals does your household normally take in a day?	Maximum number of meals for male adults	Maximum number of meals for female adults		Maximum number of meals for children	
18) How many meals did your family take yesterday?	Maximum number of meals for male adults	Maximum number of meals for female adults		Maximum number of meals for children	
19) How do you expect the amount of food available to your household to change in the coming year?		1 – We will have more food 2 – Same amount of food		3 – We will have less food 4 – Don't know	

Appendix B: FIELDWORKER GUIDELINES FOR COMPLETING THE HOUSEHOLD FOOD SECURITY QUESTIONNAIRE

Introduction to the form:

Explain the module to the respondent. Research has shown that food security, the risk of running out of food, is an important indicator of vulnerability in the rural populations of South Africa. The aim of this form is to describe these vulnerable households for the purpose of policy development and the evaluation of government programmes. It should be stressed that we are not service providers and the information we will give the government is the overall picture for the population. Except in cases of extreme destitution, we will not give the government, or any service providers, the household level information obtained by the form. [We request people are really honest and describe exactly what is happening in their household, especially about the risk of running out of food. If the respondents give a falsely negative picture it may threaten the scientific value of the findings. Therefore, a good trusting atmosphere is necessary as is careful probing by the fieldworker].

Government and University roles: The government should aim to provide support, where possible, to vulnerable households. The AHPU aims to understand the problems of food shortages and food security using the scientific method of the annual census. This data will be analysed, reports written and used to inform government policy. The values of the AHPU are to undertake good (and ethical) scientific research to benefit the community, the government, the university and humanity.

Form Header Questions:

Obtain the following information from the household census form.

Village	Dwelling	Household ID	Fieldworker	Date of Visit

Question 1: Obtaining maize meal

The research assumes (based on previous research) that all households use maize porridge or 'pap' as their staple food. If not, that could be noted as a comment at the end of the form.

Question 1 explores the methods used by the household to obtain 'maize meal' (ground maize for making maize porridge). The fieldworker should listen to the person's explanation from beginning to end. As stated below, you may select more than one option when seeing which number to choose. You can write more than one corresponding number, separated by a comma. This will occur if more than one option is covered in the explanation of the respondent. Use '6' – 'Other' if the explanation is not covered by the options given. If '6 – Other' is used, specify the means of obtaining maize meal used by this household.

Question 2: Other staple foods

Households may use other regular staples as well as maize meal. This question explores whether people are using other staple foods. If more than one option is used then write the numbers in the box separated by a comma. Use '4' – 'Other' if other staple foods are used. If '4 – Other' is written, specify staple foods used by this household.

Questions 3, 4, 5 and 6 are about food crops that are grown, in the garden (Q3 and Q4), and in a field outside of the homestead plot (Q5 and Q6).

Question 3: Non-staple food crops grown in the garden

Question 3 concerns crops other than maize being grown in the garden on the homestead plot. Write Y, N, X or Q in the box.

Question 4: Food crop types in home gardens

If crops other than maize are grown in the home garden, i.e. Q3 = Yes, describe which crops are grown. Put the corresponding number in the box. If more than one option is grown then write the numbers in the box separated by a comma. Use '3' – 'Other' if the crops are not fruit or vegetables. Use the 'Other, specified' box to describe the type of crop grown by this household.

Question 5: Crops in outside fields

Question 5 concerns whether food crops other than maize are being grown in a field outside the homestead plot. Write Y, N, X or Q in the box.

Question 6: Food crop types in outside fields

If crops other than maize are grown in a field outside the home plot, i.e. Q5 = Yes, describe which crops. Put the corresponding number in the box. If more than one option is grown then write the numbers in the box separated by a comma. Use '3' – 'Other' if other crops are grown in the outside field. If '3 – Other' is written, specify which crops are grown by this household.

Question 7: Adequate food production from fields and gardens

This is a straightforward question exploring whether there are self-sufficient, subsistence farmers currently supporting households. Ask the question, i.e. Have your fields and gardens produced enough crops to feed all the members of your household over the whole of the last year? Record Y, N, X or Q in the box.

Question 8: Why are crops not enough?

We expect the answer to Q7 to be 'No' in most cases. This question, Q8, looks for reasons given by the respondents that the fields and gardens are not enough to feed the family. You should listen to the person's explanation from beginning to end. You may select more than one option. Then, write each corresponding number separated by a comma. This will occur if more than one option is covered by the explanation of the respondent. Use '5' – 'Other' if the explanation is not covered by the options given.

Question 9: Obtaining food

Again, we expect most people will respond with a 'No' to Q7. This question, i.e. Q9, looks for the method of obtaining food that a family uses. You should listen to the person's explanation from beginning to end. As stated below, you may select more than one option. In this case you write more than one corresponding number, separated by a comma. This will occur if more than one option is covered in the description given by the respondent. Use '9' – 'Other' if the explanation is not covered by the options given. When '9 – Other' is used, record in the last box, the means of obtaining food for this household.

Question 10: Frequency of food from the bush

If the family gets food from the bush, how often are different foods gathered? The best estimates are obtained by careful probing for each question. The unit of measurement must be based on the response given by the respondent. She will express herself with the best unit of measurement, i.e. W for 'per Week', M for 'per Month', and Y for 'per Year'. Usually, the more frequent the food type is gathered from the bush the smaller the unit of expression. 'Per Week' is used for frequently gathered food (e.g. we gather wild herbs once per week), the less frequently gathered food may be expressed 'per month' (e.g. we eat bush meat three times 'per Month'), and a very rare occurrence, is expressed using 'per Year' (e.g. we gather wild fruit four times per year).

If other food is gathered than the options described here, ask: What do you gather, and how often, and record it in the 'If other specify' box.

Question 11: Serious food shortage in the last month

This question refers to a period of serious food shortage. Has this family experienced such a thing in the last month? Write Y, N, X or Q in the box.

Question 12: Frequency of serious food shortage

If the family says yes, they have had a serious food shortage in the last month, then ask how often the food shortage occurred.
Tick the appropriate box.

Question 13: Serious food shortage in the last year

This question refers to a period of serious food shortage. Has this family experienced such a thing in the last year? Write Y, N, X or Q in the box.

Question 14: Season of food shortage

If the family says yes to Q13, i.e. they have had a serious food shortage in the last year, then ask whether it was in the Winter or in the Summer. Write '1' or '2' or '1, 2' based on the response you get to the question.

Question 15: Why was food not available?

You should listen to the person's explanation from beginning to end. As stated below, you may select more than one option. In this case you write more than one corresponding number, separated by a comma. This will occur if more than one option is covered by explanation of the respondent. Use '6' – 'Other' if the explanation is not covered by the options given, and specify below.

Question 16: How regularly are the key food groups taken?

This question refers to how regularly the household eats certain key types of food. The best estimates are obtained by careful probing for each answer. The unit of measurement must be based on the response given by the respondent. She will normally express herself with the best unit of measurement, i.e. D for 'per Day', W for 'per Week', M for 'per Month', and Y for 'per Year'. Usually the more frequently the food type is eaten, the smaller the unit of expression. As explained earlier, 'per Day' is used for frequently eaten food (e.g. we eat vegetables twice per day), the less frequently eaten food may be expressed 'per Week' (e.g. we eat chicken three times a week), the less frequent again, expressed using 'per Month' (e.g. we eat fish twice a month), and a very rare occurrence in expressed with 'per Year' (e.g. we eat fish only once per year).

Question 17: meals per normal day

A meal constitutes:
Formal sit down to take food, usually breakfast, tea, lunch or supper.
Snacks in between meals, like taking bananas or a packet of chips should not be counted. E.g. Pap with something: yes; A packet of chips: no; A serving of fruit: no.

The three categories to ask about are adult men, adult women and children. The cut off age for a child can be taken as 15 years or younger. Ask: How many meals did each person have. The fieldworker must then work out who had the maximum number of meals? Write down the maximum number of meals taken by the adult men on 'a normal day' in the first box. Include all men in the household that the respondent can report on. Write down the maximum number of meals eaten by adult females on 'a normal day' in the second box, and the maximum number of meals eaten by a child on 'a normal day'.

We ask this way because 'maximum' will produce more valid information since it is easier to calculate than the 'average' number of meals taken by the group. The question is primarily aiming at the gaps between these groups, rather than the absolute level.

Question 18: Meals yesterday

Here again, the three categories are adult men, adult women and children. The cut off age for a child can be taken as 15 years or younger.

The question of how many meals now changes from how many meals on 'a normal day' to how many meals did the adult men have yesterday? Continue also for adult females (>15) and children (<=15).

Remember, a meal constitutes:

Formal sit down to take food, usually, breakfast, tea, lunch or supper.

Snacks in between meals, like taking bananas or a packet of chips should not be counted.

Question 19: Food availability in the near future

This question is ultimately aiming at the level of optimism for food security in the near future. Does it feel like food security is going up, going down, staying the same, or is simply unknown?

Appendix C: ETHICAL APPROVAL

UNIVERSITY OF THE WITWATERSTRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Crowther

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER M070239**
PROJECT	The Association Between Household Food Security and Mortality in Children Under-Five Years of Age in Agincourt, Limpopo Province, in 2004
INVESTIGATORS	Ms P Crowther
DEPARTMENT	School of Public Health
DATE CONSIDERED	07.03.02
DECISION OF THE COMMITTEE*	Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application

DATE 07.03.05 **CHAIRPERSON**……
(Professors PE Cleaton-Jones, A Dhai, M Vorster, C Feldman, A Woodiwiss)

*Guidelines for written 'informed consent' attached where applicable

Cc: Supervisor: Prof K Klipstein Grobusch

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10005, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

UNIVERSITY OF THE WITWATERSTRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

COMMITTEE FOR RESEARCH ON HUMAN SUBJECTS (MEDICAL)
Ref: R14/49 Tollman

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER** M 960720
PROJECT	Investigating and responding to changes in the health and population dynamics of rural South Africans
INVESTIGATORS	Dr S Tollman
DEPARTMENT	HSDU/Community Health, Acornhoek
DATE CONSIDERED	970726
DECISION OF THE COMMITTEE*	Approved unconditionally Generic Protocol – "Blanket approval"
DATE	970731

CHAIRMAN …… (Professor PE Cleaton-Jones)

Cc Supervisor: Dr S Tollman
Dept of Community Health, Medical School

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10001, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

DATE…7/5/96…… SIGNATURE……..

The University's United States Federal Wide Assurance Number is: SF,IORG0000862,IRB00001223.

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix D: ADDITIONAL TABLES OF RESULTS

Table D.1 Socio-economic characteristics of the children and their households in 2004.

Characteristic	Total Number of Respondents (%) (N=7,790)	Number of Children Died in 2004 (%) (N=79)
No. of rooms		
1-5	7,226 (92.76)	71 (89.87)
6-10	460 (5.91)	7 (8.86)
>10	7 (0.09)	0 (0.00)
Unknown	97 (1.25)	1 (1.27)
Wall type		
Other informal	31 (0.40)	2 (2.53)
Traditional mud	654 (8.40)	11 (13.92)
Stabilised mud	683 (8.77)	10 (12.66)
Wood	8 (0.10)	0 (0.00)
Other modern	8 (0.10)	0 (0.00)
Cement	6,184 (79.38)	55 (69.62)
Brick	122 (1.57)	0 (0.00)
Unknown	100 (1.28)	1 (1.27)
Roof type		
Other informal	7 (0.09)	0 (0.00)
Thatch	307 (3.94)	2 (2.53)
Other modern	4 (0.05)	0 (0.00)
Corrugated iron	7,038 (90.35)	74 (93.67)
Tiles	336 (4.31)	2 (2.53)
Unknown	98 (1.26)	1 (1.27)
Floor type		
Other traditional	149 (1.91)	0 (0.00)
Dirt	329 (4.22)	9 (11.39)
Mat	1 (0.01)	0 (0.00)
Other modern	9 (0.12)	0 (0.00)
Wood	1 (0.01)	0 (0.00)
Cement	7,129 (91.51)	68 (86.08)
Modern carpet	8 (0.10)	0 (0.00)
Tiles	64 (0.82)	1 (1.27)
Unknown	100 (1.28)	1 (1.27)
Toilet facility		
Bush	1,363 (17.50)	15 (18.99)
Other house	1,421 (18.24)	17 (21.52)
In yard	4,898 (62.88)	46 (58.23)
In house	8 (0.10)	0 (0.00)
Unknown	100 (1.28)	1 (1.27)
Toilet type		
None	2,770 (35.56)	32 (40.51)
Pit toilet	4,874 (62.57)	46 (58.23)
VIP	37 (0.47)	0 (0.00)
Modern	7 (0.09)	0 (0.00)
Unknown	102 (1.31)	1 (1.27)

Water supply		
Other	16 (0.19)	0 (0.00)
Traditional well	463 (5.94)	2 (2.53)
Cement well	630 (8.09)	7 (8.86)
Truck	2 (0.03)	0 (0.00)
Tap in street	5,756 (73.89)	61 (77.22)
Tap in yard	780 (10.01)	6 (7.59)
Tap in house	42 (0.54)	1 (1.27)
Unknown	102 (1.31)	2 (2.53)
Water availability		
Very irregular	72 (0.92)	4 (5.06)
Not every day	4,900 (62.90)	50 (63.29)
Few hours a day	262 (3.36)	1 (1.27)
Most of the time	1,584 (20.33)	17 (21.52)
Always	872 (11.19)	6 (7.59)
Unknown	100 (1.28)	1 (1.27)
Power used for light		
Other	2 (0.03)	0 (0.00)
Candles	1,335 (17.14)	22 (27.85)
Paraffin	555 (7.12)	9 (11.39)
Solar power	2 (0.03)	0 (0.00)
Battery/generator	4 (0.05)	0 (0.00)
Electricity	5,793 (74.36)	47 (59.49)
Unknown	99 (1.27)	1 (1.27)
Power used for cooking		
Other	13 (0.17)	0 (0.00)
Wood	6,124 (78.61)	66 (83.54)
Paraffin	221 (2.84)	2 (2.53)
Gas bottle	126 (1.62)	2 (2.53)
Electricity	1,208 (15.51)	8 (10.13)
Unknown	98 (1.26)	1 (1.27)
Stove		
No	4,572 (58.69)	54 (68.35)
Yes	3,121 (40.06)	24 (30.38)
Unknown	97 (1.25)	1 (1.27)
Fridge		
No	3,750 (48.14)	51 (64.56)
Yes	3,943 (50.62)	27 (34.18)
Unknown	97 (1.25)	1 (1.27)
Television		
No	2,994 (38.43)	47 (59.49)
Yes	4,698 (60.31)	31 (39.24)
Unknown	98 (1.26)	1 (1.27)
Video		
No	7,030 (90.24)	72 (91.14)
Yes	658 (8.45)	5 (6.33)
Unknown	102 (1.31)	2 (2.53)
Satellite dish		
No	7,669 (98.45)	78 (98.73)
Yes	23 (0.30)	0 (0.00)
Unknown	98 (1.26)	1 (1.27)

Radio		
No	5,606 (71.96)	51 (64.56)
Yes	2,071 (26.59)	27 (34.18)
Unknown	113 (1.45)	1 (1.27)
Fixed phone		
No	7,522 (96.56)	76 (96.20)
Yes	169 (2.17)	2 (2.53)
Unknown	99 (1.27)	1 (1.27)
Cellular phone		
No	3,053 (39.19)	44 (55.70)
Yes	4,633 (59.47)	34 (43.04)
Unknown	104 (1.34)	1 (1.27)
Car		
No	6,430 (82.54)	64 (81.01)
Yes	1,262 (16.20)	14 (17.72)
Unknown	98 (1.26)	1 (1.27)
Motorbike		
No	7,649 (98.19)	76 (96.20)
Yes	43 (0.56)	2 (2.53)
Unknown	98 (1.26)	1 (1.27)
Bicycle		
No	6,663 (85.53)	73 (92.41)
Yes	1,019 (13.09)	5 (6.33)
Unknown	108 (1.39)	1 (1.27)
Cart		
No	7,459 (95.75)	77 (97.47)
Yes	227 (2.92)	1 (1.27)
Unknown	104 (1.34)	1 (1.27)
Cattle		
0	6,513 (83.61)	69 (87.34)
1-10	463 (5.94)	3 (3.80)
11-40	513 (6.59)	3 (3.80)
>40	204 (2.61)	3 (3.80)
Unknown	97 (1.25)	1 (1.27)
Goats		
0	6,557 (84.17)	71 (89.97)
1-10	455 (5.84)	1 (1.27)
11-40	547 (7.02)	5 (6.33)
>40	134 (1.72)	1 (1.27)
Unknown	97 (1.25)	1 (1.27)
Poultry		
0	2,818 (36.17)	31 (39.24)
1-10	3,023 (38.81)	26 (32.91)
11-40	1,366 (17.54)	17 (21.52)
>40	478 (6.13)	4 (5.06)
Unknown	105 (1.35)	1 (1.27)
Pigs		
0	7,463 (95.80)	75 (94.94)
1-10	191 (2.45)	3 (3.80)
11-40	31 (0.40)	0 (0.00)
>40	5 (0.06)	0 (0.00)
Unknown	100 (1.28)	1 (1.27)

Table D.2 Distribution among all respondents and those children who died in 2004 of food security characteristics representing "process indicators" of food supply and food access.

Characteristic	Total Number of Respondents (%) (N=7,790)	Number of Children Died in 2004 (%) (N=79)
How household obtained maize[a]		
Grown in own garden	2,401 (30.82)	28 (35.44)
Grown outside of own garden	225 (2.89)	2 (2.53)
Purchased	7,290 (93.58)	71 (89.87)
Borrowed	62 (0.80)	0 (0.00)
Received it free	279 (3.58)	4 (5.06)
Other	157 (2.02)	2 (2.53)
Unknown	255 (3.27)	6 (7.59)
Staple foods (other than maize)[a]		
Rice	4,887 (62.73)	42 (53.16)
Bread	6,565 (84.27)	63 (79.75)
Potatoes	1,182 (15.17)	9 (11.39)
Other	742 (9.52)	11 (13.92)
Unknown	278 (3.57)	6 (7.59)
Food crops (other than maize) grown in own garden[a]		
Fruit	2,641 (33.90)	24 (30.38)
Vegetables	3,628 (46.57)	32 (40.51)
Other	796 (10.22)	9 (11.39)
None	2,464 (31.63)	28 (35.44)
Unknown	257 (3.30)	6 (7.59)
Food crops (other than maize) grown in field[a]		
Fruit	95 (1.22)	0 (0.00)
Vegetables	817 (10.49)	8 (10.13)
Other	803 (10.31)	3 (3.80)
None	6,024 (77.33)	61 (77.22)
Unknown	261 (3.35)	7 (8.86)
Gardens/fields produced enough to feed all household last year[a]		
Yes	1,525 (19.58)	10 (12.66)
No	5,744 (73.74)	62 (78.48)
Unknown	521 (6.69)	7 (8.86)
Reasons for not enough food to feed all household last year[a] (N=6,265) / (N=69)		
Gardens/fields too small	1,659 (26.48)	18 (26.09)
Not enough fertiliser	679 (10.84)	6 (8.70)
Not enough water	3,813 (60.86)	38 (55.07)
Not enough labour	516 (8.24)	9 (13.04)
Other	476 (7.60)	5 (7.25)
Unknown	2,197 (35.07)	19 (27.54)
How food requirements were supplemented when not enough food last year[a] (N=6,265)/(N=69)		
Buy food from market	5,084 (81.15)	47 (68.12)

Relatives, friends donate	357 (5.70)	7 (10.14)
Government food aid	107 (1.17)	0 (0.00)
Gather from bush	4,354 (69.50)	50 (72.46)
Sell household goods	4 (0.06)	0 (0.00)
Sell livestock	0 (0.00)	0 (0.00)
Borrow money	64 (1.02)	3 (4.35)
Manage on food available	147 (2.35)	3 (4.35)
Other	26 (0.42)	0 (0.00)
Unknown	2,109 (33.66)	17 (24.64)
No. of times wild herbs (eg. Guxe) gathered from bush / month (N=4,354) / (N=50)		
0	10 (0.23)	0 (0.00)
1-5	1,425 (32.73)	18 (36.00)
6-10	1,285 (29.51)	13 (26.00)
>10	1,616 (37.12)	18 (36.00)
Unknown	18 (0.41)	1 (2.00)
No. of times wild fruit (eg. Marula) gathered from bush / month (N=4,354) / (N=50)		
0	2,727 (62.63)	34 (68.00)
1-5	1,193 (27.40)	13 (26.00)
6-10	145 (3.33)	0 (0.00)
>10	269 (6.18)	3 (6.00)
Unknown	20 (0.46)	0 (0.00)
No. of times wild insects (eg. locusts) gathered from bush / month (N=4,354) / (N=50)		
0	3,068 (70.46)	37 (74.00)
1-5	1,151 (26.44)	11 (22.00)
6-10	84 (1.93)	1 (2.00)
>10	47 (1.08)	1 (2.00)
Unknown	4 (0.09)	0 (0.00)
No. of times bush meat (eg. birds) gathered from bush / month (N=4,354) / (N=50)		
0	4,305 (98.87)	50 (100.00)
1-5	32 (0.73)	0 (0.00)
6-10	4 (0.09)	0 (0.00)
>10	0 (0.00)	0 (0.00)
Unknown	13 (0.30)	0 (0.00)
No. of times other (eg. frog) food gathered from bush / month (N=4,354) / (N=50)		
0	4,349 (99.89)	49 (98.00)
1-5	5 (0.11)	1 (2.00)
6-10	0 (0.00)	0 (0.00)
>10	0 (0.00)	0 (0.00)
Unknown	0 (0.00)	0 (0.00)

[a] More than one option was possible, eg. Maize was grown in own garden *and* was purchased.

Table D.3 Distribution among all respondents and those children who died in 2004 of food security characteristics representing "outcome indicators" of food consumption.

Characteristic	Total Number of Respondents (%) (N=7,790)	Number of Children Died in 2004 (%) (N=79)
Not enough food last year		
No	4,506 (57.84)	45 (56.96)
Yes	2,947 (37.83)	28 (35.44)
Unknown	337 (4.33)	6 (7.59)
Reasons for not enough food last year (N=3,286) (N=35)		
Not enough money	2,701 (82.20)	28 (80.00)
Food did not grow	27 (0.82)	0 (0.00)
Not enough money & food growth	118 (3.59)	1 (2.86)
New household members	3 (0.09)	0 (0.00)
Other	65 (1.98)	0 (0.00)
Unknown	372 (11.32)	6 (17.14)
Season of not enough food last year (N=3,284) (N=34)		
Summer only	890 (27.10)	7 (20.59)
Winter only	685 (20.86)	3 (8.82)
Both	1,350 (41.11)	17 (50.00)
Unknown	359 (10.93)	7 (20.59)
Not enough food last month		
No	4,641 (59.58)	40 (50.63)
Yes	2,832 (36.35)	33 (41.77)
Unknown	317 (4.07)	6 (7.59)
Period of not enough food last month (days) (N=3,082) (N=39)		
1-7	1,815 (58.89)	22 (56.41)
8-30	1,012 (32.84)	11 (28.21)
Unknown	255 (8.27)	6 (15.38)
No. of meals eaten / day		
0-2	822 (10.55)	4 (5.06)
3	5,207 (66.84)	56 (70.89)
4-8	1,060 (13.61)	8 (10.13)
Unknown	701 (9.00)	11 (13.92)
No. of times chicken eaten / month		
0-10	5,664 (72.71)	52 (65.82)
11-20	1,522 (19.54)	19 (24.05)
>20	188 (2.41)	2 (2.53)
Unknown	416 (5.34)	6 (7.59)
No. of times fish eaten / month		
0-10	4,554 (58.46)	40 (50.63)
11-20	1,439 (18.47)	21 (26.58)
>20	253 (3.25)	1 (1.27)
Unknown	1,544 (19.82)	17 (21.52)

No. of times red meat eaten / month		
0-10	5,508 (70.71)	57 (72.15)
11-20	283 (3.63)	0 (0.00)
>20	22 (0.28)	0 (0.00)
Unknown	1,977 (25.38)	22 (27.85)
No. of times eggs eaten / month		
0-10	3,101 (39.81)	27 (34.18)
11-20	967 (12.41)	7 (8.86)
>20	1,085 (13.93)	7 (8.86)
Unknown	2,637 (33.85)	38 (48.10)
No. of times vegetables eaten / month		
0-10	2,368 (30.40)	22 (27.85)
11-20	2,214 (28.42)	24 (30.38)
>20	2,743 (35.21)	24 (30.38)
Unknown	465 (5.97)	9 (11.39)
No. of times fruit eaten / month		
0-10	4,660 (59.82)	49 (62.03)
11-20	826 (10.60)	7 (8.86)
>20	976 (12.53)	6 (7.59)
Unknown	1,328 (17.05)	17 (21.52)
Future expected food availability		
Less food	659 (8.46)	11 (13.92)
Same food	2,136 (27.42)	18 (22.78)
More food	783 (10.05)	3 (3.80)
Unknown	4,212 (54.07)	47 (59.49)

Table D.4 Characteristics associated with the reporting of "unknown" food security variables in 2004, following univariate logistic regression.

Characteristic	Unknown period of not enough food last month	Unknown no. of meals / day	Unknown future expected food availability
Age (years)	1.15 (1.06 - 1.25) **	1.07 (1.01 - 1.12) **	1.03 (1.00 - 1.07) **
Mother education level			
None	1	1	1
Primary	0.93 (0.60 - 1.44)	1.32 (0.96 - 1.82)	0.86 (0.74 - 1.01) *
Secondary	0.74 (0.48 - 1.13)	1.41 (1.04 - 1.93) **	0.82 (0.70 - 0.95) **
Tertiary	1.30 (0.68 - 2.48)	2.96 (1.97 - 4.44) **	0.70 (0.54 - 0.90) **
Unknown	1.57 (1.01 - 2.42) **	2.53 (1.84 - 3.48) **	0.87 (0.74 - 1.04)
Father education level			
None	1	1	1
Primary	1.12 (0.69 - 1.82)	1.65 (1.16 - 2.35) **	0.89 (0.74 - 1.07)
Secondary	1.11 (0.68 - 1.79)	1.64 (1.16 - 2.32) **	0.84 (0.70 - 1.00) *
Tertiary	0.50 (0.15 - 1.66)	2.16 (1.26 - 3.69) **	0.71 (0.51 - 0.98) **
Unknown	0.90 (0.60 - 1.36)	1.60 (1.18 - 2.16) **	0.93 (0.80 - 1.07)
Parents union status at birth			
Not in union	1	1	1
Union	0.27 (0.17 - 0.43) **	0.37 (0.27 - 0.50) **	0.91 (0.74 - 1.12)
Formal married	0.19 (0.13 - 0.27) **	0.19 (0.15 - 0.25) **	0.76 (0.64 - 0.90) **
Unknown	0.24 (0.18 - 0.33) **	0.36 (0.29 - 0.44) **	0.87 (0.74 - 1.02)
Refugee			
South Africa	1	1	1
Mozambique, prior 1993	1.69 (1.05 - 2.73) **	1.45 (1.07 - 1.97) **	1.26 (1.03 - 1.55) **
Mozambique, after 1992	1.16 (0.88 - 1.52)	0.78 (0.66 - 0.94) **	1.16 (1.05 - 1.28) **
Household head age at birth (years)			
0-30	1	1	1
30-60	0.41 (0.28 - 0.59) **	0.49 (0.37 - 0.64) **	0.96 (0.79 - 1.17)
>60	0.19 (0.12 - 0.32) **	0.47 (0.35 - 0.64) **	0.99 (0.80 - 1.22)
Unknown	1.04 (0.52 - 2.10)	0.77 (0.45 - 1.32)	1.25 (0.85 - 1.82)
Household dependency ratio at birth (children:adults)			
0-2	1	1	1
>2	1.06 (0.75 - 1.51)	0.74 (0.58 - 0.94) **	1.46 (1.12 - 1.90) **
Socio-economic status			
1st tertile	1	1	1
2nd tertile	0.41 (0.31 - 0.56) **	0.54 (0.45 - 0.66) **	0.86 (0.77 - 0.97) **
3rd tertile	0.25 (0.17 - 0.35) **	0.49 (0.40 - 0.59) **	0.81 (0.72 - 0.90) **

* Statistically significant at the 10% level.
** Statistically significant at the 5% level.