An investigation of the association between household biomass fuel smoke exposure, anaemia and stunting in children aged 12-59 months participating in the 2006-2007 Swaziland Demographic and Health Survey

By

Machisa Mercilene Tanyaradzwa

Student Number 386953

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28 FEBRUARY 2012

DECLARATION

I Machisa Mercilene Tanyaradzwa declare that this research report is my own work. It is being submitted for the MSc (Med) Epidemiology and Biostatistics in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University

Signature ___________________________ ____28_____day of __February_____, 2012

DEDICATION

I am forever grateful to Kuda for his unwavering support and encouragement. You were there and stood by me all the way.

To my parents, Patience and Silver for the morale support and prayers

ABSTRACT

Background

Indoor air pollution due to use of biomass fuels (BMF) for household cooking and heating is a known risk factor of morbidity and mortality in children under the age of five years. A recent study in India suggested an association between biomass fuel smoke exposure anaemia and stunting among children under the age of five. The aim of this study was to investigate the association between BMF use, stunting and anaemia in children aged 12-59 months who participated in the 2006-2007 Swaziland Demographic and Health Survey (SDHS), whilst adjusting for potential confounders.

Methods

The study was cross-sectional and based on secondary data analysis of data collected through the household and women's questionnaires in the 2006-2007 SDHS, which employed a multistage random sampling. Anthropometric measurements taken in the SDHS and the World Health Organization (WHO) 2006 Multi-Centre Child growth reference standards were used to ascertain children's health status and the stunting outcome variable. A child, whose height-for-age ratio was below three standard deviations (SD) from the median of the WHO reference population in terms of height-for-age, was severely stunted or short for his/her age. A child, whose height-for-age ratio was between three and two SD below the median of the WHO reference population in terms of height-for-age, was mildly stunted. The exposure to BMF smoke variable was ascertained indirectly by type of fuel used for cooking. The exposure was a three category variable of cleaner fuel, outdoor BMF and indoor BMF use. All statistical analysis was done in STATA version 10. The relationship between BMF

use and stunting or anaemia was determined using multinomial logistic regression analyses, whilst adjusting for potential confounding factors, identified in previous research.

Results

Of the 1612 children included in the study, 37% were anaemic. Nineteen percent were mildly and 18% were moderate to severely anaemic. Indoor BMF use, child age, low birth weight, mother's age at birth, iron supplementation during pregnancy and mother's anaemia status was significantly associated with child anaemia in univariate analysis. Outdoor BMF exposure, low birth weight, child age, mother's anaemia status and wealth index was associated with child anaemia after adjusting for potential confounding.

Overall 31% of children were stunted. Twenty percent were mildly stunted and 11% were moderate to severely stunted. Child sex, age, birth order, preceding birth interval, low birth weight, diarrhoea in preceding two weeks, anaemia status, iron supplementation during pregnancy, mother's age at birth ,mother's body mass index, mother's education, wealth index, indoor BMF exposure and household crowding were each independently associated with stunting in univariate analysis. Only child sex, low birth weight and child age were significantly associated with stunting after adjusting for potential confounding. There was no evidence of an association between indoor BMF smoke exposure and child stunting after adjusting for all potential confounding factors.

Conclusion

This study did not find sufficient evidence to suggest that indoor BMF use is a statistically significant risk factor for anaemia or stunting in children aged 12-59 months participating in the 2006-2007 SDHS. There was however an evidence that, use of BMF outdoors significantly confers a protective effect against moderate to severe anaemia. Prospective research into these potential relationships are necessary, particularly the collection of primary data and accurate measurement of exposure to smoke emitted during BMF use for cooking and heating.

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LIST OF ABBREVIATIONS AND ACRONYMS

ALRI	-	Acute Lower Respiratory Infections
BMF	-	Biomass fuel
CI	-	Confidence Interval
CO	-	Carbon Monoxide
COPD	-	Chronic Obstructive Pulmonary Disease
DALYS	-	Disability Adjusted Life Years
DHS	-	Demographic and Health Survey
EA	-	Enumeration Area
ETS		Environmental tobacco smoke
LBW	-	Low birth weight
LPG	-	Liquid Petroleum Gas
OR	-	Odds Ratio
PM_{10}	-	Particulate matter smaller than 10µm diameter
RR	-	Relative risk
SD	-	Standard deviation
SDHS	-	Swaziland Demographic and Health Survey
SES	-	Socioeconomic Status
WHO	-	World Health Organisation

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CHAPTER 1

INTRODUCTION

1.1 Background

Biomass fuel (BMF) in the form of wood, crop residues and animal dung accounts for more than half of the domestic energy in most developing countries (Smith et al., 2004). Inefficient burning of BMF in simple, inefficient and mostly unvented household cooking stoves in poorly ventilated areas produces substantial amounts of health-damaging air pollutants, including respirable particulates, carbon monoxide, nitrogen oxides, benzene, formaldehyde, 1,3 butadiene, and polyaromatic compounds such as benzo(α)pyrene, a probable human carcinogen (World Health Organisation (WHO), 2006). The amount of exposure to BMF smoke depends on the type of fuel used, nature of the combustion, location, length of time individuals spend in the polluted environment and the composition of the smoke (WHO, 2006).

Although the WHO air quality guideline for PM_{10} (particulate matter smaller than of 10µm in diameter) is 50µg/m^3 (WHO, 2006), in many developing countries the peak indoor PM_{10} levels often exceed 2000µ/m^3 (Smith, 2002; WHO, 2006). The magnitude of exposure in terms of number of people, exposure intensity and time spent exposed has been shown to be far greater in the developing world (Smith, 2002; WHO, 2006). Household use of BMF therefore exposes many women and young children to high levels of toxic air pollutants in developing countries (Desai et al., 2004; WHO, 2006).

1.2 Literature review

1.2.1 Global burden of disease

BMF smoke exposure is a significant risk factor for morbidity and mortality (Fullerton et al., 2008). Cooking with solid fuels is responsible for about 2.6% of the global burden of disease and 3.6% of the disease burden in developing countries (WHO, 2006). Acute lower respiratory infections (ALRIs), chronic obstructive pulmonary disease (COPD) and lung cancer are the most notable health impacts of indoor BMF smoke exposure (Bruce et al., 2000; WHO, 2006). More than 1.6 million deaths and over 38.5 million of disability-adjusted life-years (DALYs) were attributable to indoor BMF smoke in 2000 (Smith, 2002). More than half of this disease burden is borne by the populations of developing countries (WHO, 2002).

1.2.2 BMF smoke exposure and negative health impacts in children

Exposure to indoor BMF smoke is associated with negative health impacts in children. Studies have shown that children exposed to BMF smoke in several countries are at increased risk of developing ALRIs (Bruce et al., 2000; Ezzati and Kammen 2001; Mishra, 2003; Torres-Duque et al., 2008). BMF smoke exposure is also associated with increased risk to infant mortality (Bruce et al., 2000; Smith, 2002; Wichmann and Voyi 2006; Torres-Duque et al., 2008). Prenatal exposures of pregnant mothers to BMF smoke have been associated with premature births, and low birth weight (Boy et al., 2002; Mishra 2003).

In rural Guatemala, babies born to women using wood as fuel were 63 g lighter ($p < 0.049$) than those born to women using gas and electricity, after adjustment for socio-economic status (SES) and maternal factors (Boy et al., 2002). In another study using a retrospective analysis of data from the 1989 Demographic and Health Survey in Zimbabwe, Mishra et al. (2004) found that babies born to mothers cooking with wood, dung, or straw were on average 175g lighter compared to babies born to mothers using liquid petroleum gas, natural gas or electricity.

Although BMF smoke exposure has been associated with health outcomes such as respiratory infections and reduced birth weight, little is known about its effects on the physical growth of children. A single study conducted in 2007 in India using data from about 30 000 children explored the existence of such a relationship and reported an association between stunting and BMF use (or BMF smoke exposure) (Mishra and Retherford, 2007). The study also postulated that although mechanisms by which BMF smoke exposure may deter physical linear growth and cause stunting are not certain, BMF smoke exposure may contribute to stunting by causing anaemia (Mishra and Retherford, 2007). The Indian study controlled for exposure to tobacco smoke, recent episodes of illness, maternal education and nutrition, and other potentially confounding factors. The prevalence of stunting was significantly higher among children in BMF-using households (Mishra and Retherford, 2007).

1.2.3 Use of BMF in Swaziland

Approximately 77% of the population of Swaziland, that is about 114000 households, lives in the rural areas and the majority use wood fuel as their primary energy source for cooking and heating (REASWA, 2005). Overall 72% of the total Swazi population use wood in their homes on a daily basis to boil water and to cook food (Central Statistics Office (CSO) and

Macro International Inc. 2008). The majority (86%) of those living in the rural area depend on wood as a main fuel source (CSO and Macro International Inc., 2008). Even 17% of those living in the urban areas rely on wood as the primary source of household energy (CSO and Macro International Inc., 2008).

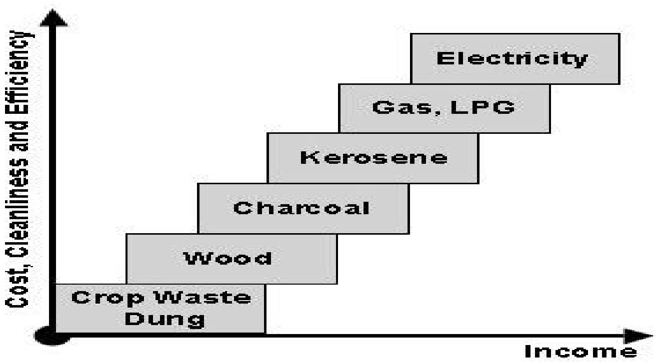
Different age, gender and SES groups are more vulnerable than others are to BMF smoke exposure. Women's traditional domestic gender roles place them at increased risk of BMF smoke exposure compared to men. Because of their customary involvement in cooking, women's exposure is much higher than men's (Behera et al., 1988). In Swaziland, women are the principal child caregivers and their responsibilities include the preparation of meals. Women spend more time doing domestic work such as food production and preparation. Most of the food is cooked using wood and BMF on open fires with tripods and three legged pots (The Environmental Centre for Swaziland, 2002). In higher income households, wood is burnt in heavy iron coal stoves that are inappropriate for firewood. Most of the coal stoves have lower conversion efficiencies than a three-legged pot on an open fire (The Environmental Centre for Swaziland, 2002).

Mothers carry infants and toddlers are often on their mothers' backs while cooking and expose them to many hours of breathing BMF smoke (Behera et al., 1988). Children under the age of five are at a high risk of BMF smoke exposure because of this set up. Children are even more vulnerable to the detrimental effects of air pollution than their adult caregivers are, because children inhale more air per unit body weight at a given level of exertion than adults do (Kleinman, 2000). This means they filter more polluted air through their lungs. Other reasons include the fact that children's respiratory and neurological systems are still developing and their immune systems are immature, making them more vulnerable to respiratory infections (Kleinman, 2000).

1.2.4 SES factors associated with BMF smoke exposure

There are several SES determinants of fuel choice at household level. Indoor BMF use and subsequent high exposure to BMF smoke occurs predominantly among poorer communities where BMF is the cheapest fuel source. According to the energy ladder model, households opt for more modern and efficient cooking fuels as income increase (Holdren and Smith, 2000). The linear process illustrated in Figure 1.1 shows that households convert from traditional BMF to modern alternatives as their affluence level increases (Holdren and Smith, 2000).

Figure 1.1 Schematic representation of the energy ladder model



Adopted from: *Holdren and Smith (2000)*

According to the findings of the Swaziland Multiple Indicator Cluster survey of 2000, wood fuel use is expected to increase by 50% by the year 2010 (Swaziland Government, 2000). Despite plans for extensive rural electrification programmes in Swaziland, it is clear that many rural and urban women will not convert to using electricity for cooking due to the unaffordable connection and tariff costs (Remmelswaal, 2006). Wood therefore remains the most important fuel on a gross energy basis among rural communities and in urban households.

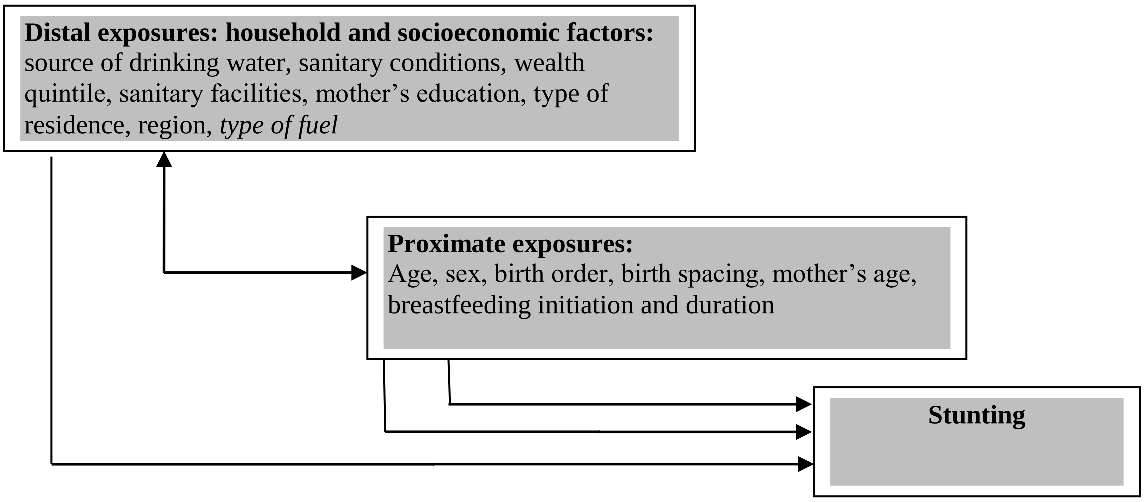
1.2.5 SES and environmental determinants of childhood stunting

Stunting, also referred to as low height-for-age, is a chronic condition that reflects poor linear growth accumulated during pre and or postnatal periods because of various causes. Tanner, (1987) concluded that height is a good marker of social inequality in a community and that a strong relationship existed between children's height and SES variables. Consequently, the growth and development of infants and children under the age of five has been associated with their particular SES and living environment. Evidence to support this postulate emanated from the observations of children from developing countries growing more slowly and achieving a shorter adult height than those from more developed regions (Tanner, 1987). Apart from poor nutrition, most of these children are vulnerable to other manifold risks such as adverse home environments, which negatively affect their development (Tanner, 1987).

Figure 1.2 illustrates the multi-dimensional aetiology of stunting. There is a complex interaction between these social, economic and environmental determinants. Detailed investigations into previously unexplored environmental factors that promote or suppress linear growth are required for a full understanding of the causes of stunting.

Poverty for example is an established determinant to the use of BMF for domestic purposes. The lower the SES of a household, the more likely they are to use BMF and the higher the exposure to BMF smoke (Holdren and Smith, 2000). Similarly the lower the SES of a household, the more likely childhood stunting propagated by the consequent inability of families to adequately care for their children.

Figure 1.2 Social determinants of childhood stunting



1.2.6 SES and environmental determinants of childhood anaemia

The prevalence of anaemia due to poor nutrition is extremely high among children in many low-income countries (Zetterström, 2004). Maternal anaemia during pregnancy is associated with multiple adverse outcomes for both mother and infant, including an increased risk of haemorrhage, sepsis, maternal mortality, perinatal mortality, low birth weight and infant anaemia (WHO, 2001). Childhood anaemia impairs the cognitive development of children, damages immune mechanisms, and is associated with increased morbidity rates.

Apart from the role of perinatal factors in contributing to childhood anaemia, previous research shows that SES factors such as household crowding, number of children in the family, education and profession of the parents, source of drinking water, type of sewage system and child's health status according to the mother are associated with childhood anaemia (Psirropoulou et al., 2008). Anaemia control programmes can be improved with better understanding of the effects of SES factors during the critical early period of growth and development.

1.3 Statement of the problem

There is paucity of data on the effects of BMF smoke exposure on linear growth in children under the age of five. A single study in Indian children reported that BMF smoke exposure is associated with stunting and anaemia (Mishra and Retherford, 2007).

This study sought to investigate whether the findings of the Indian study hold true in Swaziland, where wood fuel constitutes the most important domestic cooking fuel source (Mishra and Retherford, 2007). Apart from the predominant combustion of BMF for domestic use, prior studies reported a high prevalence of poor linear growth among children under the age of five (Swaziland Government, 2000). Findings of the 2000 Multiple Indicator Cluster Survey showed that 30% of the children were stunted (Swaziland Government, 2000).

Swaziland is thus an ideal setting to study the relationship of BMF smoke exposure and stunting because of the overlap in high BMF usage and high prevalence of stunting.

1.4 Research question

The research question of this study was whether BMF smoke exposure was associated with stunting or anaemia amongst children aged 12-59 months who participated in the 2006-2007 SDHS.

1.5 Main objective

The main objective of the study was to determine whether there was an association between the use of BMF for cooking, and stunted growth or anaemia in 12-59 month olds who participated in the 2006-2007 SDHS.

1.6 Specific objectives

The specific objectives were:

1. To determine the percentage of Swazi households who participated in the 2006-2007 SDHS that used BMF for cooking purposes.
2. To determine the prevalence of anaemia and stunting in 12-59 month old children who participated in the 2006-2007 SDHS
3. To determine the association between BMF use for cooking and stunting or anaemia in 12-59 months old children, after adjusting for potential confounders.

1.7 Hypothesis

Low SES and BMF use are associated with an increase in anaemia and a decrease in childhood linear growth.

CHAPTER 2

METHODOLOGY

This chapter summarises the methods that were followed during the primary data collection in the 2006-2007 SDHS and the methods used in this study for the secondary data analyses.

2.1 Study Design

The study was an analytical cross-sectional design using secondary data collected in the 2006-2007 SDHS.

2.2 Study settings

Swaziland is a developing country with a small population of about 1.4 million people and a population growth of 1.2% per annum. Swaziland ranks as a lower middle-income country, but it is estimated that 69% of the population lives in poverty. The infant mortality rate is very high at 63 deaths per every 1000 live births and the current life expectancy is 48.7 years. The prevalence of HIV in Swaziland's adult population is estimated at 26%, the highest in the world (US Department of State, 2011).

2.3 Description of data source

The 2006-2007 SDHS was a nationwide sample survey designed to provide information on various demographic and maternal and child health issues in Swaziland. Detailed information on the survey design is outlined elsewhere (CSO and Macro International Inc., 2008)

2.4 Study population and sampling

The 2006-2007 SDHS sampling strategy was a multistage random sampling described in detail elsewhere (CSO and Macro International Inc., 2008). The 2006-2007 SDHS sample points (clusters) were selected from a list of enumeration areas (EAs) defined in the 1997 Swaziland Population and Housing Census. Two hundred and seventy five clusters were drawn from the census sample frame, 111 in the urban areas and 164 in the rural areas. The 2006-2007 SDHS was a nationally representative survey of 4843 households, 4987 women age 15-49 years, 4156 men age 15-49 years and 3301 children below5 years (CSO and Macro International Inc., 2008). The fieldwork was conducted between July 2006−March 2007.

For this study, recoded data sets for children and households were accessed from the MeasureDHS portal and merged. The merged data set contained information on 2812 children. Children whose height measurements were missing (593) and children aged less than 12months (607) were excluded from the study. The study population for this study was therefore 1612 children aged 12-59 months whose height and age measurements were available.

2.5 Ethical Considerations

The SDHS was commissioned by the Swaziland Ministry of Health and Social Welfare. Interviewers obtained informed consent from mothers of children before a child could participate (CSO and Macro International Inc., 2008). Macro International Inc. granted Dr Janine Wichmann permission on 4 July 2008 to download and use the SDHS datasets from the MeasureDHS portal for secondary analyses (Appendix A). Ethical clearance for this secondary analyses study was obtained from the University of the Witwatersrand Human Research Ethics Committee (Appendix B). All personal identification information was removed by Macro International Inc. before the distribution of the data.

2.6 Measurement instruments and methods

2.6.1 Questionnaire content

Five types of questionnaires were used in the 2006-2007 SDHS namely the household, women's, men's, youth and older adult questionnaires. The questionnaires were developed for the MeasureDHS Programme. The 2006-2007 SDHS questionnaires were translated into the local SiSwati language (CSO and Macro International Inc., 2008).

This study used data collected from the household and women's questionnaires. The household questionnaire was used to list all the usual members and visitors in the selected households. Basic information was collected on the characteristics of each person listed, including age, sex, education and relationship to the head of the household. The household questionnaire was used to identify persons eligible for the individual interview. In addition, information about the dwelling, such as the source of water, type of toilet facilities, materials used to construct the house, ownership of various consumer goods, use of bed nets and care and free external support received by chronically ill household members and orphans and vulnerable children, was collected (CSO and Macro International Inc., 2008). The results of anthropometric measurement and anaemia testing were recorded in the household questionnaire, as was the information on the consent of eligible household members for the

HIV testing. The children's health status was ascertained in the women's questionnaire (CSO and Macro International Inc., 2008).

2.6.2 Questionnaire testing

Two formal pilots were conducted to pre-test the SDHS questionnaires. The first was aimed at testing the flow of the questions and the translation from English to SiSwati and obtaining consent from the participant. Given that this was the first SDHS to be conducted in the country, this pre-test was also viewed as a pilot exercise for the survey organising committee (CSO and Macro International Inc., 2008).

2.6.3 Quality assurance

Training followed standard DHS training procedures and involved interviewing techniques and the study of the contents of the questionnaires. During the primary data collection stakeholders review, training, data entry, verification, consistency checks, monitoring, and evaluation were done. Data capturing and quality control was done by staff that was specifically trained for that particular task (CSO and Macro International Inc., 2008).

2.6.4 Anthropometric measurements

Height measurements were done using a measuring board produced by Shorr Productions. Children younger than 24 months were measured while lying down (recumbent length) on the board and height was measured for children older than 24 months while standing up (CSO and Macro International Inc., 2008).

2.6.5 Haemoglobin measurement

To assess the anaemia status of children and their mothers, blood haemoglobin levels were measured using the portable HemoCue system (CSO and Macro International Inc., 2008). The system uses a drop of blood from a finger prick (or heel prick for infants below six months), which is drawn into a cuvette and then inserted into a portable battery-operated instrument to obtain a digital reading on haemoglobin concentration.

2.7 Definitions of health outcomes and independent variables

2.7.1 Definition of stunting

The primary health outcome of interest was stunting. In this study a child whose height-for age-ratio was below three standard deviations (SD) from the median of the World Health Organisation (WHO) reference population in terms of height-for-age, was severely stunted or short for his/her age. A child whose height-for-age ratio was between two to three standard SD below the median of the WHO reference population in terms of height-for-age, was mildly stunted. Children with missing data on height and age observations were excluded from the analysis.

2.7.2 Definition of anaemia

To assess the anaemia status of children and their mothers, haemoglobin measurements were adjusted for altitude. Haemoglobin levels of individuals tend to be higher at high altitudes. Adjustment was necessary to ensure that the prevalence of anaemia was not underestimated in persons residing at high altitudes. Children were categorised as not anaemic (>11.0 g/dl), mildly anaemic (10.0–10.9 g/dl), moderately anaemic (7.0–9.9 g/dl), or severely anaemic

(<7.0 g/dl) (WHO, 2011). Because the proportion of severely anaemic children was small (<5%) in the study population, a three-category response variable for anaemia was used: not anaemic, mildly anaemic and moderately/severely anaemic.

2.7.3 Definition of "exposure to BMF smoke"

The main exposure variable - exposure to BMF smoke – was ascertained indirectly by type of fuels used and the cooking location. The question '*What fuel does your household mainly use for cooking?*' was used as a proxy measure of exposure to actual air pollution and smoke due to BMF combustion. The households were grouped into two categories representing the extent of exposure to BMF smoke:

- "BMF use" if wood, dung, coal or paraffin was used in the fuel combination with or without using liquid petroleum gas (LPG)/natural gas or electricity, and
- "Cleaner fuel use" if LPG/natural gas or electricity was used as the main fuel type (no BMF use).

Data for the question '*Is the cooking usually done in the house, in a separate building or outdoors*?' were used to categorise the cooking location: indoors or outdoors. The main exposure variable was thus a three category variable – no BMF use, outdoor BMF and indoor BMF. No data on the actual indoor air pollution concentrations or exposures of pollutants from BMF use was collected during the 2006-2007 SDHS, therefore epidemiological evidence on the health effects of BMF smoke exposure in this study was based on the above categorical proxy classification.

2.7.4 Potential confounders

The association between BMF smoke exposure and stunting is likely to be confounded by other factors, so it was necessary to statistically adjust for such factors. Possible confounders, as identified in previous research included those pertaining to the:

- child (sex (boy, girl), age group (12-23, 24-35, 36-47 and 48-59 months), birth order (1, 2, 3, >=4), preceding birth interval (<24, 24-35, 36-47, 48-60, >=60 months), low birth weight (<2500g, >=2500g), recent episodes of illness (ARI, fever or diarrhoea in past 2 weeks (yes/no)), anaemia status at the time of the SDHS (none, mild, moderate/severe)),
- biological mother (age at birth (<18, 18–24, 25–34 and ≥35 years), body mass index (BMI) at the time of the SDHS (18.5, 18.5–25.0, >25.0 kg/m^2), anaemia status at the time of the SDHS (mild anaemia: blood haemoglobin level 10.0–10.9 g/dl for pregnant women and 10.0–11.9 g/dl for non-pregnant women, moderate anaemia: blood haemoglobin level 7.0–9.9 g/dl, severe anaemia: blood haemoglobin level < 7.0 g/dl), highest educational status at the time of the SDHS (no education, primary, secondary, tertiary), iron supplementation during pregnancy (no, yes), employment status in the past 12 months (yes/no)),
- household (wealth index at the time of the SDHS (low, high, middle class), household location during the 2006-2007 SDHS (urban, rural), region of household at the time of the SDHS (Hlohlo, Shesweleni, Lubombo, Manzini), crowding at the time of the SDHS (<3 persons/room, >=3 persons/room)).

The wealth index was a measure of the standard of living of a household based on a household’s ownership of assets, materials used for housing construction and access to water and sanitation facilities. The wealth index placed individual households on a continuous scale of relative wealth. The cut points in the wealth index at which to form the quintiles were calculated by obtaining a weighted frequency distribution of households, the weight being the product of the number of de jure members of the household and the sampling weight of the household. Thus, the distribution represented the national household population, where each member was given the wealth index score of his or her household. Details of the method are described elsewhere (Macro International Inc., 2004).

2.8 Statistical analysis

All statistical analysis was done in STATA version 10. A weighting factor (svy: set) was applied to all observations to compensate for over-sampling of households in the rural EAs. A descriptive analysis was employed before inferential analysis.

2.8.1 Descriptive analyses

The descriptive analysis addressed specific objectives one and two of this study. The prevalence of stunting and anaemia was calculated by using the “svy: tab” command. Tables of results will show the proportion of children stunted or anaemic by the different characteristics in a table.

2.8.2 Inferential analysis

Estimation of the effects of BMF use on stunting and anaemia were determined using multinomial logistic regression analyses. Relative risks (RR) as a measure of association of being anaemic (none, mild, moderate/severe) and stunted (none, mild, moderate/severe) were first estimated among children from households using BMF outdoors and indoors relative to children from households using only cleaner fuels. Associations between separate characteristics and stunting or anaemia in univariate models were first assessed to identify potential confounders. Only variables that are significantly associated with either outcome in the full model were included. Results in the form of relative risk (RR) with significance levels (p-value) and 95% confidence intervals (CI) will be presented. The estimation of CI was used to adjust for clustering at the level of the primary sampling unit.

CHAPTER THREE

RESULTS

This chapter outlines a description of the children aged 12-59 months participating in the 2006-2007 SDHS and whose age and height measurements were available. The description of the sample and the results from descriptive analysis on prevalence of stunting and anaemia among participating children are presented. This is followed by a last section on the observed effects of BMF smoke exposure on both stunting and anaemia.

3.1 Demographic, health and SES characteristics

The study population was 1612 children from all of Swaziland's regions namely Manzini, Hhohho, Shiselwe and Lubombo. Seventy two percent of children were from households using BMF for cooking indoors. Twenty five percent of children were from households using cleaner fuels.

Table 3.1 shows the general demographic, health and SES characteristics of the children disaggregated by rural or urban residence. There was no statistically significant difference in the proportion of children living in rural or urban areas by sex, age, preceding birth interval ,birth weight, experience of diarrhoea in preceding two weeks, mother's age at birth, mother's body mass index and mother's anaemia status($p>0.05$). There was evidence for a statistically significant difference in the proportion of children by household BMF use, birth order, experience of ARI in preceding two weeks, experience of fever in preceding two weeks, iron supplementation during pregnancy, mother's education, mother's employment, wealth index and region of origin ($p<0.05$) between rural and urban children.

The highest proportion of urban households used cleaner fuels for household cooking while the highest proportion of rural households used BMF. Seventy nine percent of urban households used cleaner fuels while 82% of rural households used BMF indoors.
A greater proportion of urban children were of birth order three or less compared to the rural children Sixty six percent of all children in the study were birth order three or less. Seventy eight percent of all children were of birth order three or less while 62 % of rural children were of birth order three or less The proportion of children of birth order four or more was significantly greater in rural than urban households

A greater proportion of rural than urban children suffered from ARI and fever two weeks before the survey. Sixteen percent of children suffered from ARI in the two weeks preceding the survey. Seventeen percent of children from rural households suffered from ARI while 10% of children from the urban households suffered from ARIs two weeks preceding the survey. The proportion of rural children suffering from ARIs was significantly greater than the proportion of urban children ($p=0.00$). Twenty eight percent of children, suffered from fever in the 2weeks preceding the survey. The proportion of children suffering from fever was greater among rural children ($p=0.01$).Thirty percent children from rural households had fever in the two weeks preceding the survey.

A significantly greater proportion of the urban children had educated mothers, who were employed in the 12 months before the survey and a high household wealth status compared to the rural children. Forty-three percent of all the children's mothers, 58% of urban mothers and 40% of rural mothers were employed in the 12 months preceding the survey.

A greater proportion of the children were from urban households with a high wealth status while a greater proportion of the rural children were from poor households. Fifty three percent of the rural households had a low wealth index while 81% of urban households had a high wealth index.

Table 3.1 Demographic, health and SES characteristics

Characteristic	Urban N (%)	Rural N (%)	Chi^2	p
Demographic factors				
Child's sex				
Male	162(48.7)	644 (50.2)	0.2	0.63
Female	160 (51.3)	646 (49.8)		
Child's age (in months)				
<24	108 (30.1)	371 (28.9)		
25-35	71 (23.8)	321 (24.7)		
36-47	68 (20.9)	302 (23.7)	1.6	0.69
48-60	75 (25.3)	296 (22.8)		
Child's birth order				
1	99 (30.3)	358 (28.1)		
2	85 (28.0)	262 (20.6)		
3	62 (20.0)	183 (14.3)	26.4	0.00
>=4	76 (21.7)	487 (37.1)		
Child's preceding birth interval (in months)				
<24	30 (10.3)	139 (10.9)		
24-35	50 (15.5)	301 (23.0)		
36-47	48 (15.1)	186 (14.3)	8.7	0.10
48-60	23 (8.1)	107 (8.1)		
60+	171 (51.1)	557 (43.8)		
Household region				
Hhohho	85 (30.7)	330 (26.7)		
Manzini	113 (47.3)	310 (25.6)		
Shiselwe	40 (5.7)	352 (27.4)	84.80	0.00
Lubombo	84 (16.3)	298 (20.4)		
Health factors				
Child's birth weight				
< 2500g	24 (7.7)	61 (4.8)	3.80	0.07
>= 2500g	298 (92.3)	1229 (95.2)		
Child had acute respiratory illness in past 2 weeks				
No	284 (90.4)	1070 (82.7)	10.11	0.00
Yes	38 (9.6)	220 (17.3)		

Table 3.1: Continues

Characteristic	Urban N (%)	Rural N (%)	Chi^2	p
Child had fever in past 2 weeks				
No	243 (79.2)	900 (70.2)	9.09	0.01
Yes	77 (20.8)	382 (29.8)		
Child had diarrhoea in past 2 weeks				
No	282 (89.8)	1109 (86.0)	2.87	0.11
Yes	40 (10.2)	181 (14.0)		
Mother' age at birth (in years)				
<18	25 (6.6)	120 (9.2)	4.64	0.30
18-24	118 (39.8)	525 (41.1)		
25-34	140 (41.6)	460 (35.7)		
>=35	39 (12.0)	185 (13.9)		
Iron supplements taken during pregnancy				
No	22 (15.0)	97 (11.2)	16.7	0.02
Yes	213 (85.0)	805 (88.9)		
Mother's body mass index (in kg/m^2)				
<18.5	7 (2.0)	15 (1.3)		
18.5-24	115 (36.7)	550 (41.7)	2.91	0.39
>=25	200 (61.3)	725 (57.0)		
Mother's anaemia status				
None	236 (71.6)	1006 (77.4)		
Mild	63 (21.4)	218 (17.7)	4.5	0.22
Moderate/severe	23 (7.0)	66 (4.9)		
Biomass fuel use				
None, only cleaner fuels	254 (79.0)	167 (14.4)		
Biomass fuels used outdoor	3 (0.6)	50 (3.8)	501.3	0.00
Biomass fuel used indoors	65 (20.5)	1073(81.9)		
SES factors				
Mother's highest level of education				
No education	13 (3.0)	141 (10.5)		
Primary	83 (24.6)	520 (39.8)		
Secondary	164 (54.0)	578 (45.5)	99.59	0.00

Table 3.1: Continues

Characteristic	Urban N (%)	Rural N (%)	Chi^2	p
Higher education	62 (18.4)	51 (4.3)		
Mother employed in past 12 months				
No	128 (41.6)	751 (60.0)		
Yes	184 (58.4)	494 (40.0)	30.6	0.00
Household crowding				
<3 persons per room	167 (52.4)	514 (40.1)		
>=3 persons per room	155 (47.6)	776 (59.94)	14.2	0.03
Household wealth index				
Low	19 (4.9)	709 (53.4)		
Middle	43 (14.4)	272 (20.8)	318.8	0.00
High	260 (80.7)	309 (25.7)		
Number of children	322	1290		

3.2 Prevalence of stunting and anaemia

Table 3.2 shows the prevalence of stunting and anaemia by selected characteristics. Overall 31% of children were stunted. One in every five of the children was mildly stunted while 11% were moderately to severely stunted. There was evidence of a statistically significant difference in the prevalence of stunting in children by sex, fuel use, age, preceding birth interval, birth weight, child anaemia status, diarrhoea in two weeks before survey, iron supplementation during pregnancy, mother's age at birth, mother's body mass index, mother's level of education, and wealth index ($p<0.05$).

Twenty three percent of boys were mildly stunted and 12% were moderately/severely stunted. For girls 17.8% were mildly stunted and 9.3% were moderately/severely stunted.Prevalence of stunting was highest among boys, children whose households used BMF indoors, children from rural homes, from low wealth status households, with a low birth weight, who were moderate to severely anaemic, who suffered from diarrhoea in preceding two weeks, and whose mothers were malnourished, illiterate and did not receive iron supplementation during pregnancy.

Table 3.2 also shows the prevalence of anaemia by selected characteristics. Overall 37% of children were anaemic, 19% were mildly anaemic and 18% were moderately to severely anaemic. There was evidence of a statistically significant difference in the prevalence of anaemia by sex, age, fever in preceding two weeks, diarrhoea in preceding two weeks, mother's body mass index, mother's anaemia status and mother's level of education ($p<0.05$).

Prevalence of mild and moderate to severe anaemia was highest among children aged less than 24months, who suffered from diarrhoea in preceding two weeks, suffered from fever in preceding two weeks and whose mothers were mildly anaemic and moderate to severely anaemic respectively. Prevalence of mild and moderate to severe anaemia is lowest among children of educated mothers.

Table 3.2 Prevalence of anaemia and stunting

Characteristic	Anaemia Mild N (%)	Moderate/ Severe N (%)	Chi^2(p)	Stunting Mild N (%)	Moderate/ Severe N (%)	Chi^2(p)
Demographic factors						
Child's sex						
Male	158 (19.7)	139 (17.3)	1.0 (0.04)	176 (22.1)	97 (12.4)	
Female	151 (19.4)	140 (17.6)		147 (17.8)	69 (9.3)	10.5 (0.01)
Child's age (in months)						
<24	115 (24.1)	176 (37.4)		100 (19.9)	70 (15.9)	
25-35	87 (23.1)	60 (15.5)	257.6(0.00)	104 (26.8)	47 (12.3)	48.1 (0.00)
36-47	61 (17.4)	16 (4.7)		65 (18.1)	24 (6.9)	
48-60	46 (12.4)	27(7.4)		54 (14.8)	25 (7.2)	
Child's birth order						
1	85 (18.8)	86 (18.7)		76 (16.7)	56 (12.8)	
2	63 (17.8)	66 (19.1)	3.4 (0.8)	64 (18.9)	35 (10.6)	11.0 (0.10)
3	46 (20.4)	38 (17.0)		46 (18.3)	22 (10.0)	
>=4	115 (20.9)	89 (15.6)		137 (24.0)	51 (9.9)	
Child's preceding birth interval (in months)						
<24	35 (20.7)	26 (16.4)		38 (15.2)	24 (15.2)	
25-35	53 (15.1)	61 (17.4)		89 (24.9)	30 (8.6)	
36-47	52 (24.3)	39 (17.0)	9.1 (0.43)	55 (23.1)	22 (10.3)	22.2 (0.01)
48-60	27 (22.1)	21 (16.0)		27 (19.6)	11 (9.4)	
60+	142 (19.5)	132 (18.2)		114 (15.7)	79 (11.3)	
Household region						
Hhohho	77 (19.1)	72 (17.7)		92 (22.0)	48 (11.6)	
Manzini	86 (20.7)	77 (18.6)	5.0 (0.69)	84 (19.4)	49 (11.5)	5.3 (0.58)
Shiselwe	81 (21.5)	61(15.8)		73 (18.6)	41 (11.7)	
Lubombo	65 (16.2)	69 (17.4)		74 (19.5)	28 (8.1)	
Residence						
Urban	63 (21.8)	67 (20.2)	3.6 (0.30)	57 (18.5)	22 (7.4)	
Rural	246 (19.1)	212 (16.9)		266 (20.3)	144 (11.6)	

Characteristic	Anaemia Mild N (%)	Moderate/ Severe N (%)	Chi^2(p)	Stunting Mild N (%)	Moderate/ Severe N (%)	Chi^2(p)
Health factors						
Child's birth weight						
< 2500g	13 (15.1)	21 (26.5)	5.5 (0.08)	26 (30.0)	14 (17.9)	12.4 (0.00)
>= 2500g	296 (19.8)	258 (17.0)		297 (19.4)	152 (10.5)	
Child anaemia status						
No anaemia	-	-		186 (18.5)	89 (9.1)	
Mild	-	-		67 (20.6)	39 (12.7)	17.4 (0.00)
Moderate/severe	-	-		70 (24.5)	38 (15.2)	
Child had acute respiratory illness in past 2 weeks						
No	256 (19.1)	232 (17.4)		271 (20.0)	142 (11.2)	0.8 (0.66)
Yes	53 (22.2)	47 (17.8)	1.5 (0.48)	52 (19.6)	24 (9.4)	
Child had fever in past 2 weeks						
No	213 (18.8)	182 (16.3)	6.4(0.05)	227(20.0)	110(10.3)	1.4(0.55)
Yes	94 (21.4)	95 (20.3)		94 (19.9)	55(12.3)	
Child had had diarrhoea in past 2 weeks						
No	262 (19.5)	211 (15.3)		267 (19.2)	139 (10.5)	
Yes	47 (20.3)	68 (31.3)	35.8 (0.00)	56 (25.1)	27 (13.5)	7.0 (0.03)
Mother' age at birth (in years)						
<18	22 (15.8)	38 (23.8)		26 (16.5)	22 (17.4)	
18-24	130 (20.5)	116 (18.7)		133 (21.4)	77 (12.3)	
25-34	116 (20.2)	90 (15.4)	9.0 (0.18)	108 (17.4)	49 (8.9)	19.5 (0.01)
>=35	41 (17.6)	35 (15.3)		56 (24.7)	18 (7.7)	
Iron supplements taken during pregnancy						
No	28 (23.6)	32 (27)	5.1 (0.09)	32 (24.8)	17 (15.3)	7.1 (0.04)
Yes	201 (20.2)	202 (19.9)		191 (18.9)	104 (10.7)	

Table 3.2 Continues

Characteristic	Anaemia Mild N (%)	Moderate/ Severe N (%)	Chi²(p)	Stunting Mild N (%)	Moderate/ Severe N (%)	Chi²(p)
Mother's body mass index (in kg/m²)						
<18.5	4 (17.5)	6 (31.8)		5 (26.3)	6 (31.7)	
18.5-24	137 (22.0)	135 (20.7)	20.2 (0.00)	139 (20.5)	79 (12.3)	16.4 (0.00)
>=25	168 (17.9)	138 (14.8)		179 (19.4)	81 (9.4)	
Mother's anaemia status						
None	217 (17.4)	197 (16.0)		250 (20.2)	119 (10.1)	
Mild	69 (26.8)	60 (22.0)	29.7 (0.00)	58 (19.8)	34 (12.9)	4.7 (0.38)
Moderate/severe	23 (25.5)	22 (23.1)		15 (16.8)	13 (16.0)	
SES						
Biomass fuel use						
None, only cleaner fuels used	80 (20.0)	82 (19.8)		64 (15.2)	28 (7)	
Outdoors	9 (16.8)	6 (9.5)	5.0 (0.29)	7 (11.0)	2 (3.7)	29.4 (0.00)
Indoors	220 (19.6)	191 (17)		252 (22.0)	136 (12.6)	
Mother's highest level of education						
No education	26 (17.3)	25 (15.7)	15.5 (0.02)	42 (27.3)	21 (14.0)	46.1 (0.00)
Primary	118 (20.0)	110 (18.4)		139 (22.9)	76 (13.8)	
Secondary	152 (20.7)	135 (18.4)		135 (18.0)	66 (9.1)	
Tertiary	13 (12.7)	9 (8.1)		7 (6.9)	3 (2.7)	
Mother employed in past 12 months						
No	168 (19.7)	167 (19.2)	6.6 (0.07)	183 (20.6)	97 (11.6)	
Yes	132 (19.7)	96 (14.4)		130 (19.4)	62 (9.8)	1.9 (0.4)
Household crowding						
<3 persons per room	126 (39.6)	115 (41.4)	1.3 (0.58)	136 (42.3)	67 (39.3)	0.6 (0.74)
>=3 persons per room	183 (60.4)	164 (58.6)		187 (57.7)	99 (60.7)	

Characteristic	Mild N (%)	Moderate/ Severe N (%)	Chi^2(p)	Mild N (%)	Moderate/ Severe N (%)	Chi^2(p)
Household wealth index						
Low	143 (20.3)	112 (15.9)		175 (23.7)	101 (14.5)	
Middle	54 (16.5)	67 (21.5)	6.2 (0.25)	67 (21.2)	24 (8.6)	42.4 (0.00)
High	112 (20.4)	100 (17.2)		81 (14.4)	41 (7.5)	
Overall	**309(19.6)**	**279(17.5)**		**323(20.0)**	**166(10.9)**	

3.3 Factors associated with household fuel use

Table 3.3 shows the results from the statistically significant factors associated with the type of fuel used by households. Children whose mothers had completed secondary school or tertiary education were significantly more likely to use cleaner fuels for cooking than children whose mothers were uneducated. Children whose mothers had completed secondary school were three times more likely to use cleaner fuels for cooking than children whose mothers were uneducated (RR 3.3; 95% CI:1.9-5.5; $p<0.05$). Children whose mothers had tertiary education were 56 times more likely to use cleaner fuels for cooking than children whose mothers were uneducated (RR 55.8; 95% C1: 24.8-125.4; $p<0.05$).

Households with a middle and higher wealth index were significantly more likely to use cleaner fuels than those with a low wealth index. Households with a middle wealth index were almost 10 times more likely to use cleaner fuels (RR 9.9; 95% CI: 5.1-19.1; $p<0.05$) compared to the low wealth index households. High wealth index households were 88 times more likely to use cleaner fuels than those with a low wealth index (RR 88.0; 95% CI: 44.2-175.3; $p<0.05$).

Rural and more crowded households were less likely to use cleaner fuels than urban households were. Rural households were significantly less likely to use cleaner fuels than urban households (RR 0.05; 95% CI: 0.02- 0.08; $p<0.05$). Households that were more crowded were 44% less likely to use cleaner fuels compared to households with no crowding. (RR 0.56; 95% CI: 0.4-0.8; $p<0.05$).

Table 3.3: Factors associated with household fuel use in Swaziland during July 2006−March 2007

Characteristic	Cleaner fuels RR (CI)	Biomass fuels RR (CI)
Mother's highest education		
No education	1	1
Primary	1.3(0.8;2.2)	1.1(0.2;4.8)
Secondary	3.3*(1.9;5.5)	1.4(0.3;5.4)
Tertiary	55.8*(24.8;125.4)	1.9(0.2;21.4)
Household wealth index		
Low	1	1
Middle	9.9*(5.1;19.1)	1.80(0.6;5.2)
High	88.0*(44.2;175.3)	1.4(0.5;4.0)
Household crowding		
<3 persons/room	1	1
>=3 persons/room	0.56*(0.4;0.8)	0.80(0.3;2.0)
Household location		
Urban	1	1
Rural	0.05*(0.02;0.08)	1.62(0.40;6.50)
Household region		
Hhohho	1	1
Manzini	1.2(0.6;2.2)	0.6(0.1;2.9)
Shiselwe	0.3*(0.1;0.5)	3.6(0.9;14.6)
Lubombo	0.7(0.4;1.3)	2.3(0.6;9.3)

* means statistically significant difference i.e chi(p)<0.05

3.4 Risk factors for anaemia

Table 3.4 shows the results of univariate analysis for factors associated with anaemia in this study. Factors that are significantly associated with anaemia are child's age, child's birth weight, iron supplementation during pregnancy, mother's age at birth and mother's anaemia status.

The risk of both mild and moderate anaemia decreases as age increases. There was a 20% decrease in risk to mild anaemia with increase in age group from the 12-24 years age group to the 48-60 years age groups. There was a 70% decrease in risk to moderate to severe anaemia between children in the 25-35 years age group and children in the 12-24 years age group. The decrease in risk to moderate to severe anaemia was the same for the 36-47 and the 48-60 age groups. Children in the 36-60 years ages were 90% less likely to be moderate to severely anaemic compared to the children in the 12-24 years age group.

Children whose mothers were anaemic were at increased risk of anaemia. Children whose mothers were mildly anaemic were twice more likely to be mildly or anaemic (RR 2.0; 95% CI: 1.4-2.8; $p<0.05$) compared to children whose mothers were not anaemic. Children whose mothers were moderate to severely anaemic were 90% more likely to be moderately to severely anaemic (RR 1.9; 95% CI: 1.1-3.3; $p<0.05$) compared to children whose mothers were not anaemic.

Children whose mothers received iron supplementation during pregnancy were at reduced risk of moderate to severe anaemia compared to children whose mothers did not receive iron supplementation in pregnancy (RR 0.6; 95% CI: 0.4-0.98; $p<0.05$).

Children whose mothers gave birth after 25 years of age were at reduced risk of 40 moderate to severely anaemia (RR 0.6; 95% CI:0.4-0.96; $p<0.05$) compared to children whose mothers gave birth in the 18-24 years age group.

Table 3.4: Unadjusted effects of biomass fuel use and other risk factors on anaemia in children (12-59 months) in Swaziland during July 2006−March 2007

Characteristic	Mild anaemia RR (95% CI)	Moderate/Severe anaemia RR (95% CI)
Biomass fuel use		
None, only cleaner fuels	1.00	1.00
Outdoors	0.7(0.3;1.4)	0.4(0.4;1.2)
Indoors	0.9(0.7;1.3)	0.8(0.6;1.1)
Child's birth weight		
< 2500g	0.83(0.4;1.7)	1.67*(1.0;3.3)
>= 2500g	1.00	1.00
Child's age (in months)		
<24	1.00	1.00
25-35	0.6*(0.4;0.9)	0.3*(0.2;0.4)
36-47	0.4*(0.2;0.5)	0.1*(0.03;0.1)
48-60	0.2*(0.2;0.4)	0.1*(0.06;0.1)
Mother's anaemia status		
None	1.00	1.00
Mild	2.0*(1.4;2.8)	1.8*(1.3;2.6)
Moderate/severe	1.9*(1.1;3.4)	1.9*(1.1;3.3)
Iron supplements taken during pregnancy		
No	1.00	1.00
Yes	0.7(0.5;1.1)	0.6*(0.4;0.98)
Mother' age at birth (in years)		
<18	1.00	1.00
18-24	1.3(0.8;2.2)	0.8(0.5;1.2)
25-34	1.2(0.7;2.0)	0.6*(0.4;0.96)
>=35	1.0(0.6;1.8)	0.6*(0.4;0.96)

* means statistically significant difference i.e chi(p)<0.05

3.5 Risk factors for stunting

Table 3.5 shows the results of univariate analysis for factors associated with stunting. Factors associated with stunting were household indoor BMF use, child's sex, birth weight, age, birth order, preceding birth interval, child's anaemia status, diarrhoea in preceding two weeks, mother's body mass index, mother's age at birth, mother's education, iron supplementation during pregnancy and household wealth index.

Girls were at reduced risk to stunting than boys. Girls were 30% less likely to be mildly stunted (RR 0.7; 95% CI: 0.6-0.9; $p<0.05$) and 30% less likely to be moderate to severely stunted than boys (RR 0.7; 95% CI: 0.5-0.9 $p<0.05$). The risk of both mild and moderate to severe stunting decreases as age increased. Children of birth order of four or more were at increased risk of being to be mildly stunted compared to children of birth order one (RR 1.5; 95% CI: 1.1-2.2; $p<0.05$).

Children with a low birth weight were at increased risk of stunting than the children with a normal birth weight. Children with a low birth weight were twice more likely to be mildly stunted (RR 2.0; 95% CI: 1.3-3.3; $p<0.05$) and 2.5 times more likely to be moderate to severely stunted than the children with a normal birth weight (RR 2.5; 95% CI: 1.3-5.0; $p<0.05$).

Moderate to severely anaemic children were at increased risk of stunting than children with no anaemia. Children who were moderate to severely anaemic were 60% more likely to be mildly stunted (RR 1.6; 95% CI: 1.1-2.2; p<0.05) and at increased risk of being moderate to severe stunted than children with no anaemia (RR 2.0; 95% CI: 1.3-3.0; p<0.05).

Children whose mothers received iron supplementation during pregnancy were at reduced risk of being mildly stunted (RR 0.6; 95% CI: 0.4-1.0; p<0.05). Children whose mothers were aged 25 years or more at birth at reduced risk of being moderate to severely stunted compared to children whose mothers were less than 18 years of age at birth. Children whose mothers were aged 25-34 years of age at birth, were 50% less likely to be moderate to severely stunted compared to children whose mothers were less than 18 years of age at birth (RR 0.5; 95% CI: 0.3-0.8; p<0.05). Children whose mothers were aged over 35 years at birth, were 60% less likely to be moderate to severely stunted compared with children whose mothers were less than 18 years of age at birth (RR 0.4; 95% CI: 0.2-0.8; p<0.05).

Children from households with a high wealth index were at reduced risk of mild or moderate to severe stunting. Children from households with a high wealth index were 50% less likely to be mildly stunted (RR 0.5; 95% CI: 0.3-0.7; p<0.05) and 60% less likely to be moderate to severely stunted (RR 0.4; 95% CI: 0.3-0.6; p<0.05) compared to children from low wealth index households.

Table 3.5 Unadjusted effects of biomass fuel use and other risk factors on stunting prevalence in children (12-59 months) in Swaziland during July 2006−March 2007

Characteristic	Mild stunting RR (95% CI)	Moderate/Severe Stunting RR (95% CI)
Demographic factors		
Child's sex		
Male	1	1
Female	0.7*(0.6;0.9)	0.7*(0.5;0.9)
Child's birth weight		
< 2500g	2.00*(1.3;3.3)	2.5*(1.3;5.0)
>=2500g	1	1
Child's age (in months)		
<24	1	1
24-35	1.4*(1.0;2.0)	0.9(0.5;1.2)
36-47	0.8*(0.5;1.1)	0.4*(0.2;0.6)
48-59	0.6*(0.4;0.9)	0.4*(0.2;0.6)
Child's birth order		
1	1	1
2	1.1(0.8;1.6)	0.8(0.5;1.3)
3	1.1(0.7;1.6)	0.8(0.5;1.3)
>=4	1.5*(1.1;2.2)	0.8(0.5;1.3)
Health factors		
Child's preceding birth interval (in months)		
<24	1	1
24-35	1.0(0.6;1.5)	0.5*(0.3;1.0)
36-47	0.9(0.5;1.4)	0.6(0.3;1.2)
48-59	0.7(0.4;1.3)	0.5(0.2;1.2)
>=60	0.5*(0.4;0.8)	0.6 (0.4;1.1)
Child's anaemia status		
None	1	1
Mild	1.2(0.9;1.7)	1.5(1.0;2.3)
Moderate/severe	1.6 *(1.1;2.2)	2.0*(1.3;3.0)

* means statistically significant risk difference i.e chi(p)<0.05

Characteristic	Mild stunting RR (95% CI)	Moderate/Severe Stunting RR (95% CI)
Child had diarrhoea in past 2 weeks		
No	1	1
Yes	1.5*(1.1;2.1)	1.5(0.9;2.2)
Mother's body mass index (in kg/m^2)		
<18.5	1	1
18.5-25	0.5(0.2;1.5)	0.2*(0.1;0.6)
>25	0.4(0.1;1.4)	0.2*(0.1;0.5)
Mother's age at birth (in years)		
<18	1	1
18-24	1.3(0.8;2.1)	0.7(0.4;1.2)
25-34	0.9(0.6;1.6)	0.5*(0.3;0.8)
>35	1.5(0.9;2.5)	0.4*(0.2;0.8)
Iron supplements taken during pregnancy		
No	1	1
Yes	0.6*(0.4;1.0)	0.6(0.3;1.0)
SES factors		
Mother's highest level of education		
No education	1	1
Primary	0.8(0.5;1.3)	0.9(0.5;1.8)
Secondary	0.5*(0.3;0.8)	0.5(0.3;1.0)
Tertiary	0.2*(0.1;0.4)	0.1*(0.03;0.4)
Household wealth index		
Low	1	1
Middle	0.8(0.6;1.1)	0.5*(0.3;0.9)
High	0.5[*](0.3;0.7)	0.4*(0.3;0.6)

[*] means statistically significant difference i.e chi(p)<0.05

Characteristic	Mild stunting RR (95% CI)	Moderate/Severe Stunting RR (95% CI)
Biomass fuel use		
None, only cleaner fuels	1	1
Outdoors	0.7(0.3;1.6)	0.5(0.1;2.4)
Indoors	1.7*(1.2;2.5)	2.2*(1.4;3.4)

* means statistically significant risk difference i.e chi(p)<0.05 check if this is supposed to be here!!

3.6 Relationship between BMF use and anaemia

Table 3.6 shows the results of multivariate analysis to investigate the relationship between BMF and anaemia whilst adjusting for potential confounding. The potential confounders in the analysis included all factors associated with child anaemia in the univariate analysis. After adjusting for potential confounders in the multivariate model there is no evidence of a statistically significant relationship between indoor BMF smoke exposure childhood anaemia and SES factors such as mother's education and wealth index

Factors significantly associated with anaemia in the final model are outdoor BMF use, birth weight, child age, mother's anaemia status and wealth index. Low birth weight was protective against mildly anaemia. Children with a low birth weight were 70% less likely to be mildly anaemic compared with normal birth weight babies (RR 0.3; 95% CI: 0.1-0.9; $p<0.05$). Risk of mild anaemia increased with age.

Children whose mothers were anaemic were at increased risk of anaemia. Children whose mothers were mildly anaemic were twice more likely to be mildly anaemic compared with children whose mothers were not anaemic (RR 2.0; 95% CI; 1.3-2.9; $p<0.05$). Children whose mothers were moderate to severely anaemic were three times more likely to be mildly anaemic compared to children whose mothers were not anaemic (RR 3.2; 95% CI: 1.7-6.3; $p<0.05$). Children whose mothers were mildly anaemic were twice more likely to be moderately to severely anaemic compared to children whose mothers were not anaemic (RR 2.1; 95% CI: 1.3-3.4; $p<0.05$). Children whose mothers were moderate to severely anaemic were four times more likely to be moderate to severely anaemic compared to children whose mothers were not anaemic (RR 3.7; 95% CI: 1.9-7.3; $p<0.05$).

Children from middle wealth index households were at increased risk of moderate to severe anaemia compared to the children from low wealth index households (RR 1.7; 95% CI: 1.1-2.7; $p<0.05$).

Table 3.6: Adjusted effects of biomass fuel use and other risk factors on anaemia in children (12-59 months) in Swaziland during July 2006−March 2007

	Mild anaemia RR (95% CI)	Moderate/Severe Anaemia RR (95% CI)
Demographic factors		
Household location		
Urban	1	1
Rural	0.8(0.5;1.5)	0.9(0.5;1.7)
Household region		
Hhohho	1	1
Manzini	0.9(0.6;1.5)	0.9(0.5;1.6)
Shiselwe	1.2(0.7;1.9)	1.0(0.5;1.8)
Lubombo	0.8(0.5;1.3)	0.9(0.5;1.7)
Child's age (in months)		
<24	1	1
24-35	0.6*(0.4;0.9)	0.2*(0.2;0.4)
36-47	0.3*(0.2;0.5)	0.05*(0.02;0.09)
48-59	0.3*(0.2;0.5)	0.1*(0.04;0.2)
Health factors		
Child's birth weight		
< 2500g	0.3*(0.1;0.9)	1.5(0.8;2.5)
>= 2500g	1	1
Iron supplements taken during pregnancy		
No	1	1
Yes	0.8(0.5;1.2)	0.7(0.4;1.1)
Mother's anaemia status		
None	1	1
Mild	2.0*(1.3;2.9)	2.1*(1.3;3.4)
Moderate/severe	3.2*(1.7;6.3)	3.7*(1.9;7.3)
Mother's age at birth (in years)		
<18	1	1
18-24	0.9(0.4;1.8)	0.7(0.4;1.3)

* means statistically significant risk difference i.e chi(p)<0.05

	Mild anaemia RR (95% CI)	Moderate/Severe Anaemia RR (95% CI)
25-34	0.9(0.5;1.8)	0.7(0.3;1.3)
>=35	0.9(0.4;1.9)	0.7(0.4;1.4)
SES factors		
Biomass fuel use		
None, only cleaner fuels	1	1
Outdoors	0.8(0.3;2.0)	0.2*(0.1;0.7)
Indoors	1.0(0.6;1.7)	0.8(0.5;1.4)
Mother's highest level of education		
No education	1	1
Primary	1.3(0.7;2.3)	1.1(0.5;2.2)
Secondary	1.3(0.7;2.2)	1.1(0.5;2.2)
Tertiary	0.7(0.3;1.6)	0.5(0.2;1.4)
Household wealth index		
Low	1	1
Middle	1.0(0.6;1.7)	1.7*(1.1;2.7)
High	1.0(0.6;1.7)	1.2(0.7;2.0)
Household crowding		
<3 persons/room	1	1
>=3 persons/room	1.1(0.8;1.5)	1.0(0.7;1.4)

3.7 Relationship between indoor BMF use and stunting

Table 3.7 shows the results of multivariate analysis to investigate the relationship between indoor BMF use and child stunting while adjusting for different characteristics. There was no evidence of an association between indoor BMF use and child stunting after adjusting for identified potential confounders.

Only child sex, birth weight and child age remain significantly associated with stunting. Girls were less likely to be mildly stunted or moderately to severely stunted than boys. Girls were at reduced risk of mild stunting (RR 0.7; 95% CI: 0.5-1.0; $p<0.05$) and moderate to severe stunting compared to boys (RR 0.6; 95% CI: 0.4-1.0; $p<0.05$).

Children with a low birth weight were at increased risk of moderate to severe stunting than normal birth weight children (RR 2.5; 95% CI: 1.1-5.0; $p<0.05$).

Children aged 24-35 months were at increased risk of mild stunting compared to children in the 12-24 months age group (RR 1.6; 95% CI: 1.0-2.4; $p<0.05$). Children aged 36-47 months were at reduced risk of moderate to severe stunting (RR 0.3; 95% CI: 0.2-0.7; $p<0.05$) compared to children in the 12-24 months category. Children aged 48-59 months were at reduced risk of mild stunting (RR 0.5; 95% CI: 0.3-1.0; $p<0.05$) compared to children in the 12-24 months category.

Table 3.7 Adjusted effects of biomass fuel use and other risk factors on stunting in children (12-59 months) in Swaziland during July 2006−March 2007

Characteristic	Mild Stunting RR (95% CI)	Moderate/Severe Stunting RR (95% CI)
Demographic factors		
Child's sex		
Boy	1	1
Girl	0.7*(0.5;1.0)	0.6*(0.4;1.0)
Child's age (in months)		
<24	1	1
24-35	1.6*(1.0;2.4)	1.0(0.6;1.7)
36-47	0.9(0.6;1.6)	0.3*(0.2;0.7)
48-59	0.5*(0.3;1.0)	0.5(0.2;1.0)
Health factors		
Child's birth weight		
< 2500g	1.7(0.8;3.3)	2.5*(1.1;5.0)
>=2500g	1	1
Child's birth order		
1	1	1
2	0.7(0.4;1.3)	1.2(0.5;2.7)
3	0.8(0.4;1.5)	1.0(0.4;2.7)
>=4	1.0(0.5;2.2)	1.3(0.4;3.5)
Child's preceding birth interval (in months)		
<24	1	1
24-35	1.0(0.6;1.9)	0.5*(0.2;1.0)
36-47	0.8(0.4;1.4)	0.7(0.3;1.4)
48-59	0.8(0.4;1.7)	0.6(0.2;1.6)
>=60	0.5*(0.3;1.0)	0.5 (0.2;1.2)
Iron supplements taken during pregnancy		
No	1	1
Yes	0.7(0.4;1.2)	0.8(0.4;1.5)
Child's anaemia status		
None	1	1
Mild	1.0(0.7;1.5)	0.9(0.5;1.6)
Moderate/severe	1.3(0.8;2.1)	1.3(0.7;2.1)

Table 3.7: Continues

Characteristic	Mild Stunting RR (95% CI)	Moderate/Severe Stunting RR (95% CI)
Child had diarrhoea in past 2 weeks		
No	1	1
Yes	0.9(0.7;1.4)	0.9(0.6;1.5)
Mother's body mass index (kg/m^2)		
<18.5	1	1
18.5-25	0.6(0.2;1.6)	0.5(0.1;2.4)
>25	0.5(0.2;1.6)	0.5(0.1;2.3)
Mother's age at birth (in years)		
<18	1	1
18-24	1.0(0.5;1.9)	0.9(0.4;2.1)
25-34	0.6(0.3;1.4)	0.5(0.2;1.3)
>=35	0.9(0.4;2.2)	0.5(0.2;1.6)
SES factors		
Biomass fuel use		
None, only cleaner fuels	1	1
Outdoors	0.3(0.1;1.1)	0.3(0.03;3.0)
Indoors	1.1(0.6;1.8)	1.4(0.7;2.6)
Mother's highest level of education		
No education	1	1
Primary	0.8(0.4;1.4)	0.9(0.4;2.1)
Secondary	0.8(0.4;1.4)	0.6(0.3;1.5)
Tertiary	0.5(0.2;1.6)	0.1(0.01;1.1)
Household wealth index		
Low	1	1
Middle	0.9(0.6;1.3)	0.7(0.4;1.4)
High	0.6(0.3;1.0)	0.7(0.4;1.3)

CHAPTER 4

DISCUSSION AND CONCLUSIONS

This chapter presents a comprehensive discussion and conclusion of the results of this study. The study aimed to investigate the association between BMF smoke exposure and stunting or anaemia after adjusting for potential confounding. The study identified high prevalence of BMF use by households, high prevalence of anaemia and stunting in children aged 12-59 months old. Risk factors associated with anaemia include mother's anaemic status, low birth weight, child's age and household wealth index. Risk factors for stunting include child's sex, low birth weight and child's age. No association was observed between indoor BMF use and stunting or anaemia after adjusting for potential confounders.

4.1 High usage of BMF for cooking purposes

The study confirms that the majority of Swazis rely on BMF as a household energy source. Additionally it shows strong association between types of fuel used and household wealth status, mother's education status and whether the household was rural or urban. Women of higher educational status would more likely belong to more affluent households using cleaner fuels. Similarly, children residing in rural areas were more likely to belong to households with lower wealth index. As postulated by Holdren and Smith,2000 in the energy ladder, the households with a high wealth index were more likely to use cleaner fuels compared to the households with a low wealth index.

4.2 Prevalence and risk factors of anaemia

The results from this study show that anaemia is a major health problem among children in Swaziland. Prevalence of anaemia of 37% among children is ranked as moderate public health significance by the WHO (WHO, 2002). A severe public health problem exists when anaemia prevalence is above 40% in any group (WHO, 2002). Severe anaemia is considered a public health problem if prevalence exceeds 2% (WHO, 2002).This study found that more than 2% of children are moderately to severely anaemic.

This study shows a strong positive relationship between maternal anaemia, low birth weight and childhood anaemia. These findings are consistent with previous studies and provide further evidence for the benefits of routine iron supplementation in pregnancy. Children whose mothers received iron supplement during pregnancy were at reduced risk of anaemia. The positive effects in this regard extend to both maternal and child health by preventing antenatal anaemia. Anaemia in pregnancy has been shown to contribute to low birth weight and prematurity, both of which increase the risk of childhood anaemia (Wharton, 1999; Steketee, 2003; Miller et al., 2003). In this study, children with a low birth weight were more likely to be anaemic compared to normal birth weight children.

Severe maternal anaemia may also contribute to child anaemia through reduced iron content being available for the breastfeeding infant from the mother’s milk (Kumar et al., 2008). The association between mother’s anaemia status and child anaemia many months after birth, in this case ≥12 months, could also be attributed to a socioeconomic environment in which the child’ dietary quality becomes the same as that of the mother’s (Pasricha et al., 2010).

Pasricha et al.,2010 found a strong association between wealth and food insecurity and anaemia. The study concluded that SES conditions play a critical role in influencing haemoglobin levels in children.

The relationship between mother's anaemia status and child anaemia in this study shows a dose response relationship. The risk of anaemia in children was highest when mothers were moderately to severely anaemic. This finding is consistent to findings from a previous study that analysed the relation between the haemoglobin concentration of pregnant women and the risk of anaemia in infants at 12 months of age. Infants born to anaemic mothers were more likely to become anaemic themselves independent of feeding practices, morbidity, and socioeconomic status (Colomer et al., 1990).

The risk of mild anaemia in children decreased with age and this is consistent with findings of a three-year longitudinal survey conducted in Cameroon that specified an age-related decrease in the prevalence of anaemia in children from six to 60 months of age (Cornet et al., 1998).

4.3 Prevalence of and risk factors for stunting

This study shows evidence of the role of perinatal factors in determining a child's early life and health. As shown in previous studies this study also found that mother's nutritional status, low birth weight and iron supplementation during pregnancy are independently associated with the poor child's linear growth (Aerts et al., 2004; Marins and Almeida, 2002).

Wealth status was independently associated with both indoor BMF smoke exposure and stunting. Households with a middle and high wealth index were more likely to use cleaner fuels compared to poorer households. Children from households with a high wealth index were less likely to be stunted. The association between indoor BMF became insignificant after adjusting for wealth index. This finding shows further evidence in support of the fact that child height is a significant marker of social inequality (Tanner, 1987).

Apart from the role of perinatal factors in affecting child health, this study shows that stunting is both a proxy for child health inequalities and a proxy for socio-economic inequalities. Mother's education status was another significant risk factor for childhood stunting. In the univariate analysis, children whose mothers were more educated were more likely to use cleaner fuels. These children were also less likely to be stunted. The association between child nutritional status and mother's education is well documented. Maternal education has been associated in previous studies with increased income and a positive influence on food security, quality of diet and use of health services (Willey et al., 2009).

Girls in this study were at significantly reduced risk of stunting compared to boys. This is consistent with several studies conducted in Sub-Saharan Africa that have shown that under-five male children are more likely to be stunted than females (Wamani et al., 2007). The observed sex differences in stunting tended to be more pronounced in the poorest households (Wamani et al., 2007). The sex differences in stunting have also been explained by biological mechanisms and evolutionary theory. Both morbidity and mortality are consistently reported to be higher in males than in females in early life because males are more vulnerable to environmental stress in early life (Wells, 2000).

Low birth weight in this study was associated with moderate to severe stunting. Even though a statistically significant relationship could not be established between low birth weight and indoor BMF use, previous studies have reported reduction in mean infant birth weight due to BMF smoke exposure among pregnant women (Boy et al., 2000; Mishra et al., 2004). Similarly Siddiqui et al (2008) found that exposure to wood fuel burning for cooking during pregnancy was associated with significantly increased odds of low birth weight and a reduced mean birth weight of infants after adjusting for other covariates. The association observed in this study shows evidence that the hazards of indoor air pollution in children occur from a continuum of exposures, pregnancy followed by childhood.

4.4 Strengths of the study

The 2006-2007 SDHS study employed a multistage random sampling thus every household had an equal opportunity of being selected hence representativeness of the sample was ensured. As such, these findings apply beyond the sample population. A wide range of household, maternal and child characteristics data was collected through the SDHS. This means a wider range of variables could be adjusted for in regression modelling ensuring a precise observed relationship.

4.5 Limitations of the study

Although this analysis included a wide range of possible confounding variables collected during the survey, there is potential for residual confounding by factors on which data was unavailable such as poor nutritional status, micronutrient deficiencies, intestinal helminths and HIV infection.

The division of the population into children exposed or not exposed to biomass smoke in this study on the basis of BMF use for cooking overlooked the large variability of exposures due to differences in fuel mix by households and limited the estimation of an exposure-response curve for different combinations of BMF use patterns and housing conditions.

Another limitation worth noting is the fact that factors such as different household cooking and space heating practices and ventilation factors were not measured in the SDHS. The exposure to indoor BMF smoke in this study was also underestimated because BMF use for heating purposes, a common practice in Swaziland was not accounted for. Uncertainty in the assessment of individual exposure levels often but not always leads to bias towards the null. In the future SDHS it may be imperative to include the question on the type of fuels used for space heating purposes.

The collection of data on many variables especially symptoms of disease was self-reported. The possibility that answers to some questions could have been modified to make them more socially desirable cannot be completely ruled out. Socially desirable responses can have result in the reporting incorrect information, omitting information or altering the magnitude of the reported information. Other information collected within the survey relied mainly on the participants in this case the mother's ability to remember.

The study was cross sectional study and waslimited in determining causality. Both exposure and health outcome are measured at the same time and temporality could not be ascertained due to the structuring of the questionnaire. There is no time component to the exposure question and it may be inappropriate to assume that a certain household has always used one particular fuel since the child's pregnancy. It was also difficult to ascertain which came first the BMF smoke exposure or the poor linear growth in the child.

The failure to detect any association in this study may be a result of a small sample size or the inability to measure the true extent of exposure. The exclusion of a large number of cases with missing height values reduced sample size and could have introduced bias. However, a sample size of 1612 gave enough statistical power to the study.

4.6 Conclusion

This study provides further evidence to the high levels of BMF use in Swazi households and the high levels of toxic respirable particles that children aged 12-59 months are exposed to on a daily basis. Burning BMF indoors is thus a significant contributor to childhood morbidity and mortality in Swaziland. On the contrary to the huge overlap between the use of BMF for cooking purposes and a high prevalence of anaemia and stunting, there is insufficient evidence to suggest that exposure to BMF smoke is associated to either stunting or anaemia among Swazi under fives.

4.7 Recommendations

I recommend further primary and more detailed research on the relationship between indoor BMF smoke exposure, anaemia and stunting. Further research should aim to accurately measure the exposure taking into consideration the fuel type, the composition of the fuel smoke, the household purpose, the length of exposure and a model for estimating ventilation factors that are crucial in estimating exposure levels. Primary data collection will allow researchers to measure all conceivable potential risk factors and eliminate residual confounding.

This study shows that iron supplementation has a significant benefit in reducing child anaemia. Iron supplementation should be routinely taken by pregnant women to reduce the incidence of anaemia and low birth weight that in turn are associated with childhood anaemia and stunting. The identification and treatment of iron deficiency anaemia in pregnancy should continue to be placed as a health care priority targeted at both reducing risk to maternal and infant morbidity and mortality. Programs aimed at reducing the burden of anaemia and stunting in children in Swaziland should target the improvement of maternal nutrition during and after pregnancy.

There is need to intensify programmes aimed at introducing more cost effective and efficient energy technologies for household use. Given that burning BMF outdoors was shown to provide a protective effect on anaemia, introduction of cheap ventilation systems for the traditional kitchen or encouragement to cook outdoors will go a long way in reducing the amounts of toxic particles inhaled by children in a confined environment.

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APPENDIX A

Email from Macro International Inc. to Dr J Wichmann

Subject: DHS Download Account Application

From: archive@measuredhs.com

Date: Fri, 4 Jul 2008 13:49:21 -0400 (EDT)

To: jwichmann@med.up.ac.za

You have been authorized to download data from the Demographic and Health surveys (DHS) on-line archive. This authorization is for unrestricted countries requested on your application.

All DHS data should be treated as confidential, and no effort should be made to identify any household or individual respondent interviewed in the survey.

The data sets must not be passed on to other researchers without the written consent of DHS. Users are requested to submit an electronic or hard copy of any reports/publications resulting from using the DHS data files. These reports should be sent to the attention of the DHS Data Archive, so that it may be forwarded to the country(ies) whose data has(ve) been used.

To begin downloading the DHS data files, please LOGIN at http://www.measuredhs.com/login.cfm. You may also access My Account at the same address to edit your contact information and/or apply for access to additional countries.

The files you will download are in zipped format and must be unzipped before analysis. Following are some guidelines:

Download the zipped data and use WINZIP or PKUNZIP to unzip the files. After unzipping, print the file with the .DOC extension. This file contains useful information on country specific variables and differences in the Standard Recode definition.

Download the DHS Recode Manual at http://www.measuredhs.com/accesssurveys/technical_assistance.cfm. The DHS Recode Manual contains the documentation and map for use with the data. The Documentation file contains a general description of the recode file, including the rationale for recoding; description of the physical structure in which the recode file is available; how to weight the data for any analysis; coding standards used in the data file; location of identification information; use of century month codes for dates and imputation of partial dates; DHS model questionnaires; sections and occurrences; description of each variable in the data file, giving additional information that is not available in the dictionary. The Map file contains a listing of the standard dictionary with basic information relating to each variable.

It is essential that you consult the questionnaire for a country, when using the data files. Questionnaires are in the appendices of each survey's final report, which can be downloaded or ordered from: http://www.measuredhs.com/pubs.

DHS statistics can also be obtained using the STATcompiler tool at: http://www.statcompiler.com. This online database tool allows users to select numerous countries and hundreds of indicators to create customized tables that serve their specific data needs. It accesses nearly all of the population and health indicators that are published in DHS+ final reports. Authorization is not needed to use the STATcompiler.

DHS Data Archive

Macro International Inc.

Suite 300

11785 Beltsville Drive

Calverton, MD 20705

E-mail: archive@measuredhs.com

Web: www.measuredhs.com

Tel.: 301-572-0851

Fax: 301-572-0999

APPENDIX B:

Ethical Clearance Letter from the University of Witwatersrand Ethics Committee on Human Research

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Ms Machisa M Tanyaradzwa

CLEARANCE CERTIFICATE	**M090942**
PROJECT	An Investigation of the Association between Household Biomass Fuel Smoke Exposure and Stunting in Children aged 12-59 Months in Swaziland during 2006-7 Swaziland Demographic and Health Survey Period
INVESTIGATORS	Ms Machisa M Tanyaradzwa.
DEPARTMENT	School of Public Health
DATE CONSIDERED	2009/10/02
DECISION OF THE COMMITTEE*	Approved unconditionally

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

DATE 2009/10/02 **CHAIRPERSON** ....
(Professor PE Cleaton-Jones)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : Mr P Nyasulu

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 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...

APPENDIX C:

Letter to approve research title from the WITS Faculty of Health Sciences Postgraduate Research Office

Faculty of Health Sciences
Medical School, 7 York Road, Parktown, 2193
Fax: (011) 717-2119
Tel: (011) 717-2745

Reference: Ms Tania Van Leeve
E-mail: tania.vanleeve@wits.ac.za

12 October 2009
Person No: 386953
PAG

Miss MT Machisa
Randburg Clinic School
Unit M29
51 Milner Street
Kensington
2194
South Africa

Dear Miss Machisa

Master of Science in Medicine (Epidemiology & Biostatistics): Approval of Title

We have pleasure in advising that your proposal entitled "*An investigation of the association between household biomass fuel smoke exposure and stunting in children aged 12-59 months in Swaziland during the 2006-7 Swaziland demographic and health survey period*" has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences