

**Socioeconomic status (SES), food insecurity and the Double Burden of
Malnutrition within South African households**

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DECLARATION PAGE

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THESIS ABSTRACT

The co-existence of under- and over-nutrition, termed the double burden of malnutrition (DBM), is associated with a high prevalence of both communicable and non-communicable diseases and is becoming a large public health concern. In general, DBM development is associated with populations undergoing a nutrition transition and urbanisation. DBM can exist at a population, household or individual level. The household form is particularly difficult to target with interventions, because households, and particularly mother-child pairs, are often consuming the same foods. For example, frequent consumption of energy dense and nutrient poor ('junk') foods can concurrently result in overweight adults, but underweight children. Although, household DBM is linked with poverty and food insecurity and its prevalence is steadfastly increasing it is yet to be investigated in South Africa, despite this country being one of the most inequitable in the world. In addition, South Africa has a high prevalence of obesity (34% of adult females obese), undernutrition (9% of children underweight) and poverty (25% unemployment). with a high prevalence of poverty and food insecurity. Therefore, this study aims to estimate the prevalence, and examine the associated factors of DBM, in South African households. Using the nationally representative data from 2014, South Africa National Income Dynamic Survey wave 4, , the prevalence of household DBM pairs (overweight/obese mother and underweight/stunted child) was estimated. Multivariate logistic regression was applied to examine the relationship between mother-child DBM pairs and (i) socioeconomic status (per capita household income, number of household residents, and mother's race, education, marital status, household head status), (ii) food security (per capita food expenditure), and (iii) potentially important confounders (mother's age and urban/rural household). The regression was adjusted for mother's age as a potential confounder. Mother-child DBM prevalence was 11% in this nationally representative sample of South Africa. Mother's characteristics of being African (adjusted odds [aOR]: 1.3; 95% confidence intervals [95%CI]: 1.0-1.7) and married (aOR: 1.4, 95%CI: 1.1-1.6) were associated with increased odds of DBM. In contrast mother's having tertiary education (aOR: 0.7, 95%CI: 0.5-1.0) and greater household per capita income (aOR: 0.9, 95%CI: 0.8-1.0) were protective against DBM. This South African household DBM prevalence is higher than most other developing countries and is associated with mother's being African, married and having less education; as well as households with less per capita

income. This high prevalence warrants urgent attention by policy makers to further investigate this issue in South Africa. Moreover, interventions such as Brazil's "Green my Favela" should be considered to reduce the cost and increase the supply of nutritious foods to impoverishes households of South Africa.

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PART 1: PROTOCOL

1.1 Background

The double burden of malnutrition (DBM) is the coexistence of under- and overweight at a population, household or individual level (Abdullah, 2015). At the household level, DBM can simply indicate that at least one overweight and one underweight household member are cohabiting (Abdullah, 2015). However, in developing countries, household DBM is more generally characterised by an underweight child and overweight mother combination (Abdullah, 2015). Of the countries that have estimated prevalence for household DBM, Brazil has the highest proportion (11%) (Shrimpton and Rokx, 2012) and Sub-Saharan African have some of the lowest measured (<5%) (Wojcicki, 2014). However, South Africa was not one of the Sub-Saharan African countries in this report (Abdullah, 2015), and there are no known estimates for the country's household DBM prevalence. However, based on South Africa's high rates of both underweight/stunted children and overweight adults - in particular women – one would assume that the rates are higher than in other Sub-Saharan countries (Mayosi *et al.*, 2012).

Importantly, when one uses the terms “underweight” and “overweight”, these descriptions of malnutrition are generally referring to body mass index (BMI) measurements (Jones *et al.*, 2013). BMI is measured by dividing one's weight (in kilograms) by one's height (in m), squared. According to the World Health Organisation (WHO), adults with a BMI below 18 are classified as “underweight” and adults with a BMI greater than 30kg/m² are “overweight”. In children under the age of 5, the WHO has norms for BMI depending on age, height and weight. Children who are more than two standard deviations below and above these norms are classified under- and overweight, respectively. Other researchers have shown that mid-upper arm circumference (Mazicioğlu *et al.*, 2010) or triceps skinfold thickness (Sardinha *et al.*, 1999) to be sensitive measures of children's weight status. However, both of these measures have been shown to have low sensitivity at certain age groups, which may differ by gender (Sardinha *et al.*, 1999; Mazicioğlu *et al.*, 2010).

While the causes of household DBM are multifactorial, many theories refer to food insecurity as an important factor – particularly in under-resourced settings, such as South Africa (Mayosi *et al.*, 2012). Food insecurity is defined as ‘limited or uncertain availability of nutritionally adequate and safe foods, or limited or uncertain ability to

acquire acceptable foods in socially acceptable ways' (Gulliford, 2003). Food insecurity is a problem for the majority of South Africans (Frayne *et al.*, 2010). For example, 80% of South Africans living in Cape Town households are rated as food insecure, which is higher than the continent average (78%) (Frayne *et al.*, 2010). In South Africa, food insecurity is also associated with socioeconomic status (SES), in that it is mainly the poorest households that experience this phenomenon (Koch, 2011). South Africa is a one of the most inequitable countries in the world and this inequity manifests in health and health care (John E Ataguba, Akazili and McIntyre, 2011). In addition, about 50% of South Africa's population live below the poverty line (\$2 per day) (Frayne *et al.*, 2010). Some experts (Shrimpton and Rokx, 2012; Abdullah, 2015) believe that the consumption of energy-dense, but nutritionally deficient foods in these under-resourced settings gives rise to household DBM. While the developing child's needs are not being met by the nutritionally deficient food, this same food is simultaneously exceeding the sedentary mother's nutritional needs (Shrimpton and Rokx, 2012; Abdullah, 2015). This proposed series of events could lead to an underweight child and overweight mother under the same living conditions.

In addition, both under- and overweight are associated with many acute and chronic health issues (Kimani-Murage *et al.*, 2011; Abdullah, 2015; World Health Organization, 2015). If underweight children survive early life, they tend to be less resistant to disease and less productive at school and physical pursuits than their better-nourished peers (Shrimpton and Rokx, 2012). In South African low SES settings, the high living densities, coupled with very high prevalence of infectious diseases place these already disease-susceptible children at even greater risk (Kimani-Murage *et al.*, 2011). In comparison to their better-nourished peers, these undernourished children are also at increased risk of becoming overweight as adults (Shrimpton and Rokx, 2012). Overweight and obesity in adults is associated with elevated risk of non-communicable diseases (for e.g. hypertension, cancer, diabetes), which are responsible for the majority of global deaths (Shrimpton and Rokx, 2012). While there are numerous interventions aimed at either child underweight and adult overweight, there are few that target both issues simultaneously (Shrimpton and Rokx, 2012). Such an intervention would be necessary to combat household DBM in South Africa. Thus, it is important to understand the prevalence of household DBM, but also the underlying factors associated with this household DBM.

1.2. Problem statement/study rationale

DBM is said to affect almost every country, regardless of their wealth (FAO/WHO, 1992; Shrimpton and Rokx, 2012). However, DBM is also associated with the “nutrition transition” - a dietary shift during the transition from famine to affluence (Steyn and Mchiza, 2014; Abdullah, 2015). Thus, these improving economic conditions, necessary for this nutrition transition to occur, are more likely to occur in developing, than developed, countries. The potential burden of DBM is large for two reasons: (1) many developing countries are currently experiencing a “nutrition transition” as a result of improving economic conditions globally, and (2) the effects of DBM are long-lasting as they are noticeable throughout one’s life-course (Shrimpton and Rokx, 2012; Abdullah, 2015).

With its unique history, South Africa presents a particularly risky environment for the development of DBM. Not only is it a developing country experiencing a nutrition transition with increased amounts of dietary saturated fats (Steyn and Mchiza, 2014; Kimani-Murage *et al.*, 2015), but it is also still dealing with the effects of Apartheid (Mayosi *et al.*, 2012). In 2009, South Africa’s population was ranked 158 out of 176 countries (90th worst percentile) for average life expectancy (Koch, 2011). Although numerous recent interventions have improved the healthcare landscape of South Africa with respect to infectious diseases, many non-communicable disease risk factors are still rising rapidly (Shrimpton and Rokx, 2012). This has resulted in South Africa’s having high rates of both underweight children and overweight adults (Kimani-Murage *et al.*, 2011). Of further concern, DBM itself has been suggested to increase the prevalence of non-communicable diseases as the young under-weight individuals are at greater risk of becoming overweight as adults (Kimani-Murage *et al.*, 2011; Shrimpton and Rokx, 2012; Abdullah, 2015).

Although studies in South Africa have investigated the determinants of under- and overweight – these outcomes have only been examined separately (Kimani-Murage *et al.*, 2011). Until household DBM is examined as one condition, it will be difficult to design an effective intervention to reduce it (Shrimpton and Rokx, 2012). Despite South Africa representing a highly risky environment for DBM, no study has yet investigated the prevalence of household DBM.

1.3 Literature Review

There is substantial literature agreement that a country experiencing a nutrition transition is at risk of developing a population with the double burden of malnutrition (DBM) (Kimani-Murage *et al.*, 2011; Shrimpton and Rokx, 2012; Steyn and Mchiza, 2014; Abdullah, 2015). Broadly, a nutrition transition occurs when improving economic conditions are associated with a reduction in famine conditions at a population/community level (Steyn and Mchiza, 2014). Concurrently, diet shifts from unrefined foods to animal proteins, saturated fat and refined sugar (Steyn and Mchiza, 2014). These changes place the population at risk of becoming overweight/obese (Steyn and Mchiza, 2014). It has been noted that South Africa is indeed undergoing a particularly rapid nutrition transition and this is confirmed with high rates of obesity (Kimani-Murage *et al.*, 2011; Steyn and Mchiza, 2014). In addition, South Africa's apartheid past is linked to general poor health in the black population, including very high levels of HIV/AIDS. This is evident in high rates of underweight, particularly in South African children (Kimani-Murage *et al.*, 2011). Although it hasn't been described, these high rates of both under- and over-weight would mean that South Africa might have a high rate of DBM at a population level (Kimani-Murage *et al.*, 2011).

Indeed, population level DBM has been described as a ratio of underweight to overweight people in that population (Abdullah, 2015). The most commonly used metric of over- and underweight is BMI, as described previously. While the population ratio of overweight to underweight is useful for a general population perspective, it continues to dichotomise these two extremes of malnutrition. Thus, a more useful measure of DBM, particularly for the development of an intervention, would be at a household or individual level (Shrimpton and Rokx, 2012).

Household DBM is the coexistence of both underweight and overweight members living under the same roof (Abdullah, 2015). At a household level, DBM has generally been described dichotomously – as being present or absent (Shrimpton and Rokx, 2012; Roemling and Qaim, 2013). For example, some have described DBM as existing simply if one household member is underweight and one is overweight (Doak *et al.*, 2005). Others have focused on the most common form of household DBM - the combination of an overweight mother and underweight child (Garrett and Ruel, 2003; Abdullah,

2015). In contrast, a recent study of Indonesian households made use of a continuous outcome for classifying household DBM (Roemling and Qaim, 2013). In order to create this continuous outcome, the BMIs of the household members were entered into a formula known as the Theil index (Roemling and Qaim, 2013). However, these authors mainly found this continuous variable to be useful in describing changes in DBM over time.

In contrast, individual level DBM is generally measured over a lifetime: for example an underweight baby that develops into an overweight adult (Abdullah, 2015). Other forms of individual DBM have been described, but these require the measurement of nutrition status, rather than just a proxy, such as BMI (Shrimpton and Rokx, 2012; Jones *et al.*, 2013). For example, the same individual could be overweight with a diet deficient in micronutrients (Abdullah, 2015). However, as implied, these measures of malnutrition require highly detailed diet assessments over a long period of time, making them difficult to study at a national level (Jones *et al.*, 2013).

Regardless of the level of DBM, most reviews of developing countries, and South Africa specifically (Abdullah, 2015), identify the consumption of energy dense/nutrient poor food and a concurrent lack of physical activity as important contributors. In South Africa, it has been reported that more than a quarter of one's diet was comprised of fat, sugar and alcohol (Food and Agriculture Organization (FAO), 2006). This was higher than other countries experiencing a nutrition transition such as China, Mexico, Egypt and the Philippines (Food and Agriculture Organization (FAO), 2006). To target DBM, Abdullah suggests that interventions should focus on the first 1000 days of life (from conception) (Abdullah, 2015). In contrast, the FAO's review of South Africa DBM suggest focusing on addressing unhealthy behaviours, such as the consumption of energy-dense/nutrient-poor foods (Food and Agriculture Organization (FAO), 2006). The former strategy could be seen to be targeting individual-level DBM as it aims to prevent a low birth weight baby, and the negative cycle that develops thereafter into adulthood (Figure 1). The latter strategy is more of an immediate intervention that attempts to address household DBM in both the underweight child and overweight mother.

However, a recent study from Brazil - a developing country similarly to South Africa – concluded that household DBM was associated with the household's food security (Gubert *et al.*, 2017). This is not surprising, given that the FAO recognises food insecurity as a root cause of malnutrition (FAO, IFAD and WFP., 2015). Food insecurity has been defined as 'limited or uncertain availability of nutritionally adequate and safe foods, or limited or uncertain ability to acquire acceptable foods in socially acceptable ways' (Gulliford, 2003). As such, this definition includes a broad range of issues relating to food: from micro- to macronutrients. Food insecurity is critically important and is linked to most aspects of life (Jones *et al.*, 2013). In South Africa, food insecurity is highly correlated with poverty and low socioeconomic status (SES) in South Africa (Frayne *et al.*, 2010). Thus, it is plausible that in South Africa household DBM is associated with both SES and food security. Despite this theoretical link, these factors – food insecurity and SES - are yet to be investigated for their relationship with household DBM in South Africa. Indeed, the prevalence of DBM in South African households is yet to be described, let alone the factors associated with it.

1.4 Research aim

The primary aim of this study is to explore the relationship between socioeconomic status, food security and the double burden of malnutrition, in a representative sample of South African households in 2014-2015.

1.4.1 Specific Objectives

1. Estimate the prevalence of DBM in South African households
2. Examine the link between SES and food security in DBM in South African households

1.5 Conceptual framework

1.5.1 Study conceptual framework

The DBM conceptual framework (Figure 1) was developed by the World Health Organisation (WHO) and separates the phenomenon's determinants into three categories: basic, underlying and immediate (World Health Organization, 2015). Basic causes refer to the broader issues included social, economical and political contexts, which are difficult to modify. The underlying determinants stem from the household's

socioeconomic status (SES), which could be described by many factors including the household’s asset index and location (urban/rural); and the household head’s income/education/employment status. Low SES is then related to a sedentary lifestyle, insufficient access to health foods, inadequate care (such as breastfeeding) and a generally unhealthy environment (running water and sanitation, and access to good quality health services). These underlying factors contribute to the “immediate household causes” of DBM. The combination of physical inactivity, poor diet (quality and/or quantity) and disease together contribute to household DBM with an overweight mother and underweight child.

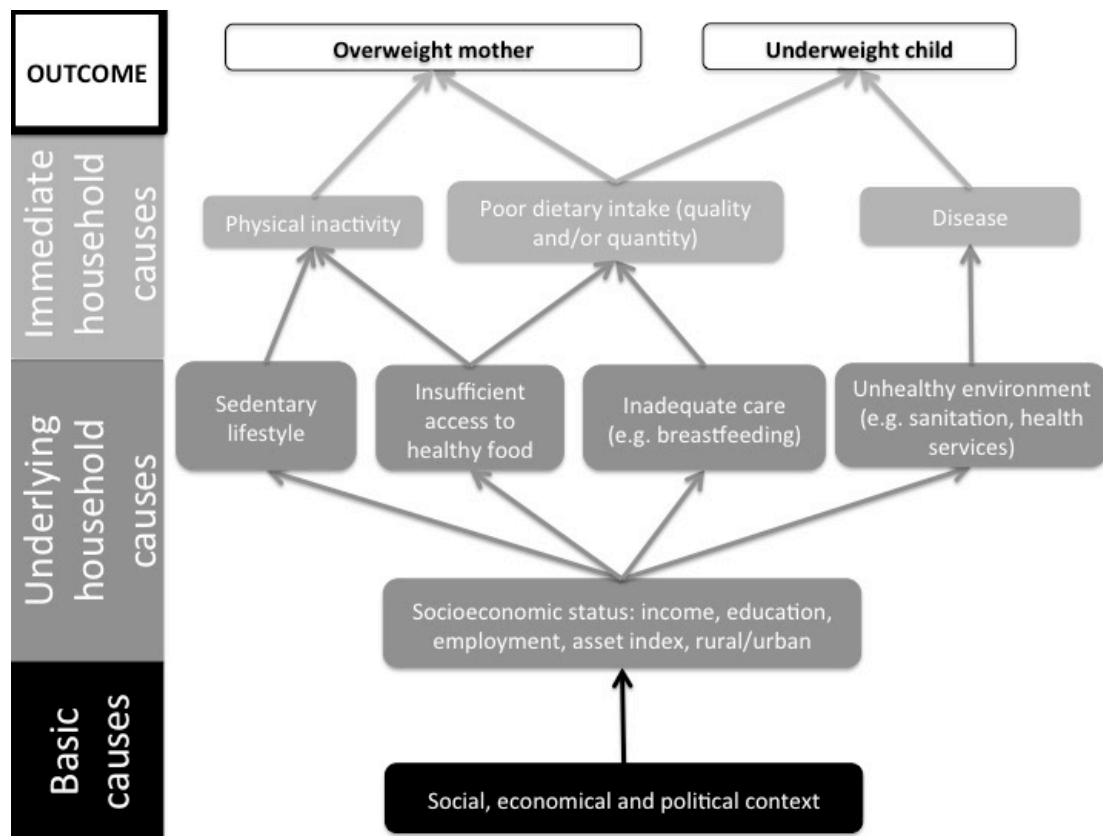


Figure 1.1. Based on the conceptual framework of double burden of malnutrition (DBM) (World Health Organization, 2015).

1.6. Methodology

1.6.1 Dataset

This study will make use of Wave 4 of the National Income Dynamics Study (NIDS) to answer this research question. NIDS is a South African government-led initiative to investigate poverty in the country (Chinhema *et al.*, 2016). Importantly, it includes a nationally representative sample of households of South Africa. NIDS ensured this with a two-stage cluster sample design to decide on households included in Wave 1 (Chinhema *et al.*, 2016). NIDS randomly selected 400 primary sampling units (PSUs) from StatsSA's Master Sample of 3000 PSUs. The randomisation was performed within strata, which were representative of South Africa's 53 district councils.

The study was developed by the South African Labour and Development Unit (SALDRU), based at the University of Cape Town. NIDS is actually a panel (longitudinal) design study, which began in 2008 with wave (panel). The 4000 PSUs this initial wave included 28,000 individuals in 7,300 households. For this study, we will only be using one wave (Wave 4) and thus the design will be cross-sectional.

For each wave, up to four different questionnaires might be administered per household on a once-off occasion:

1. *Household questionnaire* – completed by the oldest female or whomever is most knowledgeable about the household's affairs, and in particular spending.
2. *Adult questionnaire* – all household members over the age of 15 years.
3. *Proxy questionnaire* – completed by an adult on behalf of another adult household member who was unavailable at the time of the researcher's visit.
4. *Child questionnaire* – completed by the child's caregiver and focuses on the child's educational history, education, anthropometrics and access to grants.

For children younger than 14 years of age, the mother, caregiver or household head answered the questionnaire on their behalf. Since 2008, these households have been followed-up biennially. Including the most recent wave 4, the NIDS dataset includes 42,337 individuals (adults and children) from 11,895 households.

1.6.2 Variables

1.6.2.1 Dependent (outcome) variable

1.6.2.1.1 Measurement of underweight child

In the NIDS dataset, a child is defined as being between the ages of 0 and 14 years of age. Stunting will be used as the proxy of underweight for these children. Stunting will be defined using height/length for age z-scores (HAZ), which are calculated in the NIDS dataset. Any child below two standard deviations for their age, will be classified as “stunted”. Thus, this will be a binary variable as either “stunted” (=1) or not stunted/healthy (=0).

1.6.2.1.2 Measurement of overweight mother

The mother’s weight status will be defined according to body mass index (BMI) cut-points suggested by the WHO (Table 1). These cut-points are specific for those older than 19 years of age.

Table 1.1. World Health Organization (WHO) body mass index (BMI) cut-points for different weight categories.

WHO classification	BMI cut-point in (kg/m²)
Underweight	< 18.5
Normal range	18.5 – 24.9
Overweight	≥ 25.0 – 29.9
Obese	≥ 30.0

Should the mother be younger than 20 years or age, Center for Disease Control criteria for overweight and obesity will be used (Table 2).

Table 1.2. Center for Disease Control (CDC) criteria for weight categories for ages 2-19 years of age.

CDC classification	BMI cut-point in (kg/m²)
Underweight	< 5 th percentile
Normal range	> 5 th - 85 th percentile
Overweight	85-95 th percentile
Obese	> 95 th percentile

This measure still uses BMI, but compares it with age- and gender-related norms using standard curves. In contrast to children, BMI cut-points for adults are age- and gender-independent. For the purposes of this investigation, overweight/obese mothers will be a binary variable: they will either be classified as overweight/obese (=1) or not (=0).

1.6.2.1.3 Measurement of household Double Burden of Malnutrition

Household DBM has been defined as the concurrent presence of at least one underweight and one overweight individual under the same roof (Abdullah, 2015). However, the combination of an underweight child and overweight mother pair has been identified as particularly problematic phenomenon in developing countries such as South Africa (Abdullah, 2015). Thus, for the purposes of this study, we will be focusing on this household DBM represented by a mother-child pairing.

1.6.2.2 *Independent variables*

1.6.2.2.1 Measurement of food insecurity

In the NIDS questionnaire, the eldest household female was sequentially asked about whether they had consumed a particular food item - for example, pasta – and the associated monetary value that was spent on this food item. This was repeated for 32 food categories (including ‘pasta’). According to Jones et al. (Jones *et al.*, 2013), this would be classified as a “Household consumption and expenditure survey”.

This measure can be used for two calculations: (i) total household expenditure on food, and (2) household dietary diversity score (HDDS). The former measure is criticised as it might be influenced by households who go through periods of stockpiling food. However, this is more of a problem when assessing the longitudinal changes in household food security. For the purposes of the present study, it should at least provide a global measure of food expenditure, which could also be presented as a proportion of household income.

For the HDDS, these 32 foods can be grouped into 12 categories: 1. cereals, 2. meats, 3. oils&fats, 4.fish&other seafood, 5.legumes, nuts and seeds, 6. Milk and milk products, 7. White tubers and roots, 8. sweets, 9. Eggs, 10. Spices, condiments and beverages, 11. Fruit, and 12. Vegetables. Once grouped as such, the household can be

scored from 0 to 12, depending on the foods the purchase in the past month. Although there are no recommended cut-points for dietary diversity, a recommendation is to split the sample into tertiles or quartiles (Frayne *et al.*, 2010; Jones *et al.*, 2013). Alternatively, the households HDDS could also be compared between income quintiles (Jones *et al.*, 2013).

Both food expenditure and this derived HDDS will be used as a continuous measure of food security.

1.6.2.2.2 Measurement of household socioeconomic status (SES)

Based on recent studies in LMICs, we have opted to examine SES proxies, such as asset indices, employment status, household income and area of residence (Alaba and Chola, 2013).

For asset index, a continuous variable will be created based on the following assets:

1. Type of housing, including materials of roof and walls,
2. Water and sanitation access, including proximity/convenience of safe drinking water, toilet, and source of energy for lights.
3. Ownership of various objects such as television and cable network, radios, cars and cellphones.

For household income, NIDS has a derived income score that is appropriate for South Africa. The employment status (employed/unemployed) of the household head will be also be examined. Finally, the household's area of residence (urban/rural) will also be considered.

1.6.3 Data analysis

As recommended by SALDRU, this NIDS data will be analysed using Stata (Stata Corp. Inc., College Station, Texas, USA). Initially the data will be checked against the most recent records to ensure the household and individual numbers match up with those published by NIDS (Chinhema *et al.*, 2016). All variables will be analysed at a household level.

1.6.3.1 Model Specification

The outcome/dependent variable is DBM and it will be expressed as a binary variable. Although household DBM can have many interpretations, for the purposes of this study it will be specifically the concurrent presence of an underweight (stunted) child with an overweight/obese mother. This variable will be a binary variable reflecting either the presence or absence of DBM.

The main explanatory/independent variables will be food security (binary variable) and SES. Food security will be calculated using food variety (0-32 point scale) and food expenditure. From these two measures, a weighted mean will be used to convert these two measures into a binary variable of food insecurity or security.

Other potential confounders will also be included in the analysis. The most important potential confounders of this relationship, based on previous research on DBM in developing countries is income (Abdullah, 2015). Whether the household is in an urban or rural area might be an important confounder of this relationship and will therefore be added to the analyses. Moreover, the age of mother when she gave birth to the child is important for DBM (Shrimpton and Rokx, 2012; Abdullah, 2015). Thus, this continuous variable will be derived from the age of the child subtracted from the age of the mother.

1.6.3.2 Statistical analysis

Simple frequencies will be calculated to assess the prevalence of DBM households in South Africa. For the secondary aim, a logistic regression will be used to assess if SES and food security are determinants of household DBM. Once it has been established if aforementioned confounders (age of mother, urban/rural area) are assessed for relevance, they will be added to the logistic regression.

1.7. Research limitations

Although the proposed dataset, NIDS, is a panel dataset, the analyses will be cross-sectional in nature. Therefore, relationships that are discovered could only be ascribed as associations, not causal. However, this cross-sectional study is an important first step if one is to elucidate a causal pathway. In addition, the use of stunting as a proxy of

malnourishment could be criticised due to the fact that other factors (such as genetics) could be the cause of stunting.

1.8. Ethical considerations

This study proposes to use depersonalised, secondary data - the NIDS open access data. As such, there are minimal to no chance of risks to the participant.

1.9. References

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PART 2: LITERATURE REVIEW

This literature review consists of three main sections: a theoretical review (2.1), a methodological review (2.2) and an empirical review (2.3). The theoretical review examines the main concepts of this thesis – the double burden of malnutrition (DBM), socioeconomic status (SES) and food security from a theoretical perspective, while the methodological section looks at methods used to describe these concepts and finally the empirical section presents a structured review of these concepts.

2.1 Theoretical review

This theoretical review examines the double burden of malnutrition (DBM) from a number of angles. Firstly, the development of this concept of DBM in extant literature is examined (2.1.1 – 2.1.2), followed by a focus upon a specific form of DBM – household DBM (2.1.3). Finally, the link between household DBM, food security and socioeconomic status (SES) is described (2.1.5 – 2.1.6).

2.1.1 Theories of Double Burden of Malnutrition (DBM)

Although malnutrition is commonly thought to refer to undernutrition only, it actually refers to both under- and over-nutrition (Shrimpton and Rokx, 2012). The Double Burden of Malnutrition emerged as a concept for the first time at the 1992 International Conference of Nutrition, which was co-hosted by the FAO and WHO (FAO/WHO, 1992). Although the term “double burden of malnutrition” has taken on various meanings of late, an overarching definition is “undernutrition, including micronutrient deficiencies, coexisting with overnutrition: overweight and obesity” (Shrimpton and Rokx, 2012). According to the World Health Organisation (WHO) (World Health Organization, no date): “*The double burden of malnutrition is characterised by the coexistence of undernutrition along with overweight and obesity, or diet-related noncommunicable diseases, within individuals, households and populations, and across the lifecourse.*” Some authors also refer to this concept as the “dual burden of malnutrition”.

DBM is commonly associated with countries experiencing high levels of nutrition transition (Doak *et al.*, 2005; Shrimpton and Rokx, 2012; Abdullah, 2015). Nutrition transition occurs when economic conditions improve, allowing a shift from famine-type conditions to those of less famine (Steyn and Mchiza, 2014). This shift is generally associated with less physical activity and a move towards “junk food”, which is energy-dense, but nutrient-deficient

(Shrimpton and Rokx, 2012; Steyn and Mchiza, 2014; Abdullah, 2015). In general, this diet includes less unrefined food, high in saturated fats and animal proteins and sugar (Shrimpton and Rokx, 2012).

2.1.2 Levels of DBM

DBM can be described at any of the following levels: (i) population (or community), (ii) household, or (iii) individual (Shrimpton and Rokx, 2012; Abdullah, 2015). Population DBM is described by comparing the prevalence of underweight to overweight individuals within the same population. Household DBM is the co-existence of both underweight *and* overweight individuals living together under the same roof. Finally, individual-level DBM is when an overweight/obese individual has micronutrient deficiencies or stunting {Abdullah:2015fa}. It should be noted that one can also describe different levels of DBM that are said to exist “across the life-course”. An example of this at the individual level could be when an overweight/obese adult was an underweight child (Shrimpton and Rokx, 2012; Abdullah, 2015).

2.1.3 Household DBM - SCOWT

Of all the levels of DBM, household poses a particular challenge for intervention development due to the requirement to achieve two different aims – weight gain and reduction - within the same house (Garrett and Ruel, 2003; Doak *et al.*, 2005; Food and Agriculture Organization (FAO), 2006; Shrimpton and Rokx, 2012). The implication is that previous interventions that are aimed at households, actually need to be re-aimed at the individuals within households (Garrett and Ruel, 2003). It has been hypothesised that this level of DBM results from households undergoing a nutrition transition and, as result, becoming more sedentary and purchasing more energy-dense/nutrient-poor foods (Kimani-Murage *et al.*, 2011; Shrimpton and Rokx, 2012; Steyn and Mchiza, 2014; Abdullah, 2015). This nutrient-deficient diet simultaneously results in weight gain in adults, but stunting or another form of undernutrition in the developing child (Shrimpton and Rokx, 2012; Abdullah, 2015).

Moreover, within the household level DBM, the specific DBM combination within mother-child pairs has been recognised as a specific intervention issue (Jehn and Brewis, 2009; Wojcicki, 2014; Abdullah, 2015). Indeed ‘stunted child and overweight mother’ (SCOWT) has been further identified as a distinct phenomenon, and emerging policy concern (Garrett and Ruel, 2003; Abdullah, 2015). This SCOWT phenomenon appears to be a particular concern in

developing countries (Garrett and Ruel, 2003; Abdullah, 2015). Although the “S” of “SCOWT” refers to stunting in the child, it has also been taken to refer to undernutrition in the broader sense including underweight, wasting or nutrient deficiency (Jehn and Brewis, 2009; Wojcicki, 2014) .

2.1.4 Criticisms of household DBM

However, there are authors who have argued against the observation of SCOWT pairs as a distinct entity. Specifically, Dieffenbach and Stein showed that SCOWT is largely dependent on maternal overweight, as opposed to child stunting (Dieffenbach and Stein, 2012). As a result, these authors argue that there is no need for interventions to be designed specifically for SCOWT households. Instead, they argue that interventions should rather continue to focus on the underlying drivers of SCOWT - child stunting and maternal overweight/obesity (Dieffenbach and Stein, 2012). However, this is in contrast to the policy statement of the World Bank (Shrimpton and Rokx, 2012), which states:

“The solutions for the DBM problems are reasonably well recognized for each of its parts: undernutrition and overnutrition. But the solutions have not been coordinated into an overarching policy and program framework”.

Moreover, this argument of Dieffenbach and Stein (Dieffenbach and Stein, 2012) ignores a practical consideration of intervention implementation (Glasgow *et al.*, 2001). For example, if the intervention target is the household, and the risk factors for child stunting and maternal overweight/obesity pairs are different (Kimani-Murage *et al.*, 2011), then this would pose a practical challenge for a single intervention to solve diverse risk factors in these separate groups. However, if the risk factors in the pairs are largely similar, as suggested by experts in this area (Shrimpton and Rokx, 2012; Abdullah, 2015), this implementation issue is irrelevant. Unfortunately, as the specific underlying drivers of SCOWT and household DBM are often context-specific, one first needs to investigate a setting before this becomes clear (Doak *et al.*, 2005). Moreover, experts have warned of obesity interventions inadvertently causing harm to underweight children that exist within the same household (Doak *et al.*, 2005).

2.1.5 Link between household DBM and food security and socioeconomic status (SES)

Food security is a broad concept, but was defined at the 1996 World Food Summit as follows (Jones *et al.*, 2013):

“Food security, at the individual, household, national, regional and global levels [is achieved] when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.”

Thus, the link with food security and DBM, is theoretically plausible. As stated previously, it is theorised that DBM households shift towards nutrient-deficient foods during their nutrition transition (Shrimpton and Rokx, 2012; Steyn and Mchiza, 2014). This nutrient-deficiency is, in fact, a form of ‘nutrition insecurity’, a broader form of food insecurity (Jones *et al.*, 2013). Food insecurity has been independently associated with obesity in women (Ivers and Cullen, 2011); and with stunting in children (Steyn *et al.*, 2006). Also, food security has been identified as a key policy target for reducing DBM in, especially, Low-to-Middle Income Countries (LMICs) (Shrimpton and Rokx, 2012). Indeed, the policy document of the World Bank acknowledged that DBM can’t be tackled without high-level budget policies specifically focused on food security (Shrimpton and Rokx, 2012).

Moreover, there is a theoretical association between DBM and socioeconomic status (SES). This theoretical link exists as the underlying components of DBM – undernutrition and overnutrition – are separately associated with SES. For example, undernutrition has frequently been associated with low SES (Mayosi *et al.*, 2012; Abdullah, 2015; Kimani-Murage *et al.*, 2015; Vorster, 2015). Interestingly, overnutrition has been associated with both low and high SES in various settings (Micklesfield *et al.*, 2013; Ng *et al.*, 2014; Abdullah, 2015). Thus, the link with population-level DBM and SES is obvious. Similarly, the links with SES and household DBM – the combination of under- and overnutrition in the same household - and individual-level DBM – an overweight individual with nutrient deficiency - is also theoretically plausible.

2.1.6 Conceptual Framework - food security, SES and household DBM

The United Nations International Children’s Emergency Fund (UNICEF) group are credited with development of the original conceptual framework describing malnutrition in 1991, which would now be more accurately referred to as undernutrition (Black *et al.*, 2008). This framework groups underlying causes of undernutrition into basic (e.g. access to land/water), underlying (e.g. income poverty) and immediate (e.g. inadequate dietary intake) (Black *et al.*, 2008). For their strategic action plan to reduce DBM in South-East Asia, the WHO and UNICEF applied the original UNICEF 1991 to DBM (Figure 2.1) (World Health Organization, 2015). Thus, instead of “malnutrition” or undernutrition, this updated conceptual framework had both overnutrition and maternal/child undernutrition as the outcome (World Health Organization, 2015). This framework used the same three groups of underlying causes, but some were focused at specific levels. For example, the basic causes (e.g. access to natural capital such as land) were specific to the societal level and the underlying cause were specific at a household/family level (World Health Organization, 2015).

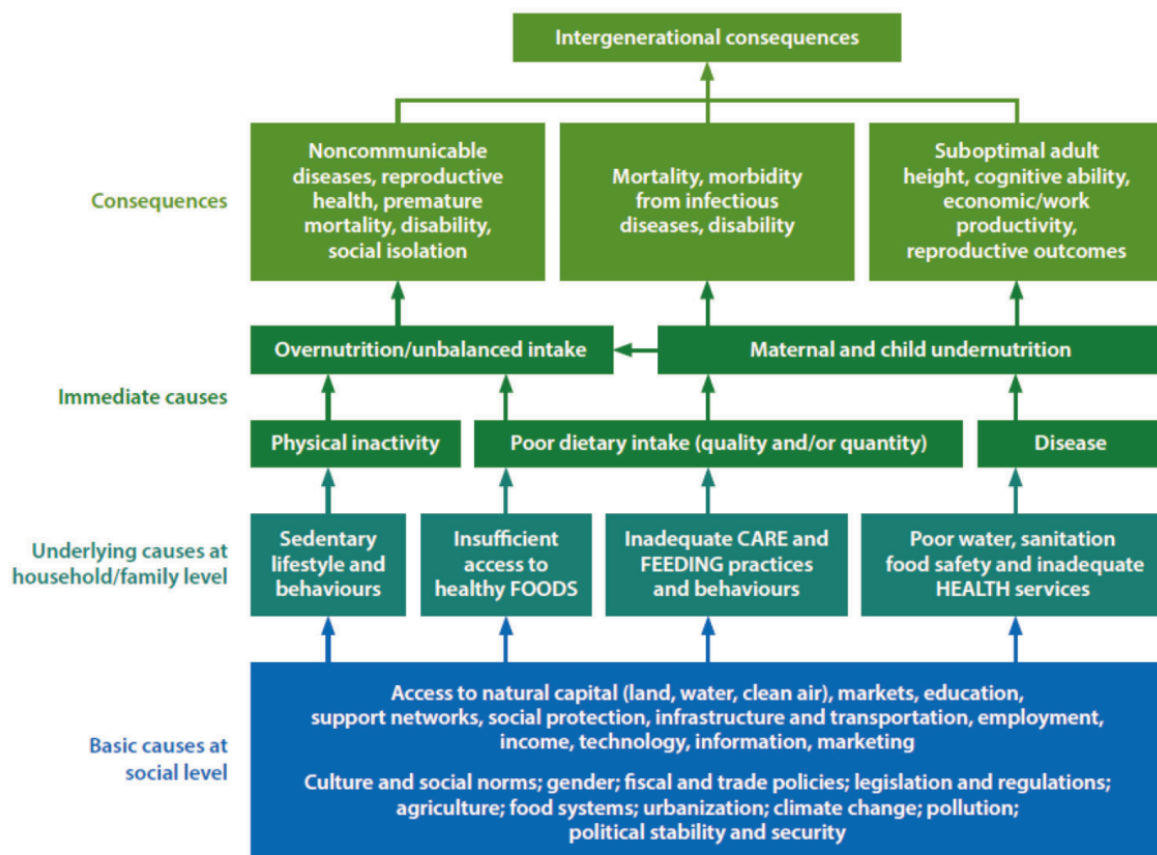


Figure 2.1. WHO/UNICEF conceptual model for Double Burden of Malnutrition (DBM) (World Health Organization, 2015).

This WHO/UNICEF DBM conceptual framework was adapted in Figure 2.2 (World Health Organization, 2015). In this adaptation of the original model, it is proposed that the social/economical/political context of the country determines the SES, which is then related to three major immediate household causes of DBM: physical inactivity, poor dietary intake (proxy of food security) and disease.

Thus, within the same household these co-existing determinants can result in an overweight mother and underweight child simultaneously.

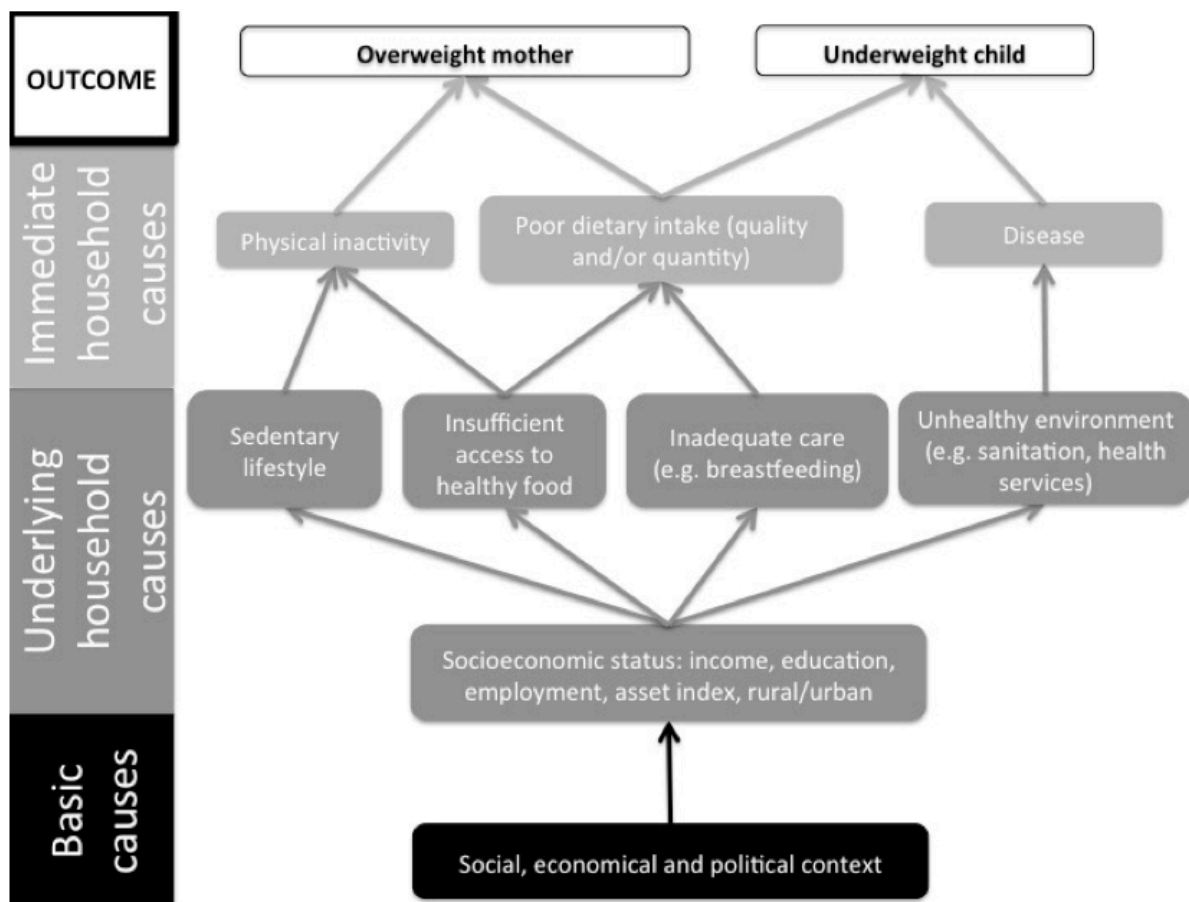


Figure 2.2. Conceptual framework for household double burden of malnutrition (DBM), based on the model proposed by the WHO (World Health Organization, 2015).

2.2 Methodological review

This methodological review section describes some of the main methods used to study the three variables of interest to this thesis: DBM, SES and food security at the household level.

2.2.1 Methods to assess household DBM

The most specific measure of nutritional status is micronutrient status (Ashworth, 2016). In particular, the measurement of Vitamin A, Iodine, Iron and Zinc levels are reported to be the

most important from a public health point of view. Although assessing micronutrient status is necessary for understanding the mechanism of under- or overweight, their invasiveness and requirement for large resources (time and money) make them unsuitable for large sample studies. Furthermore, for studies attempting to describe population prevalence, macronutrient assessments of nutrient status suffice (Svedberg, 2011).

Thus, at a macronutrient level, the three most widely adopted methods for assessing malnutrition are: (i) self-reported hunger, (ii) food supplies estimates, and (iii) anthropometrics (Svedberg, 2011).

2.2.1.1 Self-reported hunger

The initial criticism with self-reported hunger stemmed from apparent inconsistencies in malnutrition studies from India. While some studies found a low prevalence of hunger, others from similar regions found high prevalence of underweight as measured with anthropometry. Further investigations revealed that the type of food being consumed was nutrient-poor and therefore sufficient for respondents to not report being hungry, despite the food being insufficient for their actual nutritional requirements (Svedberg, 2011).

2.2.1.2 Food supplies

The FAO's method of assessing food supplies, which estimates a country's food availability as the sum of a country's food production and net food imports. By this method, the FAO have declared that there is sufficient food for the entire world (Hall, 2012). Indeed, in 2009 the FAO's Food Balance sheet indicate that the world had 2900 calories available to each person, daily (Hall, 2012). However, this method has been criticised for two main reasons – (i) as with 'self-reported hunger', it ignores the micronutrient quality of food; and (ii) the calculations for calculating food availability are based on large assumptions that are unable to survive basic sensitivity analyses for robustness (Svedberg, 2011).

2.2.1.3 Anthropometrics

Anthropometry is almost exclusively assessed through measuring body mass index (BMI) in adults. In children, this generally takes the form of weight-for-age (underweight), height-for-age (stunting) or weight-for height measurements (Ashworth, 2016). The advantage of

anthropometrics over the preceding two measures is that it provides an idea of energy imbalance, at a glance and without the need for calorie counting. In addition, when performed on a large-scale basis, anthropometry can provide a “bird’s eye view” and identify specific targets for interventions such as a particular age, gender or geographical region. This is because the WHO has established anthropometric norms for most age groups for both BMI and children’s body measurements, such as weight- and height- for age. The major disadvantages of anthropometrics is that it doesn’t tell you *why* a person is underweight or overweight as it doesn’t consider physical activity or micronutrient intake (Svedberg, 2011; Ashworth, 2016). However, these disadvantages are not unique to anthropometry and would be a drawbacks of the preceding two measures as well. Thus, it is clear that despite these drawbacks for anthropometry, their use is certainly justified for conducting large-scale studies. Should these methods discover a particular issue, it would only then be justified to continue with a more specific measurement such as a micronutrient assessment.

In general, household DBM is described as being present if at least one member of the household is underweight and at least one is overweight, using BMI measurements. Thus, household DBM is often described as a binary outcome - as either present or absent (Shrimpton and Rokx, 2012; Abdullah, 2015). Within household DBM, the mother and child pairing is often examined as a specific phenomenon (Garrett and Ruel, 2003; Wojcicki, 2014; Abdullah, 2015). For example, some authors have coined the term SCOWT – meaning Stunted Child OverWeight mother – to describe a specific version of this phenomenon (Abdullah, 2015). However, there are also more general forms of mother-child DBM pairs that include any form of undernourishment in the child (Wojcicki, 2014). Regardless, of the specific underlying measures, household DBM is often described in dichotomous terms – as either present or not (Dieffenbach and Stein, 2012). In contrast, Roemling and Qaim developed a continuous measure to investigate household DBM using the Theil Index (Roemling and Qaim, 2013). This index is calculated by first calculating z-scores of the body mass index (BMI) of all household members. Thereafter, the Theil Index is calculated by dividing the BMI z-scores by the number of household residents. However, these authors concede that continuous measure of household DBM is better suited to longitudinal comparisons of the same households, rather than cross-sectional investigations into factors associated with DBM (Roemling and Qaim, 2013). Moreover, when considering intervention development, it is sufficient to understand whether a disease/condition is present or not.

2.2.2 *Measurement/indicators of household food security*

Household food security is a broad concept, and as such, can be measured in a number of ways (Jones *et al.*, 2013). Broadly, there are four types of measurement (Jones *et al.*, 2013):

2.2.2.1 *Household consumption and expenditure surveys (HCESs)*

These household-level questions are now being used by the FAO in preference to their former food balance sheet data, for national-level undernutrition prevalence studies (Hall, 2012). Besides this use by the FAO, HCESs are widely used for estimating household food acquisition. The major assumption underlying these surveys is that food acquisition is equal to consumption. As a result, it has been argued that these data should only be used for population-level cross-sectional prevalence estimates, as there are some households that would be over-estimated, and others than are under-estimated, by this measure. The HCESs are, therefore, not and is not suitable for longitudinal comparisons of the same households (Jones *et al.*, 2013).

2.2.2.2 *Dietary diversity*

Dietary diversity is a qualitative, rather than quantitative, measure of food consumption and represents household access to food variety. For example, a household that only purchased or ate bread would have a very low dietary diversity, even if the quantity of bread consumed was high (FAO, 2011a). As such, these measures are consistently associated with both the nutrient quality of diets and child anthropometry measurements (FAO, 2011a; Jones *et al.*, 2013). In addition, dietary diversity is associated with other proxies of household food security, such as food expenditure. However, it is also highly context-specific and might be difficult to compare across multiple cultures/contexts (Jones *et al.*, 2013).

2.2.2.3 *Participatory adaptation*

These are measures that are informed by stakeholders in specific contexts. As a result, they are highly accurate for that particular context, but they are not easily compared between contexts. Thus, they would not be suitable for a population level or national study (Jones *et al.*, 2013).

2.2.2.4 *Direct method*

These methods measure behaviour and experience-based approaches to food access using questionnaires, which may include some of the participatory adaptation described in 2.2.2.3. However, these methods also try to directly measure food security, using these techniques. As such, they are often very context-specific and not suitable for population- or national-level studies (Jones *et al.*, 2013).

Based on these relative strengths and weaknesses, it appears clear that only HCESs and Dietary Diversity measures would serve as suitable proxies of food security for our purposes – a large national level prevalence study. As we are not performing a longitudinal comparison of households, the weakness of HCECs is moot. In contrast, the suitability of Dietary Diversity will have to be carefully investigated as South Africa is comprised of a vast range of cultures (Mayosi *et al.*, 2012). If it is a good measure of food security, it should be associated with food expenditure, captured by the HCESs, to assess the suitability of this measure.

2.2.3 Measurement of household SES

The measurement of SES in health research, even when only included as a covariate, is both complex and controversial (Braveman *et al.*, 2005; John E Ataguba, Akazili and McIntyre, 2011; Howe *et al.*, 2012). As a ubiquitous measure of SES is yet to be agreed upon, there is reliance on proxies of SES (Braveman *et al.*, 2005; Mfenyana *et al.*, 2006). However, there is criticism of using a single measure to describe SES (Braveman *et al.*, 2005; Howe *et al.*, 2012). Three commonly used proxies in health research are income, occupation and education (Braveman *et al.*, 2005; Mfenyana *et al.*, 2006; Howe *et al.*, 2012). For example, some authors have published articles from the large household study data in the United States, NHANES (National Health and Nutrition Examination Survey), and claimed that their results have controlled for “SES” by including income as the covariate. However, re-analysis of these data (Braveman *et al.*, 2005) has found weak correlations between education and income. Based on these discrepancies, Braveman *et al.* argue that this study’s results would be vastly different if they used education as their SES proxy instead of income and yet there is no justification as to why income was chosen over education (Braveman *et al.*, 2005). The solution, both Howe *et al.* and Braveman *et al.*, argue is (i) to use more than one SES proxy and (ii) to try and use context-specific SES proxies, based on empirical evidence (Braveman *et al.*, 2005; Howe *et al.*, 2012).

However, in developing countries, asset indices have been widely used since their inclusion in the Demographic and Health Surveys (Wittenberg and Leibbrandt, 2017). This index is comprised of noting whether respondents are in possession of 14 different assets, for example: “Do you have a Television?”. The theory is that the more assets one has, the higher one’s SES (Wittenberg and Leibbrandt, 2017). Prior to the formalisation of this 14-item asset index, there were other health studies that used assets as an SES proxy in developing countries, just in a

less formal approach. For example, the study of general health of 4,608 poor South African households conducted in 1999 (Mfenyana *et al.*, 2006). Of all the SES proxies asked about, mother's education, clean water, access to electricity and access to refuse disposal were the most important predictors of health. Of those SES proxies, clean water and access to electricity are included in the aforementioned and now widely-used asset index (Wittenberg and Leibbrandt, 2017).

Similarly, a review of obesity in black South African women reported that education was consistently associated with obesity, although the nature of the association was study-specific (Micklesfield *et al.*, 2013). Indeed, while many South African studies found that education was positively associated with obesity in these black women, the South African Demographic and Health Survey (SADHS) found a "u-shaped" relationship in that those with no education and those with tertiary education were less likely to be obese than those with a bit of education.

In contrast, household DBM studies in developing countries consistently report that household income and urban/rural region are the most important proxies (Garrett and Ruel, 2003; Doak *et al.*, 2005; Food and Agriculture Organization (FAO), 2006; Abdullah, 2015). The link with urban/rural region is plausible given the fact that underlying theory of DBM is linked to the nutrition transition, which is more likely to occur in an urban than rural region (Shrimpton and Rokx, 2012; Steyn and Mchiza, 2014; Abdullah, 2015).

Thus, when looking at a variety of empirical sources, including literature from DBM in developing countries to more general South Africa household health, the most consistently associated SES proxy is mother's education, the area of residence (urban or rural) and household income (Garrett and Ruel, 2003; Doak *et al.*, 2005; Mfenyana *et al.*, 2006; Kimani-Murage, 2013; Micklesfield *et al.*, 2013; Abdullah, 2015). These three variables (mother's education, area of residence and household income) also have strong theoretical links with DBM in South Africa, which is important in the choice of SES proxy (Braveman *et al.*, 2005). With respect to mother's education, the underlying theoretical link with health refers to the fact that a more educated mother will, in general, have fewer risk factors for ill-health in her home and also be more responsive to health interventions (Braveman *et al.*, 2005; Mfenyana *et al.*, 2006; Micklesfield *et al.*, 2013).

2.3 Empirical review

2.3.1 Literature search strategy

This section presents a scoping review, following the structured PRISMA guidelines (Moher *et al.*, 2009). The focus of the scoping review is the double burden of malnutrition (DBM) and its association with socioeconomic status (SES) and food security. By performing this scoping review, this section aims to identify gaps in the extant literature in these aforementioned areas.

2.3.2 Inclusion/exclusion criteria

PRISMA guidelines were followed, except for that fact that only one researcher was used (Moher *et al.*, 2009). PubMed was used as a search engine, in conjunction with a snowball technique whereby the identified papers were used to cross-check for papers that were not identified with the initial PubMed search strategy.

The inclusion criteria were studies that had a measure of weight status through anthropometry including, but not limited to: BMI, BMI-for-age, weight-for-age, height-for-age and weight-for-height (including z-score transformations of these). In addition, the studies needed to have assessed food security and/or SES (or a proxy thereof). Exclusion criteria were: studies that only assessed underweight or overweight, not both; highly specific or diseased populations (for example, HIV positive adults or pregnant women) that were not comparable with general populations; those studies for which the full-text or English version of the article was not available; and case-control and review articles.

Medical subject headings (MeSH) were used for searching PubMed, unless this was not possible for a particular concept. For ‘double burden of malnutrition’, the non-MeSH phrase of ‘double burden of malnutrition’ was used in conjunction with the MeSH ‘Malnutrition’. For SES, the MeSH ‘Social Class’ was used. Although a range of phrases could have been used for food security, the MeSH ‘Food Supply’ was used after a trial-and-error approach. In terms of years of publication, the concept of the “double burden of malnutrition” seems to have been officially described for the first time in 1997, by the Food and Agricultural Organisation (Food and Agriculture Organization (FAO), 2006). Thus, publication dates were considered from as early as the 1 January 1997 to the end of December 2017 – three decades of literature. Thus, on the 5th January 2018, the following search was performed for the final time:

“(“Malnutrition”[Mesh] OR “double burden of malnutrition”[All Fields]) AND “Social Class”[Mesh] AND (“1997/01/01”[PDAT] : “2017/12/31”[PDAT])”.

Where ‘Mesh’ refers to Medical Subject Headings and ‘PDAT’ refers to the publication date.

This search produced 189 records, to which four additional records were added from the additional snowball search technique, leaving 193 records. (Figure 2.3). Of these 193 records, 157 were excluded based on these articles falling within the exclusion criteria based on the reading of the title and abstract. The full-text versions of the remaining 36 articles were then obtained. From these 36 articles, a further nine were excluded for falling within the exclusion criteria. This search strategy left a total of 27 studies that were summarised in the subsequent sections.

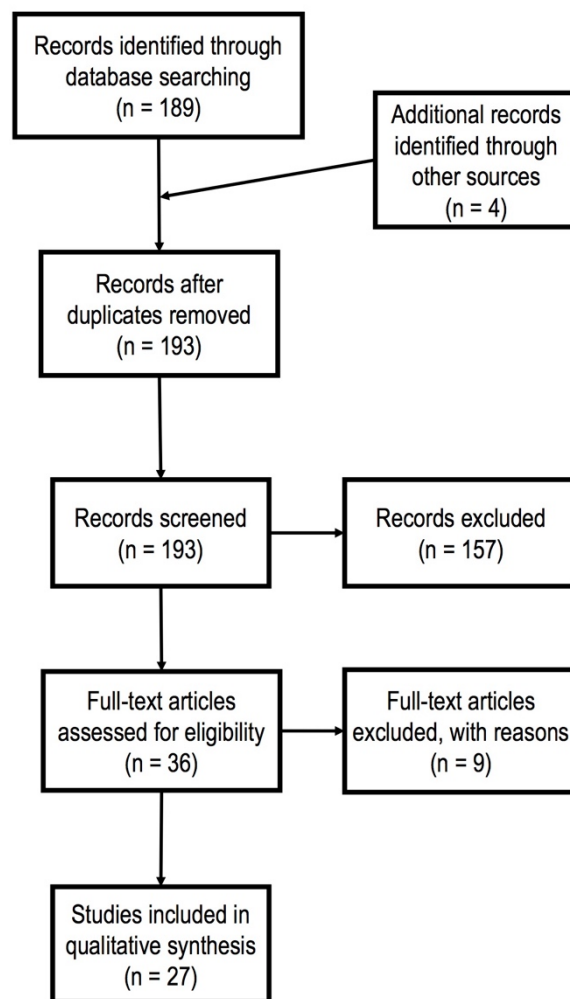


Figure 2.3. PRISMA flow chart of literature search strategy.

2.3.3 *Comparison of studies*

All 27 studies were cross-sectional in nature. Although Zhang et al. (Zhang, Bécares and Chandola, 2016) describe their data as “longitudinal”, their analyses are, in fact, also cross-sectional. Five of the 27 studies presented data from multiple countries – generally using household survey data sets, such as the Demographic and Household Survey (DHS). However, only two developed countries were studied within these 27 studies: the United States (Doak *et al.*, 2005) and Spain (Navarro *et al.*, 2013). Many studies included multiple countries – some up to 36 – and these included countries from the continents of Africa (including Sub-Saharan Africa), Latin America and Asia (including South-East Asia, China and Russia).

Of the 27 included studies, six described household level DBM, while the remaining majority (21 studies) described a version of community-level DBM. As household DBM is the focus of this thesis, these six studies will be focused on more than the community-level studies. One study from South Africa claims to investigate household DBM, but as it describes the prevalence of underweight and overweight prevalence separately, it is more technically community DBM (Abdullah, 2015). Of these six household DBM studies, the majority (n=5) examined a specific form of household DBM: mother-child pairing, with an undernourished child and overweight/obese mother. Some authors refer to this as SCOWT: Stunted Child and OverWeighT mother. For the purpose of this search, we will refer to this as mother-child DBM and ‘undernourished child’ will include stunting (height-for-age), wasting (weight-for-height), and underweight (weight-for-age or BMI-for-age); while ‘overweight mother’ included overweight and obesity through BMI and BMI-for-age assessments.

2.3.3.1 *DBM prevalence*

For the 21 studies that describe community-level DBM, the prevalence of underweight and overweight is described separately – as in, X% of the sample is underweight, and Y% of the sample is overweight.

Of the six studies that describe household DBM, five describe the overweight mother/undernourished child pair prevalence while Doak et al. (Doak *et al.*, 2005) describe the more general form of household DBM - the combination of at least one underweight and one overweight person living in the same house. Of the five mother-child pair studies, the country with the highest reported prevalence was Guatemala with 17% (Lee *et al.*, 2012). A multi-

country study using DHS data also reported Guatemala to have a high prevalence of 13%, but this was not the highest prevalence (Garrett and Ruel, 2003). Two other Latin American countries – Bolivia and Nicaragua had a similarly high prevalence to Guatemala, but Egypt had the highest SCOWT prevalence of 14% (Garrett and Ruel, 2003). Indeed, Sub-Saharan countries have in general, been reported to have a low (<5%) SCOWT prevalence (Wojcicki, 2014). This study, which also analyses DHS data, included wasted and underweight children, along with stunted children, in their SCOWT definition (Wojcicki, 2014). The only exception to this generalisation of a prevalence less than 5% was Swaziland, which had a mother-child pair prevalence of 10%. However, South Africa did not feature in this study (Wojcicki, 2014). The only South African household DBM study that was discovered by the described search strategy actually reported a community DBM prevalence (Kimani-Murage, 2013), and thus there is no known prevalence for household DBM in South Africa.

2.3.3.2 Association with DBM and SES

The proxy measures of SES in these studies ranged from poverty indices (Jehn and Brewis, 2009), to assessment of maternal occupation or education (Angeles-Agdeppa, Lana and Barba, 2003; Jehn and Brewis, 2009) to the assessment household income (Lee *et al.*, 2012). The multi-country study that investigated general household DBM used country Gross National Products (GNP) as a proxy of country SES for comparison (Doak *et al.*, 2005). This study found that DBM was most likely in mid-range SES (GNP) countries. However, it should be noted that DBM households were compared to completely underweight (not “healthy”) households in this study, making them less comparable to other DBM studies. Four of the six household DBM studies, including three of the five mother-child DBM studies, described an association between a proxy of SES and household DBM. Lee’s study of Guatemala (Lee *et al.*, 2012), Angeles-Adeppa’s study of Manila (Angeles-Agdeppa, Lana and Barba, 2003) and Jehn’s (Jehn and Brewis, 2009) study of multiple LMICs all found an association between low levels of SES and mother-child DBM, despite using different proxies of SES. For example the study of Guatemala (Lee *et al.*, 2012) used a concentration index; the Manila study used a combination of mother’s education and occupation, number of children, household income, food expenditure, type of dwelling and four asset index; the 18 LMIC study used mother’s education and occupation, type of dwelling and number of children. In contrast, the study of six countries with a range of GNPs (Brazil, China, Indonesia, Kyrgyz Republic, Russia,

Vietnam and United States), Doak et al. showed a U-shaped relationship: DBM household prevalence was highest in countries with mid-range GNP (Doak *et al.*, 2005).

2.3.3.3 Association with DBM and Food security

Only two of the five mother-child DBM studies describe an association with a form of food security. In Lee et al.'s study of Guatemala (Lee *et al.*, 2012), these authors describe an association between lower food consumption and DBM. This agrees with a study from Manila that showed energy intake was negatively associated with mother-child DBM (Angeles-Agdeppa, Lana and Barba, 2003). In addition, this Manila study found that a mother's preference for meat and fried foods, and child's preference for meats, sweets and sugar, was associated with mother-child DBM. Besides meat, these food preferences could be classified as the energy dense and nutrient poor food ("junk food") that is thought to cause household DBM (Food and Agriculture Organization (FAO), 2006; Shrimpton and Rokx, 2012).

2.3.3.3 Association with DBM and other factors

Three multi-country studies found an association between household DBM and urbanisation (Garrett and Ruel, 2003; Doak *et al.*, 2005; Jehn and Brewis, 2009), which is expected from other literature on DBM (Shrimpton and Rokx, 2012; Abdullah, 2015). One multi-country study (Jehn and Brewis, 2009) and the study of Manila found an association with mother-child DBM and increased number of children in the household (Angeles-Agdeppa, Lana and Barba, 2003). In addition, the Manila study found unique associations with a lack of physical activity and a mother's misperception of her fatness. In this study, perceptions of fatness were studied by presenting mothers with a series of caricatures in increasing order of body fatness and allowing them to select the one that matches their body shape best (Angeles-Agdeppa, Lana and Barba, 2003).

Table 2.1. Comparison of all studies (n=27) included from literature search on double burden of malnutrition (DBM), socioeconomic status (SES) and food security.

First author surname (year)	Country/ Countries	Study design (sample; sample size)	DBM level: prevalence	Main findings
Zhang (2016)	China	Longitudinal (rural-dwelling children; n=5,017)	Community: 29% UW, 10% OW.	UW associated with younger girls. Overall UW associated with maternal education and health insurance and living environment
Griffiths (2016)	India	Cross-sectional (rural-dwelling infants; n=347)	Community. DNS	SES positively associated with all anthropometry measures. SES also indirectly positively associated through maternal height
Abdollahi (2015)	Iran	Cross-sectional (Afghan refugees, n=414)	Community. 58% of females OW, 11-13% of children UW	Food insecurity in 88% of households. Food insecurity associated with unemployment + with lower levels of SES.
Manyanga (2014)	Egypt, Djibouti, Ghana, Benin, Malawi, Mauritania, Morocco	Cross-sectional (school children; n=32,496)	Community. UW: 13-32%, OW: 9-31%.	Generally, females = higher OW / males = higher OW prevalence. Tendency for UW to increase in early teens and reduce at 15-16 years.
Ene-Obong (2012)	Nigeria	Cross-sectional (school children; n=1,599)	Community. UW (thinness): 13%, OW: 14.2%.	OW associated with older age, UW with younger age. OW/UW associated with income levels and location.
Gewa (2013)	Mali	Cross-sectional (non-pregnant women; n=6,015)	Community. 11% UW, 19% OW	UW associated with rural, OW with urban areas. BMI and household use of iodised salt associated with education, age, modern contraceptive use, breast-feeding status and household wealth index.
Navarro (2013)	Spain	Cross-sectional (post-menopausal women; n=1,250)	Community. DNS	Low SES associated with higher BMI
Nikoi (2013)	Ghana	Cross-sectional (children: 0-59 months; n=2,225)	Community. DNS	Height-for-age associated with SES (wealth quintile), mother's BMI, population density, age of child, vaccination status and months of breastfeeding
Janjua (2011)	Pakistan	Cross-sectional (adults > 20 years; n=3,500)	Community. DNS	SES (wealth index - household assets/utilities) positively associated with OW, but not UW. Shift from UW to OW in Pakistan, in general.

First author surname (year)	Country/ Countries	Study design (sample; sample size)	DBM level: prevalence	Main findings
Lee (2012)	Guatemala	Cross-sectional (households; n=2,492)	Household: 17%	<i>Pairs of UW children (stunting only) with OW mothers (BMI outliers) more prevalent in low and middle, than high SES households (assessed with CI). Also, these pairs were significantly more likely in the middle (in comparison to highest) consumption households.</i>
Mandal (2011)	India	Cross-sectional (children: 2-6 years; n=1,012)	Community. DNS	Lower SES (as assessed by Caste classification) associated with less body fat % (sum of skin folds)
Firestone (2011)	Thailand	Cross-sectional (children: 2-10 years; n=4,610)	Community. 28% UW, 8% OW	OW associated with community wealth concentration and TV/sanitation coverage. UW associated with household poverty, OW associated with urban (as opposed to rural) living and household affluence.
Corsi (2011)	Bangladesh	Cross-sectional (ever-married women: 15-49 years; n=10,849)	Community: 34% UW, 8% OW	Low SES (measured with household/neighbourhood wealth and place of residence) associated with UW, and high SES with OW. Rural-dwelling was also associated with UW.
Khor (2011)	Malaysia	Cross-sectional (children: 7-12 years; n=402)	Community: 3% UW, 34% OW	BMI-for-age negatively associated with Vitamin D concentration
Hamad (2010)	Peru	Cross-sectional (adult females; n=1,593)	Community: 1% UW, 65% OW	Longer micro-loan periods were positively associated with BMI and food security.
Warraich (2009)	Pakistan	Cross-sectional (school children: grade 6-8; n=284)	Community. 52% UW, 14% OW	UW associated with low SES, OW associated with high SES. Daily meat consumption associated with OW.
Bharati (2008)	India	Cross-sectional (children: 0-36 months; n=26,369)	Community: Girls - 2% UW, 45% OW; Boys - 1% UW, 43% OW	Weight-for-age associated with household SES, mother's literacy and ethnicity (Caste classification)
Amorim (2006)	Brazil	Cross-sectional (low SES school children: 11-14 years; n=1,719)	Community. 7% UW, 10% OW	High levels of low-intensity activity and inactivity in children

First author surname (year)	Country/ Countries	Study design (sample; sample size)	DBM level: prevalence	Main findings
Doak (2005)	Brazil, China, Indonesia, Russia, Vietnam, United States	Cross-sectional (households; n=39,894)	Household (adjusted for household size). Vietnam - 3%, China - 8%, Krgyzstan - 13%, Indonesia - 11%, Russia - 9%, Brazil - 8%, US - 8%	Dual burden households (presence of OW + UW resident - as classified with BMI for adults and children) most common in countries with mid-range Gross National Product. In general, DMN (as opposed to "underweight-only" households) were associated with urban-dwelling and high SES (income tertile). However, associations are context-specific, suggesting country-specific studies are necessary.
Choudary (2003)	India	Cross-sectional (rural adolescent girls: n=270)	Community. DNS.	Girls in lower and middle SES were more likely to be in negative energy balance. UN was associated with higher energy expenditure.
Angeles-Agdeppa (2003)	Manila	Cross-sectional (mother-child pairs; n=376)	Household. 8% of pairs had SCOWT (UW=wasted)	<i>In comparison to normal weight households, SCOWT associated with: more physical activity; mother's education/occupational status; number of children in household; energy intake; preference of meats/sweets/sugar in children, and of meats/fried foods in mothers; mother's perception of body size</i>
Mukudi (2003)	Kenya	Cross-sectional (school children: n=851)	Community. DNS.	UW negatively associated with school achievement
Khongsdier (2001)	India	Cross-sectional (adult males: 18-62 years; n=946)	Community. DNS	BMI associated with lower SES
Wojcicki (2014)	28 Sub-Saharan African countries*	Cross-sectional (households; n=1,948 children)	Household. SCOWT <5% in all countries, except Swaziland (=10%) (OW=obese only, UW=wasted, stunted+underweight)	Strong associations between UW and OW in child/parent pairs.
Kimani-Murage (2013)	South Africa	Cross-sectional (children: 1-20 years; n=4000)	Community. UW: 5-32%, OW: 4-25%	UW more common in young children, OW in older children. UW associated with HIV status, age, birth weight, maternal age, age of household head and area of residence. OW associated with age, sex, pubertal development, household food security and SES and household head's highest education.

First author surname (year)	Country/ Countries	Study design (sample; sample size)	DBM level: prevalence	Main findings
<i>Jehn (2009)</i>	<i>18 low- to middle-income countries*</i>	<i>Cross-sectional (n=38,583 mother/child pairs)</i>	<i>Household. SCOWT=2%</i>	<i>SCOWT pairs associated with older mothers, maternal lack of formal education, more siblings in the household, low SES (household poverty), living in urban area.</i>
<i>Garrett (2013)</i>	<i>36 countries (Africa-23, Latin America-8, Asia-5)*</i>	<i>Cross-sectional (unclear)</i>	<i>Household. SCOWT<10% (except three Latin America countries)</i>	<i>SCOWT more prevalent in Latin America countries than African or Asian. SCOWT only associated with urbanisation in Latin America.</i>

UW - underweight, OW overweight/obese, SES - socioeconomic status (or proxy thereof), CI - concentration index, DNS - Did not state, USA - United States, TV - television;

Italics indicates mother-child DBM (undernourished child and overweight mother) pair

*Not including South Africa

2.4 Discussion

This review provides theoretical, methodological and empirical evidence that DBM, and in particular household DBM, is an important public health issue, particularly in LMICs such as South Africa. To a lesser extent, this review also provides evidence of an association between household DBM, socioeconomic status (SES) and food security.

DBM is a public health concern due to its association with both infectious *and* chronic diseases, including metabolic syndrome and other diseases (Food and Agriculture Organization (FAO), 2006; Shrimpton and Rokx, 2012; Kimani-Murage, 2013; Abdullah, 2015). Moreover, DBM is most commonly associated with the nutrition transition, which appears to be occurring in a lot of developing countries due, in part, to a global focus on achieving the Millennium Development Goals (FAO, 2011b). The nutrition transition generally occurs during improving economic conditions, which has an accompanying shift to energy-dense, but nutrient poor foods (Shrimpton and Rokx, 2012; Steyn and Mchiza, 2014). Although the World Bank clearly state that DBM can occur in any country, regardless of economic status (Shrimpton and Rokx, 2012), it is clear that the majority of concern has been in LMICs, as reflected by their over-representation of developing countries in this empirical review (Section 2.3, and Table 2.1). Indeed, only two developed countries were studied within the 27 articles discovered by a comprehensive search strategy between 1997 and 2017. Household DBM is a particular concern from the perspective of intervention implementation due to the implied requirement to target both under- and overweight in the same household, concurrently (Garrett and Ruel, 2003; Shrimpton and Rokx, 2012). There are examples of successful interventions to reduce both under- and overweight individually, but not both simultaneously (Shrimpton and Rokx, 2012). A particular form of household DBM - SCOWT (stunted child, overweight mother) – is an even trickier intervention issue due to the fact that mother/child pairs are generally exposed to similar environments, regulated by the mother. It has been hypothesised that SCOWT develops from the mother/child pair consuming the same ‘junk’ (energy dense, but nutrient poor) food, but the food having contrasting effects. Over time, the consumption of this ‘junk’ food exceeds the energy requirements of the mother, resulting in weight gain. Concurrently, this junk food does not provide sufficient nutrients to the growing child, resulting in a form of undernutrition such as stunting, wasting or underweight, over time (Garrett and Ruel, 2003; Shrimpton and Rokx, 2012; Abdullah, 2015).

Despite the public health concerns of DBM, and specifically household DBM, there are others who have shown the prevalence of this disease to be ‘acceptable’ (Wojcicki, 2014). This was supported by the empirical literature review in Section 2.3 of this chapter – the highest prevalence of household DBM was that of Lee *et al.* in their study of Guatemala, with 17% (Lee *et al.*, 2012). Moreover, the majority of Sub-Saharan African countries have a prevalence below 5% (Wojcicki, 2014). Other critics have argued that SCOWT pairing is simply a statistical artefact of overweight females, and thus not worth the public health concern (Dieffenbach and Stein, 2012). However, other experts have warned that household DBM is highly context-specific and this warrants its investigation, particularly if a region is understudied (Doak *et al.*, 2005). Thus, the fact that South Africa has not had its household DBM prevalence described as yet is both a public health concern and a justification to perform this study.

Moreover, this review highlighted the relationship between household DBM and SES/food security in other countries. As one of the least equitable countries in the world, this association should be a concern for a country such as South Africa (Mfenyana *et al.*, 2006; John E. Ataguba, Akazili and McIntyre, 2011). Owing, in part, to its Apartheid history, South Africa also has a large poor or low SES population (Mfenyana *et al.*, 2006; Steyn *et al.*, 2006; Mayosi *et al.*, 2012; Kimani-Murage, 2013). Indeed, the empirical review (Section 2.3) described three mother-child DBM studies that show a clear association with low SES – as measured by a variety of proxies (Table 2.1). Household DBM was also associated with both low food consumption (Guatemala (Lee *et al.*, 2012)) and consumption of ‘junk’ food (Philippines (Angeles-Agdeppa, Lana and Barba, 2003)).

The empirical review (Section 2.3) confirmed that DBM (both community and household) was also associated with urbanisation (Table 2.1). DBM is often attributed to the ‘nutrition transition’, which is a phenomenon that is more likely to occur during urbanisation (Shrimpton and Rokx, 2012; Steyn and Mchiza, 2014; Abdullah, 2015). Similarly, the association with DBM and physical inactivity in the Philippines (Angeles-Agdeppa, Lana and Barba, 2003) has also been mentioned in reviews of DBM (Shrimpton and Rokx, 2012; Abdullah, 2015). In addition, although not described in the theoretical review (Section 2.1), the association with SCOWT and number of household children in the Philippines also makes logical sense in that more mouths to feed within a resource-constrained setting could effectively reduce food security *within* the house (Angeles-Agdeppa, Lana and Barba, 2003).

In terms of methodology, all household DBM studies included in the empirical review used a binary approach to describe the DBM outcome. This was consistent with the methodological review (Section 2.2), which found that most studies used a binary approach, except when comparing household DBM longitudinally.

However, there are limitations that should be noted with this literature review. For example, more than one literature search database could've been used. However, the use of one is within PRISMA guidelines and the chosen search database is widely used and recommended within scientific circles (Moher *et al.*, 2009). The methods would've been strengthened if more than one reviewer had been used for each stage of the screening process, however this was not possible due to this being part of a student thesis. Should this chapter aim to be published at some point in the future, the search strategy process can easily be repeated with two authors to improve methodological rigour (Moher *et al.*, 2009).

2.5 Conclusion

Although the prevalence of household DBM is relatively low, the nutrition transition that a number of developing countries are currently experiencing, or will experience in the near future, has the potential to cause a major public health issue. This is because DBM is associated with an increased rate of infectious and non-communicable diseases. The prevalence and factors associated with household DBM are highly context-specific, but it has been consistently found to be associated with low SES households in LMIC, who might also be food insecure. With South Africa's large poor population and problems with food security, it is alarming that the country's household DBM has not been investigated.

2.6 References

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PART 3: JOURNAL ARTICLE

Written in preparation for submission to the Journal of Obesity (See Appendix I - author guidelines)

Title and authorship information

Examining the link between food security and socio-economic status with the double burden of malnutrition in South African households

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1. **Abstract**

Introduction

Although many countries are experiencing the coexistence of under- and over-nutrition (double burden of malnutrition - DBM) within the same household, it is understudied in South Africa. This study aimed to estimate the prevalence, and examine the associated factors of DBM, in South African households.

Methods

The prevalence of DBM pairs (overweight/obese mother and underweight/stunted child) were estimated from the nationally representative data from 2014, South Africa National Income Dynamic Survey wave 4. Multivariate logistic regression was applied to examine the factors associated with DBM, including socioeconomics factors (mother's race and education), and food security (per capita food expenditure).

Results

DBM prevalence was 11%. Mother's characteristics of being African (adjusted odds [aOR]: 1.3; 95% confidence intervals [95%CI]: 1.0-1.7) and married (aOR: 1.4, 95%CI: 1.1-1.6) were associated with increased odds of DBM. In contrast mother's having tertiary education (aOR: 0.7, 95%CI: 0.5-1.0) and greater household per capita income (aOR: 0.9, 95%CI: 0.8-1.0) were protective against DBM.

Discussion

DBM pair prevalence is high in South Africa. Higher education and household income are buffers against this DBM risk. Thus, an intervention that encompasses both the improvement of levels of education and the provision of high-quality food is urgently necessary in South Africa.

2. Introduction

The double burden of malnutrition (DBM) is the coexistence of undernutrition (stunting, underweight, wasting or micronutrient deficiencies) and overweight/obesity that exists simultaneously at a population, household or individual level (Abdullah, 2015). The global prevalence of underweight is about 13% or 22% in developed and developing countries, respectively (Abdullah, 2015). The overweight/obesity prevalence is generally higher – around 45% in low-to-middle-income countries (LMICs) and 56% in upper-to-middle income countries (Abdullah, 2015). Both of these ends of the spectrum are associated with acute and chronic health conditions including complex multisystem diseases such as metabolic syndrome, making it a major emerging threat to both health systems (Garrett and Ruel, 2003; Kimani-Murage *et al.*, 2011; Shrimpton and Rokx, 2012; Abdullah, 2015). From a prevention perspective, household DBM is particularly difficult as interventions at this level have typically targeted either undernutrition or overweight/obesity, but not both simultaneously (Shrimpton and Rokx, 2012).

DBM is closely associated with the ‘nutrition transition’ - a dietary shift away from famine, but that often includes the consumption of energy dense and nutrient poor (“junk”) food (Shrimpton and Rokx, 2012; Steyn and Mchiza, 2014; Abdullah, 2015; Kimani-Murage *et al.*, 2015). These transitions occur as a result of improving economic conditions, and are thus more likely to occur in developing or Low-Middle Income Countries (LMICs) (Garrett and Ruel, 2003; Doak *et al.*, 2005; Kimani-Murage, 2013). However, at a household level, DBM is associated with low socioeconomic status (SES) indicators such as household poverty (Jehn and Brewis, 2009) or income (Abdullah, 2015).

The combination of undernourished children and overweight/obese mothers is increasingly observed in LMICs (Garrett and Ruel, 2003; Shrimpton and Rokx, 2012; Kimani-Murage, 2013; Abdullah, 2015). It is posited this combination develops during the nutrition transition and the “junk” food simultaneously exceeds energy requirements of the adult mother, while being insufficient for the developing child (Shrimpton and Rokx, 2012; Kimani-Murage, 2013; Abdullah, 2015).

Besides being associated with SES, household DBM is also linked with food security (Doak *et al.*, 2005; Shrimpton and Rokx, 2012; Kimani-Murage, 2013). Food security has a broad

definition and encompasses: (i) availability, (ii) access and (iii) utilization of food, along with the barriers/facilitators of these three factors (Jones *et al.*, 2013). For example, a study of rural Kenya concluded that poor food choices, a result of education and knowledge affecting food access, was associated with household DBM (Kimani-Murage *et al.*, 2015). Moreover, in a study of household DBM in Malaysia, DBM was associated with insufficient caloric intake – part of ‘utilisation’ of food security - in children (Khor, 2008). Independently, food security and SES are also associated – in South Africa, the poorest households are far more likely to be food insecure or hungry than richer households (Frayne *et al.*, 2010).

Moreover, South Africa is one of the most inequitable countries in the world, with large differences between the lowest and highest SES population groups (John E. Ataguba, Akazili and McIntyre, 2011; Micklesfield *et al.*, 2013). As a result of its history of Apartheid, SES is also still closely associated with race (Micklesfield *et al.*, 2013). For example, Black children have a relatively high prevalence of undernourishment, which is thought to result mainly from food insecurity in these populations (Kimani-Murage, 2013) In addition, South African women, and in particular, black women, have a high prevalence of obesity, which is mainly related to SES and education (Micklesfield *et al.*, 2013). This combination of a high prevalence of both undernourishment and overweight/obesity in certain population groups, could place South Africa at high risk of household DBM. However, to our knowledge the prevalence of household DBM has not yet been described in South Africa. Although factors associated with undernourishment and overweight/obesity have been described separately in various literatures (Kimani-Murage, 2013; Micklesfield *et al.*, 2013; Steyn and Mchiza, 2014), the specific factors associated with the household DBM are yet to be specifically investigated.

Therefore, the aim of this study is to determine the prevalence of DBM and examine the relationship between socioeconomic status, food security and household DBM using a representative sample of South African households

3. Materials and Methods

3.1 Data

This study made use of Wave 4 data of the National Income Dynamics Study (NIDS) from the years 2014-2015 (<http://www.nids.uct.ac.za>). NIDS is a South African government-led initiative to investigate poverty in the country and includes a nationally representative sample of South African households (Chinhema *et al.*, 2016). NIDS ensured this with a two-stage cluster sample design to decide on households included in Wave 1. NIDS randomly selected 400 primary sampling units (PSUs) from StatsSA's Master Sample of 3000 PSUs. The randomisation was performed within strata, which were representative of South Africa's 53 district councils (Chinhema *et al.*, 2016). The study was developed by the South African Labour and Development Unit (SALDRU), based at the University of Cape Town. NIDS is actually a panel (longitudinal) design study, which began in 2008 with wave (panel) 1. However, this cross-sectional study only used the most recent wave (wave 4), including 42,337 individuals (adults and children) from 11,895 households.

For each wave, up to four different questionnaires are administered to each household:

5. *Household questionnaire* – completed by the oldest female or whomever is most knowledgeable about the household's affairs, and in particular spending.
6. *Adult questionnaire* – all household members over the age of 15 years.
7. *Proxy questionnaire* – completed by an adult on behalf of another adult household member who was unavailable at the time of the researcher's visit.
8. *Child questionnaire* – completed by the child's caregiver and focuses on the child's educational history, education, anthropometrics and access to grants. Children are younger than 14 years of age in the NIDS dataset.

For this study, household DBM pairing, represented by an undernourished child and overweight/obese mother, was the outcome of interest.

3.2 Dependent variable

A household form of DBM was created as a dichotomous variable based on mother and child pairings (Table 3.1). A DBM pair was defined as an overweight/obese mother having at least one undernourished child in the same house as her. Thus, there could be more than one DBM pairing per household. Adult (classified by NIDS as 15 years and older) females who had at

least one living child were considered as a “mother” for these analyses (n=15,906). The mother’s weight status was initially defined according to World Health Organization (WHO) body mass index (BMI) cut-points, and then created into a binary variable: overweight/obese (=1) or not (=0). For the purposes of these analyses, only males and females younger than 12 years old were considered to be children, to reduce the influence of puberty on anthropometry. Undernourishment was classified as being less than two standard deviations below the z-scores for either weight-for-age or height-for-age (WAZ or HAZ). Based on these two measures, a binary variable was created to indicate the presence (=1) or absence (=0) of at least one undernourished child in the house.

Table 3.1. Summary of variables included in analysis

	Type of variable	Range (continuous) or categories (categorical)	Missing data (n)
Dependent variable			
DBM pair (“DBM”)	Categorical	Non-DBM pair DBM pair	381
Independent variables			
Mother’s race	Categorical	African Non-African	0
Monthly income per capita (ZAR)	Continuous	42 – 38,000	407
Mother’s education	Categorical	None Primary Secondary Tertiary	249
Monthly food expenditure per capita (ZAR)	Continuous	3 – 6,347	407
Other covariates			
Mother’s marital Status	Categorical	Married/co-habiting Widowed/divorced Never married	395
Household residents (n)	Continuous	1 – 31	407
Mother is household head	Categorical	Household head Not household head	407
Mother’s age (years)	Continuous	15 – 79	0
Urban area	Categorical	Traditional/Farms Urban	49

3.3 Independent variables

A proxy of food security - food expenditure per capita, a continuous variable – was included in this study (Table 1). This variable was created by asking the eldest household female about the amount of food eaten within the past month. This was asked within 32 different food categories including pasta, red meat, tea and coffee, etc.

Three theory and context-informed proxies were used for socioeconomic status (SES): (i) household income per capita (continuous variable); (ii) mother's education (categorical variable) and (iii) mother's race (dichotomous variable) (Table 1).

3.4 Other covariates

In addition, we looked at other aspects of the mother or household that we considered, from literature) to be important in the relationship with DBM (Garrett and Ruel, 2003; Doak *et al.*, 2005; Kimani-Murage *et al.*, 2011; Micklesfield *et al.*, 2013; Abdullah, 2015). These other covariates were: mother's marital status (categorical), number of household residents (continuous), mother is the household head (dichotomous), mother's age (continuous); urban area or not (dichotomous). Descriptive data of children (gender, age and percentage malnourished) were also compared between DBM and non-DBM pairs.

3.5 Statistical analysis

A Mann-Whitney Test (due to non-normal distributions) and cross-tabulations (with a chi-square statistic) were used to compare all continuous and categorical outcomes between DBM and non-DBM pair households, respectively. Based on the mother and household variables that were significant in bivariate analyses (Table 2), a multivariate logistic regression model was built. Owing to substantial skewness, both monthly household income and household food expenditure per capita (amount divided by number of household residents) were log transformed before being added to the model. The goodness of fit of the logistic regression was assessed using the log likelihood chi-square and Pseudo-R². Multicollinearity of the model was assessed by calculating the variance inflation factor of each predictor variable (after re-running the same regression as a linear regression).

Analyses were all run using Stata, version 12 (StataCorp. 2011. College Station, TX: StataCorp LP).

4. Ethical approval

Permission (611/2017) was obtained from the University of Cape Town's Human Research Ethics Committee in order to analyse the de-identified NIDS data.

9. Results

The prevalence of the pair of an overweight/obese mother with an undernourished child was 11% (n=653 of 5,997 mothers) (Table 3.2). The mean BMI of all mothers was 29 (± 7), and this was significantly higher (32 ± 7 , $p < 0.001$) in DBM pairs. By design, DBM pairs had 100% proportion of both (i) overweight/obese mothers and (ii) at least one stunted/underweight child, and these proportions were significantly greater than in non-DBM pairs ($p < 0.001$). The proportion of mothers' age categories and of mother's who were also the household head was not different between DBM pairs. However, the proportion of mother's who were African race was significantly higher in DBM (88%), than non-DBM (85%) pairs (Odds ratio: 1.288, 95% confidence interval: 1.006-1.647). A significantly lower proportion of mothers had tertiary education in DBM pairs (15%) than in non-DBM pairs (20%) (Odds ratio: 0.628, 95% confidence interval: 0.473-0.833). Similarly, a significantly higher proportion of mothers were married or co-habiting with a partner in DBM (39%) than non-DBM pairs (34%) (Odds ratio: 1.260, 95% confidence interval: 1.065-1.490).

Table 3.2. General characteristics of mothers, children and households presented within DBM (overweight/obese mother and undernourished child) and non-DBM pairs.

	All pairs	Non-DBM pairs	DBM pairs	p-value*
MOTHER'S CHARACTERISTICS (N=5,997)				
BMI	29 (± 7)	29 (± 7)	32 (± 6)	<0.001
Overweight/obese (%)	67	62	100	<0.001
At least one stunted/underweight child (%)	22	11	100	<0.001
Age (year categories, %)				0.496
15-24	25	25	23	
25-34	44	44	44	
35+	32	32	33	
Race (% African vs other race)	85	85	88	0.044
Mother is household head (%)	33	33	32	0.959

Education				0.004
<i>None/Primary</i>	15	15	18	
<i>Secondary level</i>	65	65	67	
<i>Tertiary level</i>	20	20	15	
Marital Status				0.007
<i>Married/Co-habiting</i>	34	34	39	
<i>Never married/Widowed/Divorced</i>	66	67	61	
CHILDREN'S CHARACTERISTICS (n=8,410)				
Gender (% male)	49	49	50	0.499
Malnourished (stunted/underweight) child (%)	18	10	62	<0.001
Age, in years [mean (SD)]	5.2 (±3.4)	5.2 (±3.4)	4.9 (±3.4)	0.001
HOUSEHOLD CHARACTERISTICS (N=4,957)				
Urban area (%)	51	52	50	0.461
Number of household residents [(mean (SD)]	6 (±4)	6 (±4)	7 (±3)	<0.001
Monthly income (ZAR) per capita [mean (SD)]	1450 (±2104)	1481 (±2167)	1219 (±1541)	0.001
Monthly food expenditure (ZAR) per capita [mean (SD)]	262 (±251)	266 (±259)	229 (±175)	0.007

*Continuous variables compared with a Mann-Whitney U test, categorical variables with a chi-square test.

(SD)– standard deviation, BMI – body mass index, ZAR – South African Rands,

Amongst the children, there was no difference in the distribution of gender between DBM and non-DBM pairs (Table 1). However, children were, on average, significantly younger in DBM (4.9 ± 3.4) than non-DBM (5.2 ± 3.4) pairs ($p=0.001$). Similarly, the proportion of households living in areas classified as “urban” (51% overall) was not different between DBM pairs. As expected, the proportion of malnourished (stunted or underweight) children was significantly higher in DBM (62%) than non-DBM(10%) pairs ($p<0.001$).

In terms of household characteristics (Table 3.2), the proportion of urban households was not significantly different by DBM pair. However, DBM pairs had, on average, significantly more household residents (7 ± 3), than households of non-DBM pairs (6 ± 4 , $p<0.001$). Household monthly per capita income ($p=0.001$) and food expenditure per capita ($p=0.007$) was significantly lower in DBM pairs.

All variables that were significantly associated with DBM pairs in the bivariate analyses were included in a multivariate logistic regression (Table 3.3). In addition, mother's age category and urban dwelling were added as important potential covariates. Mother's race, education and marital status were significantly associated with DBM pairs at 95% confidence interval (CI), while household income is significant at 99% CI. The adjusted odds ratio (aOR) for DBM pairs is 30 times higher among African mothers, compared with those of other races (aOR: 1.300, 95% CI: 1.001-1.683). DBM pairs were 27 times less likely if the mothers had tertiary education, in comparison to none/primary school education only (aOR: 0.730, 95% CI: 0.536-0.996). The adjusted odds ratio for DBM pairs was 36 times greater if the mother was married or co-habiting with a partner, in comparison to never married/widowed/divorced mothers (aOR: 1.357, 95% CI: 1.131-1.628). A negative relationship was observed with DBM pairs and per capita monthly household income. With an increase in per monthly household income, the adjusted odds of observing a DBM pair decreased by about 10 times (aOR: 0.897, 95%CI: 0.794-1.014). Thus, of the four SES proxies (urban/rural, mother's race, mother's education and household income), three were indicated that DBM was associated with lower SES households.

Table 3.3. Predictors of Double Burden of Malnutrition (DBM) pair. Log likelihood chi-square <0.001; Pseudo-R²=0.0082. Average variance inflation factor (VIF) of predictor variable =1.63 (maximum VIF=2.23).

Variables	Odds Ratio	95% confidence interval		P-value
		Lower	Upper	
Mother's age (base=15-24)				
25-34	1.140	0.920	1.414	0.229
35+	1.061	0.833	1.351	0.631
Household - urban area	1.059	0.888	1.270	0.525
Mother's race - African (vs non-African)	1.300	1.001	1.683	0.049
Mother's education (base=None/Primary)				
Secondary	0.920	0.727	1.165	0.490
Tertiary	0.730	0.536	0.996	0.047
Mother's marital status (base=Never married/Widowed/Divorced)				
Married/co-habiting	1.357	1.131	1.628	0.001
Log of household monthly income per capita (ZAR)	0.897	0.794	1.014	0.082
Log of household monthly food expenditure per capita (ZAR)	0.919	0.798	1.058	0.241

10. Discussion

This paper used a South African, nationally representative, household survey to examine the prevalence and associated factors of household DBM. The main finding of this study was that DBM pairs comprised 11% of all mother-child pairs in this representative sample of South Africans. Although conducted almost two decades ago now, a 2003 study of 36 countries concluded that most country's prevalence was below 10% (Garrett and Ruel, 2003). Similarly, a 2014 study of 28 African countries found that most countries had a prevalence below 5% (Wojcicki, 2014). This present study, of a representative sample of South Africa, is above that threshold of 10%, and thus warrants concern. To the authors' knowledge, this is the first study to describe household DBM prevalence in South Africa at a national level. Although this is the first DBM prevalence reported for South Africa, there are many studies that have independently reported on undernutrition and obesity prevalence. The present study's obesity prevalence (40%) is similar to that reported by Ng in 2014 (42%) (Ng *et al.*, 2014). This study reported that 18% of children were undernourished (stunted or underweight), which is comparable with the various prevalence, by age group, reported by Kimani-Murage in a rural South African setting 2005 (Kimani-Murage, 2013). Although the present study's prevalence of undernourishment is higher than that reported by Abdullah for South Africa (Abdullah, 2015), it should be noted that the review only considered underweight children younger than 5 years of age.

This study found an association between DBM pairs and various proxies of low SES (mother's race, education and marital status). While there was a positive relationship with African race and mother being married or co-habiting, there was a negative relationship with tertiary education and household income. This association with household income was expected from a review of DBM in developing countries (Abdullah, 2015). Although similar relationships have been described with African race and obesity in South African women (Micklesfield *et al.*, 2013) and with being married (as opposed to unmarried) in obese men/women in the United States (Sobal, Rauschenbach and Frongillo, 1992), this is the first study to describe these relationships in DBM pairs. This study's findings of a negative relationship with DBM and tertiary education concur with an 18-country DBM pair study that found a positive association with low education (Jehn and Brewis, 2009). This 18-country study (Jehn and Brewis, 2009) also found an negative association between DBM pairs and number of household siblings and

household wealth – determined from an asset index - which is similar to the present study’s negative association with per capita household income. In contrast, the seven country study of Doak et al. (Doak *et al.*, 2005), found that household DBM was more likely to be associated with high income households. However, this seven country study (Doak *et al.*, 2005) compared DBM households (one member overweight, one underweight) with entirely underweight households (all household members underweight), which is a very different comparison than the present study. The fact that this seven-country study compared DBM to underweight households (Doak *et al.*, 2005), might also explain why they found an association with urbanisation while the present study and another 36-country study did not (Garrett and Ruel, 2003).

In this study, once the multivariate logistic model adjusted for SES, the strong bivariate relationship with food security - per capita food expenditure – no longer remained. However, the negative relationship between per capita food expenditure and DBM pairs is still noteworthy and implies that higher the per capita food expenditure lowers the likelihood of DBM. However, there are not many other studies that have used this measure as a food security proxy, let alone compared it to household DBM, and thus it is difficult to contextualise this finding. Nonetheless, many policies to improve food security, both globally and in South Africa, focus on improving the ability of households to purchase food (Watkinson and Makgetla, 2002; Klerk *et al.*, 2004). These food security policies in South Africa were instituted based on the fact that food expenditure, as a proportion of total household income, is relatively higher in poorer households (Watkinson and Makgetla, 2002).

As with many health issues in South Africa, this study found that household DBM is linked with poorer households (Mayosi *et al.*, 2012). Thus, interventions need to be developed for these under-resourced settings as a matter of urgency. An example of such an intervention is the government-led “*Green My Favela*” (GMF) programme in Brazil (Rekow, 2015) that provides fresh produce to poor communities in Brazil (colloquially known as ‘favelas’). This state-run GMF intervention relies on two arms: (1) provision of state-subsidised fresh agricultural produce, and (2) education and involvement of the community in the development of this produce. This study, and a successful intervention in another developing country, has justified that it is time that the South African government develops their own programme encompassing both education and provision of high-quality food at subsidised cost in areas of need.

However, this study was not without its limitations. The main one was of comparability with other studies based on operational definitions of household DBM. While our study viewed it as a pairing of an overweight/obese mother and at least one stunted or underweight child, other studies have used slightly different definitions. For example, some only use stunted children (Garrett and Ruel, 2003; Abdullah, 2015). Moreover, this study examined mother-child pairing, while other household DBM studies referred to it as any combination of overweight and underweight within the same household (Doak *et al.*, 2005). Secondly, this study's proxy of food security (food expenditure per capita) could be argued to be more of an SES proxy. It was the authors' intention to use a more specific measure of food security - dietary diversity score, constructed from the 32 food group questions that were asked by NIDS. However, these specific questions were not answered by the majority (91%) of households, rendering it useless as an explanatory variable. In addition, the median score for this discreet variable was 9 out of a possible 12 food groups, meaning that there was little variation in the few that answered provided information on this question.

Conclusion

Despite the limitations, examining the prevalence and predictors of stunted/underweight children and overweight/obese mothers (DBM) using nationally representative data is a critical first step to understanding the DBM issue in South Africa. The present study found a relatively high prevalence of DBM (11%) in this representative sample of South African households. This high prevalence of DBM pairs warrants further investigation into this phenomenon in South Africa and future studies should specifically investigate food security constructs. These findings reinforced the evidence of association between DBM and low SES measures, including mothers' education, marital status, race and household income. This requires urgent attention from government to provide state-subsidised high-quality food to poorer households, such as is already done in Brazil's *Green My Favela* intervention.

Data availability

These data are freely available from: <http://www.nids.uct.ac.za>

Conflicts of interest

None to declare

Funding Statement

None to declare

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PART 4: POLICY BRIEF

POLICY BRIEF: MARCH 2018

Household double burden of malnutrition in South Africa:

Our poorer communities need urgent help!

What is DBM?

The Double Burden of Malnutrition (DBM) is the combination of undernutrition (stunting, underweight, wasting) and overweight/obesity. It can exist at either a population, household or individual level. DBM causes a number of health complications and therefore should be prevented as far as possible. Theoretically, DBM develops when poor, rural communities become more “urbanised”. This urbanisation results in them buying and eating “junk” food – food that is high in calories, but low in nutritional value. When this junk food is eaten for an extended period of time, it can result in very different effects in adults and children. While fully-developed adults become overweight, the lack of nutrients results in the children becoming undernourished. This particular form of DBM is known as household DBM.

What did we study?

As South Africa has the unfortunate combination of many overweight adults and undernourished children, there is a possibility that we also have many households with DBM. However, this is the first study in South Africa to look at this issue in households. We decided to look at a specific form of household DBM – where the mother is overweight or obese and the child is undernourished (stunted or underweight for their age). We wanted to achieve two goals with this study (1) find out how many mother/child pairs have DBM, and (2) explore what is different between households with and without DBM.

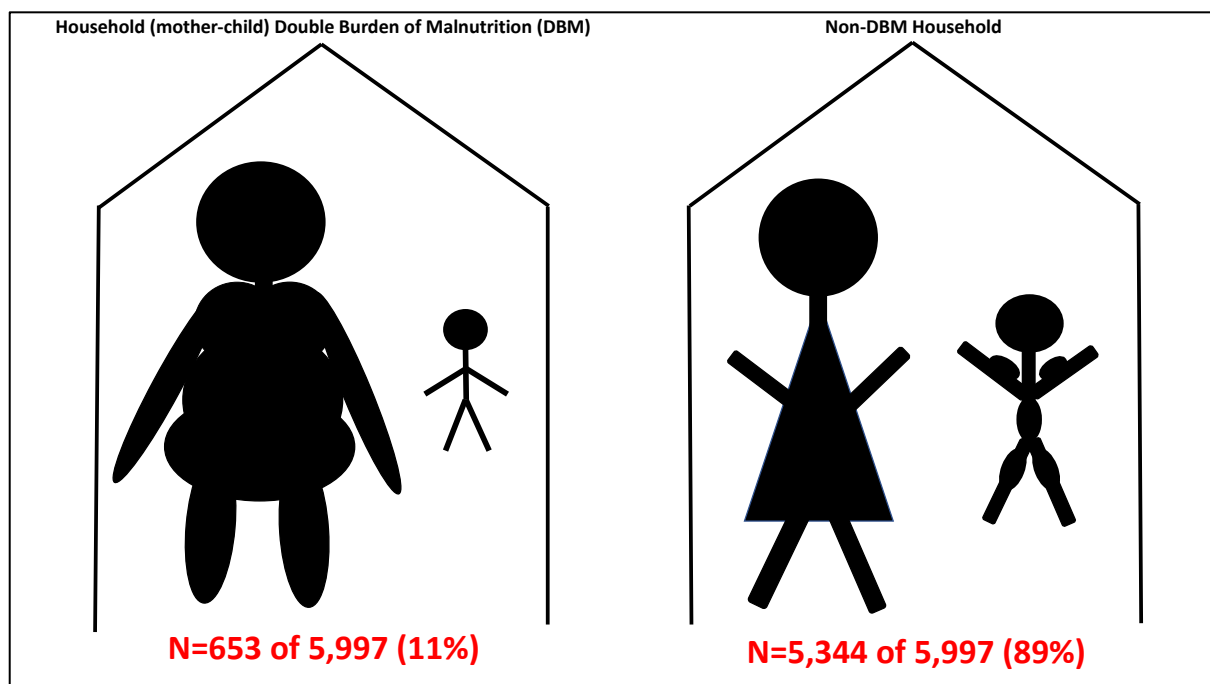
How did we do this study

We used the National Income Dynamics Study (N.I.D.S) to investigate household DBM. N.I.D.S (<http://www.nids.uct.ac.za>) is a South African government-led initiative to study the effects of, among other issues, poverty in the country. To achieve this goal, the study developers put a lot of effort into ensuring that the data are a fair representation of South Africa. N.I.D.S also collects lots of other useful information including body measurements of household members, poverty indicators and food security indicators. For this study, we made use of NIDS data from 2014-2015.

What did we find in this study?

In this representative sample of South African households, this study made three important discoveries:

1. Of all the mother and child pairs, 11% were classified as having household DBM (undernourished child and overweight/obese mother). This is higher than other countries in Africa and almost as high as Latin American countries, which have the highest rates in the world.
2. Household DBM was linked to various indicators of poverty including household income per capita and mother's education, race and marital status.
3. Household DBM was not linked with urban (in comparison to rural/farming) households. This was surprising, but has been observed previously in African countries. Also, it might be a reflection that the poverty indicators described previously (mother's education, etc) are simply more important factors than whether the household is urban or rural.



Policy implications

1. Further research of household DBM in South Africa is urgently needed. This is the first known study to examine this issue in South Africa and found a relatively high prevalence of 11%. If this is not reduced, South Africa's health and economics systems will be crippled by a subsequent rise in non-communicable diseases.
2. As with many health issues in South Africa, this study found that household DBM is linked with poorer households. Thus, interventions need to be developed for these under-resourced settings. For example, a programme such as "Green My Favela" (GMF) in Brazil (Rekow, 2015) does just this by providing fresh produce in favelas

(poor communities in Brazil). GMF relies on two arms: (1) provision of state-subsidised fresh agricultural produce, and (2) education and involvement of the community in the development of this produce. A similar state-funded intervention that encompasses both education and provision of high-quality food at subsidised cost is urgently necessary in South Africa.

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