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The Double Burden of Intra-Household Malnutrition Among Mother–Child Dyads in South Africa

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Abstract

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Abstract

Household-level double burden of malnutrition (HL-DBM) challenges traditional South African vertical malnutrition programs. Research has associated a household with an overweight/obese mother of reproductive age and her under 5-year-old child with signs of undernutrition (wasting, stunting, or thinness) with socioeconomic levels, maternal characteristics, features of the household, and child's demographics. Grounded in the social determinants of health conceptual framework, this study aimed to investigate the determinants of HL-DBM in South Africa across the reproductive-child health continuum. Using the representative 2017 Wave 5 South African National Income Dynamics Study survey secondary data, a total sample of 314 homes met this non-experimental correlation study's criteria for HL-DBM. Pearson's Chi-Square tests and binary logistic regression were conducted to answer the research questions. Statistically significant associations were found between HL-DBM midstream determinants, including household (a) income level ($p = 0.021$), (b) food security ($p = 0.052$), and (c) main water supply ($p = 0.011$) and explained variances in HL-DBM in the study population. The midstream HL-DBM determinant, maternal marital status, (a) married ($p < 0.005$) and (b) divorced/separated ($p < 0.005$),was found to decrease the likelihood ratios of HL-DBM. As a proximal determinant, the child's age was statistically significant during binary logistic regression such that younger age categories had increased likelihood ratios of being HL-DBM pair. This study's positive social change impact results include contributing to the HL-DBM knowledge base and raising awareness to address the multisectoral double-duty drivers of HL-DBM.

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Dedication

It is with deep gratitude and love that I dedicate this dissertation to my husband, Mr. Alan Crozier, my daughter, Syjil, and my son, Ethan. Alan, you have been an unwavering pillar of strength to our family and I as we have navigated this doctoral journey. I remain indebted to you and will always love you sweetheart. Syjil, you are inspirational in the ways you take on life. Ethan, I am grateful for your good humor, sparkle, and joy. This work is also dedicated to my mum, Indherani Chetty. You sacrificed so many moments in your life so that I could have them in mine. Thank you mum.

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Section 1: Foundation of the Study and Literature Review

The double burden of malnutrition (DBM) presents a complex challenge to the public health community, given the sustainable development goals of ending all types of malnutrition and ensuring universal well-being and healthy lives by 2030 (World Health Organization [WHO], 2020). Defined as the co-existence of undernutrition and overnutrition at an, individual, household, and population-level DBM has transformed the global nutrition landscape. Moreover, vertical programs targeting specific types of malnutrition are complicated by thinness, wasting, and stunting alongside obesity and overweight.

With all countries affected by malnutrition, in 2017, among the worldwide population of under 5-year-old children, approximately 22%, or nearly 151 million, were stunted, 7.5% or almost 51 million were wasted, and 5.6%, or an estimated 38 million, were overweight (WHO, 2018). Simultaneously, adult obesity reached record levels in 2017, with nearly 40% of the global population of adults being overweight or obese. The WHO (2017) attributed the increasing prevalence of DBM in low- income and middle-income countries (LMICs) to the rapid nutrition, epidemiological, and demographic transitions.

In upper middle-income democratic South Africa (World Bank, 2021), changes to dietary patterns, consumption, and physical activity levels are linked to rapid and progressive socioeconomic and political development. However, the socioeconomic advances are against a backdrop of a neoliberal political economy, trade liberalization, substantial urbanization, and globalization, contributing towards the intersecting nutrition and epidemiological transitions (Prentice, 2018). The national epidemiological profile continues to shift from predominantly infectious diseases associated with undernutrition to non-communicable diseases due to emerging patterns of overnutrition (WHO, 2017). On the other hand, the demographic transition describes the pivots in the population dynamics from a comparatively higher proportion of younger people to an older population with a longer lifespan, which is typically associated with an increased burden of non-communicable diseases. Rather than the historical, almost linear progression of these transitions in high-income countries over several decades, the pace of the concurrent nutrition, epidemiological, and demographic transitions in LMICs has led to intra-, instead of inter-generational shifts in the type, quality, and quantity of foods consumed. Ultimately, the trend is a substitution of traditional indigenous diets to a homogenous diet comprising food with higher levels of saturated fats, sugar, salt, and lower levels of nutrients, vitamins, and minerals (Prentice, 2018).

In alignment with the nutrition and demographic transitions, South Africa's epidemiological profile has shifted in that infectious diseases (e.g., HIV and tuberculosis) in addition to non-communicable conditions (e.g., diabetes and cerebrovascular disease) contribute to the national burden of mortality and morbidity (Pillay-van Wyk et al., 2016). However, violence and unintentional injuries rank second behind HIV/AIDS as the foremost national causes of death and disability-adjusted life-years in South Africa (Suffla & Seedat, 2016). Further, a third of all South African women experience some form of emotional, sexual, and physical interpersonal violence, including intimate partner violence, in their lifetimes (Treves-Kagan et al., 2019). Despite the recorded prevalence of violence in South Africa, a recent inquiry by the United Nations' Committee on Elimination of Discrimination against Women (CEDAW, 2021) observed that the South African government had failed in fulfilling its due diligence responsibility of protecting women from domestic violence, resulting in a systematic violation of the Convention on the Elimination of all Forms of Discrimination Against Women. Notably, rather than a significant public health threat, domestic violence is regarded as a private issue restricted to the confines of the home (Mazibuko & Umejesi, 2019), which is further compounded by the lack of routine statistical data and research (CEDAW, 2021). With recent research identifying violence in the neighborhood as a considerable contributor to psychosocial and environmental stress that can influence biologic pathways (Mazibuko & Umejesi, 2019), this violence leads to overweight or obese women of reproductive age, who then have young children with signs of undernourishment (Wells, 2018; Wells et al., 2020).

Though the household-level (HL)-DBM is receiving increasing attention among public health researchers, few studies have explicitly focused on HL-DBM across the reproductive, maternal, neonatal, and child health continuum by limiting their study population to women of reproductive age and their under 5-year-old children with signs of undernutrition (i.e., thinness, stunting, or wasting). Several South African HL-DBM studies examined the prevalence of either under-or over-nutrition, whereas others have investigated the population and individual levels of DBM. Therefore, this study considered all types of under-5 undernourishment and aimed to examine the associations between the known determinants of DBM and HL-DBM in South Africa. Moreover, in addition to examining the possible effect of the frequency of domestic violence in the neighborhood on the occurrence of HL-DBM, this study utilized the social determinants of health (SDH). This conceptual framework unpacked the up-, mid-, and downstream influences of well-being (Omotoso & Koch, 2018) to investigate the risk and protective factors associated with the prevalence of HL-DBM amongst mother–child dyads.

This study's possible social change implications focused on building the evidence base on the types, prevalence, and root causes of malnutrition in South Africa and other LMICs. The findings of this study could inform multisectoral social policies, guidelines, and interventions aimed at addressing the intersecting upstream and midstream determinants that influence downstream determinants of risk to HL-DBM to improve population health outcomes. Finally, given that the HL-DBM issue is relatively new in public health literature, this study forms the foundation for additional research.

Problem Statement

Prevalence of malnutrition In South Africa in 2016–2018, the State of Food Security and Nutrition in the World (FAO et al., 2019) reported that undernutrition in the total population increased to 6.2% from 4.4% in 2004–2006. Among under 5-year-old South African children in 2016–2018, the prevalence of overweight was 13.3%, nearly 4% lower than in 2004–2006. Conversely, the prevalence rate of wasting and stunting was 2.5% and 27.2%, respectively, among under 5-year-old children living in South Africa. Among South African adults older than 18 years old, the obesity rate rose by 2.5% from 2004–2006 to 27% in 2016–2018. Therefore, the co-existence of wasting and stunting and overweight and obesity highlights South Africa's population-level DBM.

Maternal health predicting child health Maternal health during the periconceptional and prenatal stages significantly impacts maternal and child health outcomes in childbirth, infancy, and early childhood. There are critical windows, or successive physiologically sensitive stages, across the maternal and child health continuum, where nutritional status and growth have significant consequences for immediate survival, long-term well-being, and human capital (Wells et al., 2020). Through, among others, biological, socioeconomic, and cultural patterning, malnourished (i.e., either over-or under-nourished) mothers are more likely to give birth to children with one of the four types of malnutrition (i.e., stunting, thinness, wasting, or overweight and obesity; Wells et al., 2020). Sufficient weight gain and excessive weight gain are associated with suboptimal postnatal health, contributing to long-term effects, including obesity in the mother-and-infant pair (Galin et al., 2017). Especially during breastfeeding, mothers and their infants share household food resources (Sassi et al., 2018). Therefore, understanding the burden of malnutrition amongst non-pregnant women of reproductive age (i.e., between 15 and 49 years old) and the associated influence of malnourishment on under 5-year-old malnutrition patterns is crucial to predicting and managing short- and long-term child health outcomes (Wells et al., 2020).

Factors affecting DBM Most recent studies examining the risk and protective factors of DBM among mother–child pairs have investigated possible associations between race, ethnicity, maternal stature, breastfeeding status, maternal education, as well as household (a) size, (b) food security, (c) dietary diversity (Mahmudiono et al., 2019), and (d) infrastructure (Senekal et al., 2019). At a population level, South Africa’s prevalence of under- and over-nutrition among under 5-year-old children is spatially heterogeneous, with the health risks associated with DBM varying by age gender, ethnicity, and geographical location (Sartorious et al., 2020). At a HL, four combinations of household malnutrition include where the (a) child is both stunted and obese; (b) the under 5-year-old child shows signs of wasting and the mother is overweight; (c) mother is overweight, and the child is stunted; or (d) mother is thin, and the child is overweight (Wells et al., 2020). At an individual level, researchers have found evidence of stunting and overweight co-occurrence in children in all LMICs (Bates et al., 2017). Identified maternal sociodemographic characteristics associated with higher risks of HL-DBM include being African and married while having a tertiary education and larger household per capita income protected against HL-DBM (Brown, 2018).

Statistically significant determinants of HL-DBM also include (a) mother's age at first birth, (b) household middle wealth index, (c) no access to media, and (d) having two or more children (Das et al., 2019; Patel et al., 2020; Sunuwar et al., 2020). Further, children older than 6 months old are more likely to be part of an HL-DBM mother—child pair (Masibo et al., 2020).

Violence as a risk factor Neighborhood violence (i.e., observing or hearing about, interpersonal violence within the community), is an adaptable determinant of gestational weight gain (Galin et al., 2017), which can affect DBM. Neighborhoods with the highest reported violence were associated with undue gestational weight gain compared to those with minor accounts of violent behavior. Violence was not related to low gestational weight gain. Despite South Africa's reported burden of interpersonal violence among women (Treves-Kagan et al., 2019), current literature regarding possible associations between interpersonal violence exposure and the occurrence of HL-DBM in South Africa is limited.

Need for the study Given the existence of the critical features of HL-DBM in South Africa, alongside the national burden of domestic violence involving women, and its potential consequences to individual, community, and population levels of psychosocial and environmental stress (Mazibuko & Umejesi, 2019), understanding the distribution and possible drivers of this phenomenon is critical. Overnutrition, undernutrition, and the three combinations of HL-DBM among children and their mothers across the reproductive, maternal, neonatal, and child health continuum in the same household have yet to be investigated across South Africa's nine regions. The SDH framework was applied to study HL-DBM across South African dwellings to examine the possible associations between sociodemographic and household characteristics. Further, I investigated potential variances in the distribution of three common variations of HL-DBM (see Sassi et al., 2017) and identified risk and protective factors of DBM. Based on the prevalence of domestic violence amongst women living in South Africa (Mazibuko & Umejesi, 2019), I examined the association of the frequency of domestic violence in the neighborhood and the occurrence of HL-DBM.

Purpose of Study

The purpose of this quantitative study was to determine the upstream, midstream, and downstream determinants of the three common combinations of HL-DBM across the reproductive, maternal, neonatal, and child health continuum in households, where residents included

- Mothers of reproductive age (15–49 years) who are overweight or obese (i.e., a body mass index (BMI) equal to, or greater than, 25.0kg/m^2),
- At least one of the overweight or obese mother's under 5-year-old children with signs of undernourishment, including
    - Thinness, where the combination of HL-DBM is overweight or obese mother and under-weight child,
    - Low weight for age, or wasting, where the HL-DBM is overweight or obese mother and wasted child, and
    - Short for age, or stunted, where the variation of HL-DBM is overweight or obese mother and stunted child (Das et al., 2019; Masibo et al., 2020; Patel et al., 2020; Sunuwar et al., 2020).

Further, the known determinants of individual-level DBM of the mother and child included maternal (a) race, (b) ethnicity, (c) stature, (d) marital status, (e) educational level, and (f) BMI. Other identified factors influencing individual-level DBM are (a) family size, (b) household food security, (c) household dietary diversity, (d) urban or rural setting, (e) household wealth quintile, and (f) access to piped water, sanitation, and hygiene facilities. Lastly, the children's age, gender, and BMI-for-Age Z-scores are known to influence the burden of HL-DBM (Wells et al., 2020). Therefore, to determine the distribution and causes of HL-DBM, I examined the association between the known determinants of the individual- and population-level DBM and the three combinations of

HL-DBM. The association between maternal employment status and the occurrence of HL-DBM among South African households was also assessed. Finally, the association between the frequency of domestic violence in the neighborhood and any of the three combinations of HL-DBM in the mother–child pair living in the house was investigated.

Research Questions and Hypotheses

Research Question 1: In South Africa, how does the distribution of HL-DBM (i.e., the combination of maternal and child malnutrition) vary by (a) income step of the household today, (b) population group, and (c) type of dwelling?

$H_0 1$: In South Africa, there is no statistically significant variance in the distribution of HL-DBM associated with differences in the household's income step today, population group, and dwelling type.

$H_a 1$: In South Africa, there is a statistically significant variance in the distribution of HL-DBM associated with differences in income step of the household today, population group, and dwelling type.

Research Question 2: What is the association between South Africa's prevalence of HL-DBM and maternal (a) marital status, (b) highest level of education, and (c) employment status?

$H_0 2$: There is no statistically significant association between South Africa's prevalence of HL-DBM and maternal (a) marital status, (b) highest level of education, and (c) employment status.

H_a2: There is a statistically significant association between South Africa's prevalence of HL-DBM and maternal (a) marital status, (b highest level of education, and (c) employment status.

Research Question 3: What is the association between South Africa's prevalence of HL-DBM and household (a) food security, (b) minimum dietary diversity for women of reproductive age, (c) primary water source, and (d) type of available toilet?

H_03: There is no statistically significant association between South Africa's prevalence of HL-DBM and household (a) food security, (b) minimum dietary diversity for women of reproductive age, (c) primary water source, and (d) type of available toilet.

H_a3: There is a statistically significant association between South Africa's prevalence of HL-DBM and household (a) food security, (b) minimum dietary diversity for women of reproductive age, (c) primary water source, and (d) type of available toilet.

Research Question 4: What is the association between South Africa's prevalence of HL-DBM and the child's age (i.e., 0–59-months old age range) and gender?

H_04: There is no statistically significant association between South Africa's prevalence of HL-DBM and the child's age (i.e., 0–59 months old age range) and gender.

H_a4: There is a statistically significant association between South Africa's prevalence of HL-DBM and the child's age (i.e., 0–59 months old age range) and gender.

Research Question 5: What is the association between HL-DBM and the frequency of domestic violence in the neighborhood in South Africa?

H_05: There is no statistically significant association between HL-DBM and the frequency of domestic violence in the neighborhood in South Africa.

H_a5: There is a statistically significant association between HL-DBM and the frequency of domestic violence in the neighborhood in South Africa.

Theoretical Foundation of Study

Due to the emergent nature of DBM, researchers have used various frameworks to explore the possible root causes of malnutrition. For instance, Mahmudiono et al. (2019) used the socioecological model (i.e., a theoretical framework recognizing the interrelated intrapersonal, interpersonal, community, and organizational influences of health outcomes, to establish possible correlates of DBM). However, most researchers have applied the conceptual SDH framework to investigate malnutrition (Little et al., 2020; Omotoso & Koch, 2018). The SDH framework posits several domains of influence on equitable population health, including income and impoverishment, education level, housing, household infrastructure, social protection, culture, and gender.

Over the last few decades, increasing evidence has highlighted the SDH as the root cause of variances observed in population-level mortality and morbidity rates (Kabudula et al., 2017). The SDH is a conceptual framework underpinned by principles of social justice and the premise that addressing the basic structures of the social ladder and the resulting socially determined settings in which individuals experience life will strengthen health equity. The SDH further identifies interrelated and complex up-, mid-, and downstream influences on health that determine the extent to which individuals participate in risky or protective health behavior. Based on this framework, in-country differences in the rate of maternal, child, and household malnourishment occur along the socioeconomic, gender, political, cultural, and ethnic axes of the social gradient.

According to the SDH framework, socioeconomic differences lead to a social gradient and social patterning of ill-health. Though household income, education level, and employment status together serve as a composite measure of socioeconomic status, other proxy measures in LMIC conditions include household food security, household dietary diversity, housing type, and available household furniture and features (Omotoso & Koch, 2018). Individuals lower down the gradient experience poorer health outcomes than those higher up. Therefore, variances in socioeconomic status lead to socioeconomic and health inequities.

Another critical SDH that influences the rate of individual and HL-DBM centers around the availability of clean piped water, routine sanitation services, and hygiene practices (Senekal et al., 2019). As a mid-stream determinant of health, socioeconomic status influences the level of access to and quality of water, sanitation, and hygiene facilities. Across the social ladder, each lower rung of the ladder has access to weaker systems for clean water and sanitation, ranging from (e.g., piped water running through a household-based tap to fetching water from a locally situated water tank). Accordingly, socioeconomic status informs the type of toilet facilities households can access, ranging from indoor flush toilets to outdoor pit latrines (Omotoso & Koch, 2018).

Though traditional SDH evidence associates rural locations with lower socioeconomic status and, as such, poorer health outcomes, developing DBM-related research shows that rural settings might protect against the occurrence of DBM (Senekal et al., 2019). However, against the backdrop of rapid urbanization and the nutrition transition, increased access to cheap and calorific food in peri-urban and urban slums have established these locations as emerging risk factors for DBM (WHO, 2017). Finally, to support physical activity, which protects against malnourishment during pregnancy, the SDH framework argues that the neighborhood's quality and safety influence the extent to which individuals participate in physical activity (Omotoso & Koch, 2018). According to the SDH framework, impoverished neighborhoods, characterized by lower socioeconomic status levels, may lack the infrastructure and social protection to enable physical activity. Further, exposure to interpersonal violence in unsafe and poor communities may also influence activity levels. Therefore, to comprehensively unpack the distribution and influences of HL-DBM in South Africa, the SDH conceptual framework informed this investigation of the association between HL-DBM and known social causes.

Nature of Study

Using the nationally representative Wave 5 of the National Income Dynamics Study (NIDS) survey dataset (Brophy et al., 2018), I employed a quantitative analysis with a non-experimental correlation design (Creswell & Creswell, 2018). Other secondary data analysis techniques were descriptive and inferential to elucidate possible correlations that answer the proposed research questions. The population under study included South African households in which residents comprised mother–child pairs where the mother of child-bearing age is overweight or obese and at the same time, the under 5-year-old child shows signs of thinness, stunting, or wasting.

Consequently, the dependent variable was the household with any of the three combinations of HL-DBM (i.e., overweight or obese mother of reproductive age and her under 5-year-old child with signs of thinness, stunting, or wasting; Wells et al., 2020). The independent variables included the known determinants of DBM and HL-DBM: (a) household income step, (b) population group, (c) type of dwelling, (d) maternal marital status, (e) maternal highest level of education, (f) maternal employment status, (g) household food security, (h) minimum dietary diversity for women of reproductive age, (i) primary water source, (j) type of available toilet, (k) the child's age (0–59 months) and gender, and (l) the frequency of domestic violence in South Africa's neighborhoods.

Literature Search Strategy

The literature search strategy involved a comprehensive and systematic search of landmark and recent literature related to DBM in middle-income countries. In addition to including studies published from January 2016 and those with full text available in English for this literature review, other inclusion criteria included if the scope of the study focused on (a) middle-income countries, (b) malnutrition or malnourishment, and (c) individual, household, or population levels of malnourishment. Studies were excluded for this literature review if the research was set in high-income countries or examined either over- or under-nutrition only. The key search terms used to explore the databases Cinahl Plus with Full Text, Cinahl & Medline Combined Search, Thoreau Multi-Database Search, and Google Scholar included *South Africa*, the *double burden of malnutrition, undernutrition, and overnutrition, determinants of the double burden of malnutrition, influences on the double burden of malnutrition, malnourishment, etiology of the double-burden of malnutrition, maternal education and double-burden of malnutrition, nutrition transition, low- and middle- income countries, gender-based* *violence and the double burden of malnutrition*, *dietary diversity score*, *food environments,* and *double-duty actions*.

Literature Review based on Key Variables/Key Concepts

Household-Level Double Burden of Malnutrition

DBM is the co-existence of the extremes of the continuum of malnourishment (i.e., undernutrition like thinness, stunting, or wasting and overnutrition like overweight and obesity; Mahmudiono et al., 2019; Popkin et al., 2020; Wells et al., 2020; WHO, 2017). Due to the concurrent and rapid demographic, nutrition, and epidemiological transitions currently happening in LMICs (Popkin et al., 2020; WHO, 2017), DBM is characterized by multiple, overlapping, and different forms of malnutrition occurring at the individual, household, and population levels. DBM features a high national prevalence of under- and over-nutrition in at least one community. Conversely, persons with signs of stunting, thinness, wasting, and overweight or obesity represent individual-level DBM (Popkin et al., 2020).

DBM at the HL, which is the focus of this study, features one or more household members with signs of undernutrition alongside other family members with overweight or obesity living in the same home. The four combinations of HL-DBM include (a) stunted and overweight child, (b) overweight or obese mother and one of her under 5-year-old children shows signs of wasting, (c) overweight or obese mother and one of her under 5-year-old children is stunted, and (d) undernourished mother and one of her under 5-year-old children is overweight or obese (Popkin et al., 2020). Most mother–child pair DBM studies investigate the most prevalent HL-DBM combination—overweight mother and stunted child (Brown, 2018; Jones et al., 2018; Sassi et al., 2018). Conversely, the fourth combination of HL-DBM—thin mother and overweight or obese under 5-year-old child—is the least prevalent in most countries. Further studies have shown that the highest prevalence of HL-DBM was among overweight or obese mothers with a stunted child at 4.7 and the lowest prevalence among overweight or obese mothers with a wasted child at 1.7 (Das et al., 2019).

Other research has investigated the risk factors associated with HL-DBM. Mothers aged between 21 and 25 years old at the birth of their first child, middle wealth index households, no media access, and having more than two children were statistically significant predictors of HL-DBM (Das et al., 2019). Additionally, statistically significant risk factors include mothers older than 35 years old, wealthiest quintile, and completion of at least secondary level education (Patel et al., 2020; Sunuwar et al., 2020). Household wealth, children older than 6 months old, and urban residences are also risk factors for HL-DBM (Masibo et al., 2020). Further, the mother's characteristics of being married and African are risk factors for HL-DBM, whereas mothers with tertiary level education and higher household income protect against HL-DBM (Brown, 2018). Factors associated with HL-DBM have also included (a) child's gender, (b) maternal BMI, (c) access to water and sanitation, and (d) rural settings that are characterized by poverty and food insecurity (Modjadji & Madiba, 2019). Finally, race, maternal stature, breastfeeding status, maternal education level, as well as household (a) size, (b) food security, (c) dietary diversity, and (d) urban or rural setting are general socio-ecological correlates of DBM (Mahmudiono et al., 2019).

Regarding populations under study, few specified the inclusion of women of reproductive age in their study population (Modjadji & Madiba, 2019). But several South African-based HL-DBM studies did explicitly exclude under 5-year-old children (Modjadji & Madiba, 2019) or included 1 to 10-year-old children (Senekal et al., 2019). Additional studies investigated HL-DBM among mother-and-child pairs using primary data collection techniques in specific South African provinces (Modjadji & Madiba, 2019; Senekal et al., 2019). Other studies used secondary survey data to examine the nationwide burden and influences of HL-DBM (Brown, 2018; Sartorius et al., 2020). As such, there are no known South African-based studies investigating the countrywide patterning of the burden and determinants of HL-DBM among pairs of women of reproductive age (i.e., 15 to 49-years-old and their under 5-year-old children). However, given the significance of the reproductive, maternal, neonatal, and child health continuum for immediate and long-term health outcomes among children, addressing this gap in understanding is critical to developing initiatives to tackle all forms of malnutrition and achieve the sustainable development goal by 2030.

The Social Determinants of Health

SDH recognize socioeconomic inequities in the settings where individuals are born, reside, work, and mature resulting in avoidable health inequities (Donkin et al., 2017). Within-country inequities in the prevalence of malnutrition, for example, are related to the varying levels of power, resources, and income that individuals possess to influence their daily living conditions. Further, the SDH framework contends that differences in socioeconomic status, a composite measure of income, education level, and employment status between groups of individuals, establishes a social gradient. Those higher up the social gradient have more power, resources, and wealth and, as such, experience better health and health care. In contrast, those on progressively lower rungs experience increasingly poor health. Levels of access to, and quality of, health care, schooling, employment and working conditions, leisure and fitness facilities, and neighborhoods decrease between each lower rung of the social ladder (Donkin et al., 2017).

South Africa's Gini index, a measure of economic inequity with higher indices representing greater income inequity, was 63 in 2014 (World Bank, 2020). Based on this Gini index, South Africa epitomizes unambiguous social inequities, translating into high burdens of early mortality and significant health inequities (Mukong et al., 2017). For instance, the maternal mortality ratio in the relatively affluent urban Cape Town metropolitan is 56 deaths per 100,000 live births compared to over 370 deaths per 100,000 in the rural and impoverished Central Karoo (Omotoso & Koch, 2018). From an HL-DBM perspective, researchers have found a spatially heterogeneous distribution of under- and over-nutrition among under 5-year-old children (Sartorius et al., 2020). Notably, areas of eastern South Africa had higher rates of obesity, and western South Africa had higher rates of undernutrition.

Though the stunting prevalence was consistent across the country, all malnutrition forms were positively associated with low household income. Researchers have argued that lower and higher household incomes were associated with higher overnutrition rates than middle-income households, establishing a U-shaped social gradient to malnutrition

(Sartorius et al., 2020). Other malnutrition risks among under 5-year-old children have differed by age, gender, ethnicity, and geographical location. Maternal education level, stature, and household water and sanitation facilities are other risk factors (Senekal et al., 2019). Food security and dietary diversity are also key mid-stream determinants of malnourishment (Wells et al., 2020).

Household Income Step, Population Group, and Type of Dwelling

Household income step and HL-DBM In their study of DBM in a South African rural health and demographic surveillance site, researchers found a positive association with HL-DBM and low-income households, featuring unemployment and low monthly incomes (Modjadji & Madiba, 2019). Conversely, in their investigation of DBM among one to ten-year-old children living in wealthy urbanized cities in South Africa, scientists found that middle-income households were protective against HL-DBM (Sartorius et al., 2020; Senekal et al. (2019). Indeed, a U-shaped social pattern to DBM was established, with higher overnutrition rates associated with low and high-income households (Sartorius et al., 2020). Yet, other researchers determined that the wealthiest quintile was a statistically significant risk factor for HL-DBM in Nepal (Masibo et al., 2020; Patel et al., 2020; Sunuwar et al., 2020). In Bangladesh, researchers found that the median wealth index was a risk factor for HL-DBM in Bangladesh (Das et al., 2019).

Regarding population groups, Brown (2018), Popkin et al. (2020), and Wells et al. (2020) found an association between population groups and the prevalence of HL-DBM.

Type of dwelling, settings, and HL-DBM Types of dwelling in peri-urban settings, (i.e., informal homes, or shacks, rooms or flatlets, and caravans or tents), in densely populated regions on the outskirts of major metropolitan cities, are associated with a higher risk of HL-DBM (Jones et al., 2018). South African peri-urban areas and urban slums feature relatively deficient infrastructure, unregulated land use, unemployment or intermittent employment, and food insecurity. These settings feature low levels of dietary diversity and high environmental degradation and vulnerabilities. Some researchers further identified rural and tribal dwellings as significantly associated with child undernourishment (Sartorius et al.,2020), whereas others established urban areas as a risk factor for HL-DBM (Masibo et al.,2020).

Maternal Marital Status, Highest Level of Education, and Employment Status

Maternal marital status and HL-DBM Although a nationally representative quantitative cross-sectional study associated married mothers with increased odds of DBM (Brown, 2018), other research in two affluent urbanized settings determined that having a married mother was protective against DBM (Senekal et al., 2019).

Maternal highest level of education and HL-DBM Maternal completion of tertiary education was identified as a protective factor of HL-DBM (Brown, 2018). Other nutrition scientists confirmed that low maternal education was a predictor of under-nourishment among children in LMICs and South Africa, respectively (Mahmudiono et al.,2019; Sartorius et al., 2020). Notably, the lack of access to media and education was associated with HL-DBM in Bangladesh, a lower-middle-income country (Das et al., 2019). In Nepal, a lower-middle-income country, higher odds of HL-DBM significantly correlate with maternal completion of secondary school than with no education (Sunuwar et al., 2020).

Maternal employment status and HL-DBM South Africa's situation is unique regarding maternal employment status since high labor migration rates across and within provinces are a leading feature (Magadla et al., 2019). Researchers contend that female employment in rural areas is culturally forbidden since communities require women to care for their families (Mkhize & Sibanda, 2020). In other instances, female migrant workers may respond to motherhood by leaving their infants in the care of grandparents or caregivers (Magadla et al., 2019). Therefore, little is known about the association between maternal employment status and HL-DBM forms among mother—child pairs living in the same household.

Household Food Security, Dietary Diversity, Primary Water Source, and Type of Available Toilet

Household food security and HL-DBM Food security is when all persons have physical and economic access to adequate, high-quality nutrient-dense foods to support an active and healthy lifestyle (Gubert et al., 2017). After adjusting for macro and household-level socioeconomic variables, household food insecurity was identified as a risk factor for HL-DBM amongst mother and child pairs (Gubert et al., 2017). Other nutrition scientists have confirmed household food insecurity as a significant risk of malnutrition, particularly undernutrition (Drammeh et al., 2019). The South African National Poverty Line (NPL) is a helpful estimate of the requisite expenditure to afford the minimum required daily energy consumption (Cheteni et al., 2020). In 2018, considering the price of goods and services, the updated NPL was reported as 547 per person per month in South African Rand (Statistics South Africa, 2018). As such, the NPL serves as a critical cut-off measure of food security (Cheteni et al., 2020).

Dietary diversity and HL-DBM The notion of food security is linked to dietary diversity, such that dietary diversity is a qualitative measure of food consumption (Chakona & Shackleton, 2017). Further, dietary diversity reflects household access to a range of food categories, from cereals to fresh vegetables and fruit, as well as animal-source protein. Researchers have highlighted the lowest minimum dietary diversity scores were found in peri-urban regions and were associated with high poverty, unemployment, and lack of land ownership for subsistence agriculture (Chakona & Shackleton, 2017).

Minimum dietary diversity and women of reproductive age Dietary diversity is a crucial component of dietary quality among women of reproductive age that ensures adequate consumption of a range of micronutrients and is associated with HL-DBM (Martin-Prevel et al., 2017; Popkin et al., 2020; Wells et al., 2020). In completing the secondary analysis of nine quantitative dietary datasets , researchers identified ten food groups required for minimum micronutrient adequacy in women of reproductive age (Martin-Prevel et al., 2017). With each food group allocated a score of one, the cut-off point of five was established for the minimum dietary diversity score for women of reproductive age (Martin-Prevel et al., 2017). Therefore, if a household accessed less than five of the ten food groups, the household was categorized as having poor dietary diversity. Good dietary diversity included those houses with access to five and more of the ten food groups.

Water, sanitation, hygiene practices and HL-DBM Improved water, sanitation, and hygiene practices were associated with a reduced risk of stunting (Dearden et al., 2017). Other researchers confirm the negative association between improved household access to clean water and toilet facilities and undernutrition (Modjadji & Madiba, 2019; Senekal et al., 2019).

The Child's Age and Gender

In their study of primary school-going children in a demographic and health site in rural South Africa, nutrition scientists found a positive association between the child's gender and maternal BMI, with boys being more likely to be undernourished than girls (Modjadji & Madiba, 2019). In studying DBM amongst one to ten-year-old children living in Cape Town and Johannesburg, South Africa, other researchers confirmed this association between the child's male gender and increased risk of undernutrition (Senekal et al., 2019).Regarding the child's age, DBM investigators identified children less than two-years-old as having an increased risk of malnutrition (Senekal et al,2019; Tziomis et al., 2016), whereas others determined a decreased risk of HL-DBM in children younger than six months compared to older children (Masibo e tal., 2020).

The Frequency of Domestic Violence in the Neighborhood

Although there is no known research investigating exposure to interpersonal violence and HL-DBM, several studies highlight the association between interpersonal violence, low birth weight, and signs of stunting amongst children (Budree et al., 2017; Chai et al., 2016; Neamah et al., 2018). However, given the high burden of interpersonal violence against women living in South Africa, (i.e., a total female homicide rate of nearly 13 per 100,000 in 2009), more than three times the global estimate (Suffla & Seedat, 2016), this is a critical area of research.

Definitions

African population group: In this study, the African population group represents indigenous people who make up the majority (80.9%; n = 48,640,329) of the total South African population (Statistics South Africa, 2021).

Body mass index (BMI): Estimated by dividing weight in kilograms by height in meters squared, adults with a BMI below 18 are underweight (WHO, 2020). Conversely, in adults, BMI measurements between 25.0 and 29.9 reflect overweight, while a BMI measure of 30.0 and above represents obesity.

Household dietary diversity: Usually determined by the quantitative Dietary Diversity Score (DDS), household dietary diversity measures the household variety in diet and, by proxy, micronutrient adequacy (Zhao et al., 2021). Researchers have established ten essential food groups required for a micronutrient-dense diet for women of reproductive age and assigned each group a score of one (Martin-Prevel et al., 2017). This measure of the minimum dietary diversity for women of reproductive age has a cut-off point of five such that households with access to less than five of the food groups have poor dietary diversity. Conversely, those houses with access to more than five of the food groups have good dietary diversity.

Food security: The household achieves food security when each household member continuously has physical and financial access to adequate, safe, and nutrient-dense food that satisfies their dietary requirements and food choices to support healthy lifestyles (FAO et al., 2019). The National Poverty Line (NPL) of 547 South African Rand (Statistics South Africa, 2018) was a helpful cut-off estimate of the required expenditure needed to afford the necessary energy intake per person daily (Cheteni et al., 2020). If the household expenditure on food per resident was found to fall at or below the NPL, the household was categorized as food insecure. Household food expenditure per member falling above the NPL were food secure.

Malnutrition: Malnutrition is an umbrella term covering undernutrition, overweight, and obesity to describe the deficits, excesses, or imbalances in individual consumption of energy and nutrients (FAO et al., 2019).

Overweight and obesity: Represented with BMI measurements ranging from 25.0 and above, overweight and obesity are usually a result of consuming energy-dense foods with little physical activity (FAO et al., 2019).

Stunting: Stunting is a form of undernutrition characterized by low length-for-age or height-for-age less than two standard deviations below the median length-for-age or height-for-age of the WHO Multicenter Growth Reference Study Group (WHO Multicenter Growth Reference Study Group, 2006) child growth standards.

Thinness: Thinness is a form of undernourishment characterized by having a weight-for-age less than two standard deviations below the median weight-for-age of the WHO Multicenter Growth Reference Study Group (2006) child growth standards.

Wasting: Wasting is a form of under-nutrition, represented by having weight-for-height or weight-for-length of less than two standard deviations below the median weight-for-height and weight-for-length of the WHO Multicenter Growth Reference Study Group (2006) child growth standards.

Assumptions

Appropriately calibrated anthropometric equipment used during the survey ensured the collection of high-quality data on (a) length measurements for children younger than two-years-old, (b) height measures for those older than two-years-old, as well as (c) weight, and (d) age for respondents (FAO et al., 2019). Further, mothers responded wholly and accurately regarding household food security, dietary diversity, and domestic violence frequency in the neighborhood. Finally, all household members under the age of 5 and their mothers were present at the survey time.

Scope and Delimitations

As discussed in the research problem, most HL-DBM studies examine the malnutrition combination of overweight mother and stunted child pairs, with little investigation of other forms of HL-DBM (Brown, 2018; Sassi et al., 2018; Das et al., 2019; Popkin et al., 2020). Despite a few researchers explicitly including mothers of reproductive age, (i.e., between 15 and 49 years old), other studies did not limit the age band for mothers included in their studies (Modjadji & Madiba, 2019). Regarding the age of children included in investigations of HL-DBM, some studies expressly excluded children under 5, whereas others focused their examination on under 5-year-old children (Modjadji & Madiba, 2019). Further, some studies considered local or regional settings only and analyzed primary data collection methods (Modjadji & Madiba, 2019; Senekal et al., 2019). Other cross-sectional design studies used nationally representative secondary survey data to investigate HL-DBM (Brown, 2018; Sartorius et al., 2020). Due to the inadequate knowledge regarding HL-DBM among mother—child pairs, where the mother is of reproductive age and her child is under 5 years, this study focused explicitly on these pairs across the reproductive, maternal, neonatal, and child health continuum. The inclusion criteria for this study included South African households with a mother—child pair where an overweight or obese mother had an underweight child, wasted child, or stunted child. Additionally, mothers were between 15 and 49 years (i.e., of reproductive age), and their children were under 5 years old (i.e., 0—59-months-old).

The SDH, the conceptual framework guiding this study, has been used extensively to investigate malnutrition determinants (Bell et al., 2019; Lakerveld & Mackenbach, 2017; Yusuf et al., 2020). Data from the 2017 NIDS survey is population-level data generalizable to the South African population for 2017. However, additional delimitations consisted of sample size and research questions because of the secondary data set chosen.

Significance and Summary

Informs improved public health practice Nutrition scientists acknowledge the public health community's slow response to the increasing manifestation of HL-DBM. Indeed, initiatives remain primarily vertical to address undernutrition or overnutrition (Popkin et al., 2020). Other researchers contend that these vertical interventions targeting undernutrition have, in some instances, inadvertently exacerbated the prevalence of obesity and overweight (Hawkes et al., 2020). Significantly, there is a growing call for double-duty actions, (i.e., public health programs or policies), that simultaneously address nutritional deficiencies that cause stunting, wasting thinness, and micronutrient deficiencies and initiatives that influence obesity (Hawkes et al., 2020). However, for public health practitioners to design and implement such targeted and efficient double-duty actions, clear evidence is required regarding the distribution of HL- DBM across the sub-national regions of South Africa. Critically, evidence-informed double-duty activities require an in-depth understanding of the interrelated upstream and midstream determinants that influence downstream determinants of risk and vulnerability to HL-DBM.

This study addresses knowledge gaps to support evidence-driven decision-making. Quantitative evidence of the nationwide distribution and the downstream and midstream determinants of HL-DBM amongst South African citizens determined by this study contributes to the growing knowledge base regarding DBM in low-income and middle-income countries. By identifying the overall determinants of HL-DBM in South Africa, policymakers can advance appropriate evidence-informed and multisectoral social policy and strategies to improve public health. Data from this research addresses several knowledge gaps in the complex area of DBM and persistent malnutrition in South Africa.

Summary of study's significance The literature review demonstrated the limited and inconsistent examination and findings of the full spectrum of HL-DBM combinations amongst mother and child pairs within the specific age categories proposed here. Additionally, no known studies have examined the association between the frequency of domestic violence in the neighborhood and HL-DBM. Notably, given South Africa's high labor migration rates across and within provinces, little is known about the association between maternal employment status and HL-DBM (Magadla et al., 2019). Lastly, the study's results can support advocacy efforts through the comprehensive literature review, research questions, and robust data analysis. Significantly, the findings generated through this study can inform policy-making initiatives tackling the root causes of the determinants of HL-DBM in South Africa.

Section 2: Research Design and Data Collection

To investigate the prevalence and factors influencing HL-DBM among mothers and children in South Africa and other LMICs, other researchers have focused on the malnutrition combination of overweight mother and stunted child dyads (Brown, 2018; Jones et al., 2018; Popkin et al., 2020; Sassi et al., 2018). Other research involved primary data collection with a comparatively small population limited to a specific region or city (Modjadji & Madiba, 2019; Senekal et al., 2019). Further, I only found one study that specified women of reproductive age (15- to 49- years old), which excluded children under 5 years from their study population (Modjadji & Madiba, 2019). To my knowledge, the association between combinations of household-level malnutrition and the frequency of domestic violence in the neighborhood had not been investigated in South Africa.

Building on previous research, the gaps in the literature included the prevalence and determinants of the four types of HL-DBM in South Africa. This study aimed to establish the intersecting upstream and midstream determinants that influence downstream factors and levels of risk to the combinations of HL-DBM. Informed by the conceptual SDH framework, the determinants of HL-DBM among household pairs of South African women of reproductive age (i.e., 15 to 49 years old) and their under 5-year-old children were investigated. In this section, the research design and rationale, methodology, threats of validity, and ethical procedures applied during this research are described.

Research Design and Rationale

This study aimed to investigate the association between HL-DBM and (a) population group, (b) type of dwelling, (c) maternal sociodemographic factors, (d) household characteristics, (e) demographic characteristics of the under 5-year-old child, and (f) the frequency of domestic violence in the neighborhood. Thus, this study called for a quantitative research methodology that measured and analyzed the association between variables using statistical data (Creswell & Creswell, 2018). Routinely used to quantify the burden of health conditions, quantitative data analysis also reveals the socioeconomic disparities of health conditions. Further, this study used cross-sectional nationally representative secondary survey data from the 2017 NIDS dataset, appropriately supporting the selected non-experimental, cross-sectional quantitative design.

The secondary dataset generated through the NIDS survey collected nationwide quantitative data at a point in time to offer numeric data on the prevalence of HL-DBM and key sociodemographic, household, and health-related data. Therefore, it was an appropriate secondary dataset to respond to the research questions. In addition to descriptive statistics on the study population’s sociodemographic characteristics and independent variables, analytical statistics were applicable for accepting or rejecting this study’s hypotheses. The selected study design was convenient, cost-effective, timely, and used a publicly available secondary dataset. Finally, this study design was consistent with other studies investigating the HL-DBM in mother and child pairs in South Africa and other middle-income countries (Brown, 2018; Das et al., 2019; Sartorius et al., 2020; Sassi et al., 2018).

Research Questions and Hypotheses

This study's foundation was the following five research questions and their related hypotheses, which are provided here to understand the variables of interest better.

Research Question 1: In South Africa, how does the distribution of HL-DBM (i.e., the combination of maternal and child malnutrition) vary by (a) income step of the household today, (b) population group, and (c) type of dwelling?

$H_0 1$: There is no statistically significant variance in the distribution of HL-DBM associated with differences in income step of the household today, population group, and type of dwelling.

$H_a 1$: There is a statistically significant variance in the distribution of HL-DBM associated with differences in income step of the household today, population group, and type of dwelling.

The independent variables for Research Question 1 are (a) the income step of the household on the day of the survey, (b) population group, and (c) type of dwelling. The dependent variable is HL-DBM, derived by the co-occurrence of overweight or obese mother of reproductive age (i.e., 15 to 49-years old) and her under 5-year-old child that shows signs of thinness, low weight for age or wasting, or short stature for age or stunting (Das et al., 2019; Sunuwar et al., 2020). Therefore, the dependent variable is South African households with any combinations of HL-DBM (i.e., overweight or obese mother and underweight child, overweight or obese mother and wasted child, and overweight or obese mother and stunted child).

Research Question 2: What is the association between South Africa's prevalence of HL-DBM and maternal (a) marital status, (b) highest level of education, and (c) employment status?

$H_0 2$: There is no statistically significant association between South Africa's prevalence of HL-DBM and maternal (a) marital status, (b) highest level of education, and (c) employment status.

$H_a 2$: There is a statistically significant association between South Africa's prevalence of HL-DBM and maternal (a) marital status, (b) highest level of education, and (c) employment status.

The independent variables for Research Question 2 are maternal (a) marital status, (b) highest level of education, and (c) employment status, and the outcome variable is South African households with any one of the three combinations of HL-DBM (i.e., overweight or obese mother and underweight child, wasted child, or stunted child).

Research Question 3: What is the association between South Africa's prevalence of HL-DBM and household (a) food security, (b) minimum dietary diversity for women of reproductive age, (c) primary water source, and (d) type of available toilet?

$H_0 3$: There is no statistically significant association between South Africa's prevalence of HL-DBM and household (a) food security, (b) minimum dietary diversity for women of reproductive age, (c) primary water source, and (d) type of available toilet.

H$_a$3: There is a statistically significant association between South Africa's prevalence of HL-DBM and household (a) food security, (b) minimum dietary diversity for women of reproductive age, (c) primary water source, and (d) type of available toilet.

The independent variables for Research Question 3 are household (a) food security, (b) minimum dietary diversity for women of reproductive age, (c) primary water source, and (d) type of available toilet. The outcome variable is South African households with any one of the three combinations of HL-DBM (i.e., overweight or obese mother with underweight child, wasted child, or stunted child) .

Research Question 4: What is the association between South Africa's prevalence of HL-DBM and the child's age (i.e., 0—59-months old age range) and gender?

H$_0$4: There is no statistically significant association between South Africa's prevalence of HL-DBM and the child's age (i.e., 0—59 months old age range) and gender.

H$_a$4: There is a statistically significant association between South Africa's prevalence of HL-DBM and the child's age (i.e., 0—59 months old age range) and gender.

The independent variables for Research Question 4 are the under 5-year-old child's age (i.e., 0—59 months) and gender. In contrast, the outcome variable is South African households with any one of the three combinations of HL-DBM (i.e., overweight or obese mother and underweight child, wasted child, or stunted child).

Research Question 5: What is the association between HL-DBM and the frequency of domestic violence in the neighborhood in South Africa?

*H_0*5: There is no statistically significant association between HL-DBM and the frequency of domestic violence in the neighborhood in South Africa.

*H_a*5: There is a statistically significant association between HL-DBM and the frequency of domestic violence in the neighborhood in South Africa.

The independent variable for Research Question 5 is the frequency of domestic violence in South Africa's neighborhoods. Consequently, the outcome variable is South African households with any one of the three combinations of HL-DBM (i.e., overweight or obese mother and underweight child, wasted child, or stunted child).

Variable Description and Measurement

Among the independent and dependent variables were nominal (i.e., categorical), dichotomous, and scale (i.e., continuous measurements scales). However, the continuous variables were converted into categorical measures through different computation methods (e.g., food security and the child's age in months). Regarding the variable food security, the South African national poverty line served as a valuable measure of finances required by an individual to afford the minimum required daily energy intake (Cheteni et al., 2020). In 2018, considering the price of goods and services, Statistics South Africa (2018) reported a revised national poverty line of 547 per person per month in South African Rand. Based on the national poverty line and using the variables monthly food expenditure with imputations and number of household residents, household monthly food expenditure per capita were derived and served as a dichotomous measure of household food security. If the derived value was equal to or less than the 2018 national poverty line, the household was categorized as food insecure, and households with values above the national poverty line were food secure. Regarding the independent variable child's age in month, this variable was recoded into suitable age ranges including 0–6 months, 6–24 months, 25–36 months, 37–48 months, and 49–59 months to serve as a categorical measure of the child's age.

Categorical variables included (a) income step of the household, (b) population group, (c) type of dwelling, (d) maternal marital status(e) maternal employment status, (f) maternal highest level of education, (g) household's primary water source, (h) household type of available toilet, and (h) the frequency of domestic violence in the neighborhood. The child's gender, maternal marital status, minimum dietary diversity for women of reproductive age, and the dependent variable (i.e., the three combinations of HL-DBM) were measured as dichotomous variables.

Methodology

Study Area

Occupying the southernmost tip of the African continent, South Africa, making a peaceful transition to democracy nearly 25 years ago, is an ethnically diverse upper-middle-income country (Schneider, 2018). Of the country's almost 56 million citizens (Statistics South Africa, 2021), females constitute 51%, and those 15 to 34-years old make up over 36% of the total population. An estimated 79% of all South Africans live in formal housing, nearly 84% have access to piped water and over 90% access electricity. However, this overall progress hides the entrenched socioeconomic inequity reflected by the country's high Gini index of 63, as measured last in 2014 (World Bank, 2021). Some population groups are wealthy across the country, having access to privately funded education and health care. At the same time, nearly 56% of people live at the national poverty line (i.e., $1.90 a day) as estimated last by the World Bank (2021) in 2014.

Furthermore, the country's two-tiered health system remains underfunded and understaffed, with the government-funded system providing health care to 84% of the population. In comparison, the privately funded sector delivers health care services to the remaining 14%. South Africa's epidemiological profile also comprises several colliding diseases. These include (a) communicable diseases (e.g., HIV, AIDS, and tuberculosis); (b) non-communicable diseases (e.g., cardiovascular disease, mental health issues); (c) substance abuse, interpersonal violence, and road accidents; and (d) high mortality rates driven by poor maternal and child health outcomes (Sartorius et al., 2020). Against the background of rapid urbanization, globalization, and a neoliberal political economy, the intersection of these multiple epidemics further emphasizes the country's rapid economic, nutrition, and epidemiological transition, resulting in the DBM.

Data and Sampling Methods

Researchers using quantitative methods intend to quantify and analyze variables to develop generalizable findings across the population and increase the understanding of an issue (Creswell & Creswell, 2018). Quantitative researchers use specific sampling strategies to identify a representative sample (i.e., a subset group that resembles the broader population). In 2008 with the first round of face-to-face biennial data collection, Wave 5 of the government-led South African NIDS was conducted in 2017, marking 10 years of the panel longitudinal study (Brophy et al., 2018). Importantly, since this study only used Wave 5 of the NIDS, the design was cross-sectional (Creswell & Creswell, 2018). With households and individuals as the units of analysis, the NIDS covered all nine South African provinces.

The population targeted for the NIDS was private households and residents in workers' hostels, convents, and monasteries. Simultaneously, collective living quarters, (e.g., nursing homes and hospitals) were excluded from the sampling frame (Brophy et al., 2018). Using the 2003 Statistics South Africa Master Sample of 3,000 primary sampling units, the NIDS researchers used a stratified two-stage cluster sampling strategy to include 400 primary sampling units across South Africa's district councils at baseline in 2008. The researchers proportionally allocated the master sample of 3,000 to the 53 district councils that served as explicit strata. The final primary sampling unit was subsequently randomly selected within strata. NIDS data were collected at baseline from 7,305 participating households, comprising 28,255 household members, who would become continuing sample members (CSMs). The design of the NIDS survey involved following the baseline CSMs (Brophy et al., 2018).

Due to attrition of White and Indian CSMs across the primary sampling units, Wave 5 of the NIDS included a top-up sampling design that used the same sampling strategy as Wave 1. However, researchers applied one exception. The sampling frame only included urban residential areas from the 2011 Census (Statistics South Africa, 2012), where the proportion of White and Indian residents was more than 50% and 20%, respectively (Branson, 2019). With the top-up sample in 2017, NIDS reached a representative sample of 13,719 households, 13,464 adults (15 years old and older), and

6,878 children (14 years old and younger). In 2017, NIDS completed data collection by administering four different questionnaires at households, including

- The household questionnaire that the oldest female resident completes, or whomever else is knowledgeable about the household characteristics, with a focus on spending,
- The adult questionnaire administered to all those above 15 years old,
- The proxy questionnaire that another adult completes in the absence of the head of the household, and
- The child questionnaire administered to the child's primary caregiver collects data on educational history, access to social and other government grants, and anthropometry measurements for those under 14 years of age (Brophy et al., 2018).

Power Analysis

In hypothesis testing, power analysis allows researchers to determine the sample size required to maximize the probability of observing the hypothesized effect (Perugini et al., 2018). Power analysis depends on the sample size, effect size, and alpha level to prevent Type I and Type II errors (Anderson, 2019). Therefore, the magnitude of the effect size in the study population influences the sample size necessary to achieve the expected statistical power. The study population was South African households with any of the three combinations of HL-DBM (Anderson, 2019).

Larger effect sizes, including the size of correlations between dependent and independent variables, are linked to a greater probability of statistical significance, as determined by the level set as the alpha value, and greater statistical power. In contrast, the appropriate sample size allows researchers to draw valid and reliable conclusions (Perugini et al., 2018). Although acknowledging the equal importance of small effect sizes, increasing the sample size offers a flexible approach to increasing the statistical power and effect size (Anderson, 2019). A large sample size improves the study's replicability (internal validity) and the generalizability of findings across the study's target population (external validity).

G*Power v 3.1.9.7 was used to conduct a priori power analysis to establish the minimum required sample size for this study. Significance level, effect size, the test power, and statistical test are factors needed to determine the sample size (Anderson, 2019). As researchers contend, a 95% confidence level and power set at 95% in most quantitative studies provide adequate statistical evidence of a test (Perugini et al., 2018). Other scientists argues for a medium effect size rather than a small effect size (strict) or a large effect size (lenient) (Anderson, 2019). A logistic regression statistical test was used for this power analysis. To conduct a logistic regression to detect a medium effect size, the Odds Ratio (OR) = 1.5 at the 5% level of significance with 95% power, the minimum required sample size was 337. Table 1 shows the parameters used to estimate the minimum required sample to conduct a logistic regression test.

Table 1

Logistic Regression for Sample Size

Input	Tails	Two
	Odds Ratio	1.5
	Pr(Y=1|X=1) H0	0.5
	α err prob	0.05

	Power (1-β err prob)	0.95
	R^2 other X	0
	X distribution	Normal
	X parm μ	0
	X parm σ	1
Output	Critical z	1.9599640
	Total sample size	337
	Actual power	0.9500770

Note. Options: Large sample Z test, Demidenko (2007) with var corr. Analysis: A priori: Compute required sample size.

Academics note that the estimation of a minimum required sample size for a logistic regression test requires an understanding of the expected effect size, or odds ratio, a proportion of observations of the dependent variable, and the distribution of every independent variable (Anderson, 2019; Perugini et al., 2018). If these factors are unknown, a minimum sample of 30 observations per independent variable is proposed (LeBlanc & Fitzgerald, 2000), which for this study implied a minimum required sample of 30 x 13 = 390 survey respondents. Three hundred and sixty-four (364) respondents were needed to achieve a power of 95%, considering the average of the two estimations of the minimum sample size (Anderson, 2019; Le Blanc & Fitzgerald, 2000; Perugini et al., 2018).

Study Population

The sample in this study consisted of South African households surveyed in 2017 with mother—child pairs showing signs of the three combinations of HL-DBM, including overweight or obese mother and children under 5 showing signs of thinness, wasting, or stunting (Das et al. , 2019; Sunuwar et al., 2020).

Anthropometric data collection techniques and interpretation Fieldworkers applied anthropometry techniques to collect data for the three combinations of HL-DBM by completing (a) weight measurements for mothers between 15 and 49 years old and their under-5-year-old children, (b) height measurements for mothers of reproductive age and children older than two-years-old and under-5-years-old, and (c) length measurements for children under two-years-old (Brophy et al., 2018). Based on the WHO’s Global Database on BMI (2020), women of reproductive age whose ratio of the weight to height squared, (i.e., BMI) is equal to or greater than 25kg/m^{2}are considered overweight. Alternatively, those with a BMI equal to or greater than 30kg/m^2 are considered obese. For children, 0—59 months old, the WHO’s Global Database on Child Growth and Malnutrition (UNICEF & WHO, 2019; WHO Multicenter Growth Reference Study Group, 2006) utilizes a z-score cut-off point below two standard deviations for their age to classify moderate low weight-for-height (thinness), low length/height-for-age (stunting), and low weight-for-length/weight (wasting).

Descriptive statistics revealed the frequencies of HL-DBM of the identified households with any of the three forms of HL-DBM across the total study population of households comprising women of reproductive age and an under-5-year-old child in South Africa. Imputed variables from collected data included (a) income step of the household today, ranging from ladder rung one (poorest) to ladder rung six (richest), (b) maternal employment status (employed and unemployed), and (c) total food expenditure, which is the aggregated value of food and non-food items purchased in the previous 30 days (Brophy et al., 2018).

Data elements collected Other collected data included(a) population group (African, Colored, Asian/Indian, and White), (b) type of dwelling (ranging from dwelling/house or brick structure on a separate stand or yard or the farm to caravan/tent), (c) maternal marital status (ranging from married to never married), and (d) maternal highest level of tertiary education completed by the mother. Regarding household characteristics, fieldworkers collected data on(a) household consumption of different food categories, including the ten food groups required to compute the Minimum Dietary Diversity Score for Women of Reproductive Age, (b) household's primary water source (ranging from piped tap water inside the dwelling to springs), (c) the type of toilet facility available to the home (running from flush toilet with onsite disposal to bucket toilet to no toilet facility), and (d) the frequency of domestic violence in the neighborhood (ranging from never happens to very common). Finally, the child, (i.e., under 14-year-old children), gender, and age in months data were also collected (Brophy et al., 2018).

Data Sources and Data Collection

Surveys designed by public health researchers allow practitioners to quantify variables of interest, (e.g., the prevalence of a health issue) (Dworkin, 2018). Researchers can also examine statistical associations between the variables of interest and sociodemographic and other characteristics within the study population. These surveys usually employ a weighted, non-experimental research design. In this study, Wave 5 of the panel NIDS survey collected data mainly from the same study population starting in 2008, with Wave 1 (Brophy et al., 2018). Commissioned by the South African Presidency in 2006 and conducted by the Southern Africa Labor and Development Research Unit, situated within the University of Cape Town's School of Economics, the South African Department of Planning funded the NIDS study Monitoring and Evaluation. The panel survey investigates South African households' dynamic nature, including shifts in household income, assets, expenses, health, and additional aspects of well-being.

Population groups targeted for the survey Focusing on private households, residents in workers' hostels, convents, and monasteries across all of South Africa's nine provinces and 53 district councils, fieldworkers collected NIDS collected from 7,305 households 28,255 household residents in 2008. This baseline study population became CSMs, intending to follow these CSMs every second year (Brophy et al., 2018). However, by 2017, in planning for Wave 5 data collection, researchers noted the attrition of White and Indian/Asian CSMs across the primary sampling units. Using the updated Census (Statistics South Africa, 2012), researchers applied the original sampling approach to include a top-up sample. The limited sample frame included urban residential areas for the top-up sample, where the proportion of White and Indian residents was more than 50% and 20%, respectively. With the top-up sample, Wave 5 data collection reached 36,046 CSMs, of which 82.2% (n = 33,642) were African, 8.3% (n = 3,397) were Colored, 3.3% (n = 1,350) were Indians, and 6.2% (n = 2,537) were White.

Survey data collection tools With all household residents becoming NIDS CSMs, fieldworkers used the adult, (i.e., over 15-years-old), questionnaire to collect data on (a) population group, (b) type of dwelling, (c) maternal marital status (ranging from married to never married), and (d) maternal highest level of tertiary education completed by the mother (Brophy et al., 2018). Using the household questionnaire, fieldworkers collected data regarding (a) household consumption of different food categories, (b) household's primary water source, (c) the type of toilet facility available to the home, and (d) the frequency of domestic violence in the neighborhood. Lastly, for those under 14-years-old, child data on gender and age in months were collected using the child questionnaire (Brophy et al., 2018).

Wave 5 of the NIDS survey reached a representative sample of 13,719 households, 13,464 adults (15-years-old and older), and 6,878 children (14-years-old and younger).

Data Storage

The DataFirst servers house the electronic version of the public release NIDS study dataset (Brophy et al., 2018). Users must register on DataFirst and complete a brief online form to download the dataset. For this study, the researcher provided DataFirst with personal information, including my contact details, and a summary of my intended use of the data, allowing the NIDS researchers to understand how the public health community uses the NIDS data. Lastly, the researcher had to agree to the terms and conditions to using the NIDS dataset, which encourages users not to (a) disseminate the dataset and (b) re-identify respondents, in addition to requiring that publications cite the data source and send the link to publications to DataFirst (Brophy et al., 2018). On October 29, 2020, the online registration and form and access to the dataset were received the same day. Although the data are stored using the STATA format, the statistical software package used during data analysis can appropriately transform the dataset and maintain its integrity.

Data Analysis Plan

IBM's Statistical Program for the Social Sciences (SPSS) version 27, a widely used statistical software platform, was used to analyze this study's data. Given its comprehensive set of features, the selected statistical application allowed for the (a) descriptive and inferential analyses required to answer the research questions of this study, and (b) the researcher has the necessary level of competence to use SPSS. Secondary data extracted from Wave 5 of NIDS (Brophy et al., 2018) were used to answer the research questions posed in this study.

However, since the original researchers did not collect NIDS data for the specific purpose of this study, the secondary dataset required (a) merging across the adult, child, and household questionnaires datasets, (b) identifying and coding the measurement scales of the variables of interest, (c) recoding and computing other variables of interest, and (d) resolving other emerging data quality issues, e.g., missing data. Given that the dependent variable, (i.e., the three combinations of HL-DBM), remained consistent across all the research questions, it was unlikely that the sample size would change during data analysis.

Data Analysis Plan for Individual Research Questions

This section outlines the data analysis plan for the five research questions considered in this study and the hypotheses.

Data Analysis Plan for RQ 1. Research Question 1: In South Africa, how does the distribution of HL-DBM, (i.e., the combination of maternal and child malnutrition), vary by (a) income step of the household, (b) population group, and (c) type of dwelling?

The independent variables are (a) income step of the household, (b) population group, and (c) type of dwelling, the dependent variable is the prevalence of HL-DBM derived by the co-occurrence of overweight or obese mother of reproductive age (i.e., 15 to 49-years old) and her under-5-year-old child who shows signs of thinness, low weight for age or wasting, or short stature for age or stunting (Wells et al., 2020).

In addition to using descriptive statistics, (i.e., frequencies), to summarize the categorical independent variables and the dichotomous nominal dependent variable, the nonparametric Chi-Square test was used to establish whether a statistically significant association exists between (a) income step of the household, (b) population group, (c) type of dwelling, and (c) the distribution of HL-DBM South Africa. Given the research question, study design, and the level of measurement of the independent and dependent variables, the Chi-Square test was the most appropriate statistical test. Further, to quantify the strength of associations between categorical independent and dependent variables, the multivariable analysis was binary logistic regression (Smeden et al., 2016).

Data Analysis Plan for RQ 2. Research Question 2: What is the association between South Africa's prevalence of HL-DBM and maternal (a) marital status, (b) highest level of education, and (c) employment status?

The independent variables, (i.e., (a) maternal marital status, (b) maternal highest level of education, and (c) maternal employment status), were categorical. The outcome variable was a nominal dichotomous dependent variable. The nonparametric Chi-Square was used to examine the statistically significant association between the independent and dependent variables. The multivariable analysis was binary logistic regression to quantify the strength of the associations.

Data Analysis Plan for RQ 3. Research Question 3: What is the association between South Africa's prevalence of HL-DBM and household (a) food security, (b) minimum dietary diversity for women of reproductive age, (c) primary water source, and (d) type of available toilet?

The independent variables were household (a) food security, (b) minimum dietary diversity for women of reproductive age, (c) primary water source, and (d) type of available toilet. Whereas household food security and minimum dietary diversity for women of reproductive age were computed before data analysis, all independent variables in this research question were categorical. The outcome variable was a dichotomous nominal variable (yes/no) measuring South African households with any of the three combinations of HL-DBM (i.e., overweight or obese mother with an underweight child, wasted child, or stunted child).

Due to the nature of the research question and the level of measurement of the independent and dependent variables, the nonparametric Chi-Square test was appropriate for the bivariate analysis. Additionally, for the multivariable analysis, binary logistic regression was suitable for measuring the association's strength between categorical and nominal variables.

Data Analysis Plan for RQ 4. Research Question 4: What is the association between South Africa's prevalence of HL-DBM and the child's age, i.e., 0—59-months old age range, and gender?

The independent variables were the under-five-year-old child's age (i.e., 0—59 months) and gender. The outcome variable was South African households with any one of the three combinations of HL-DBM (i.e., overweight or obese mother with an underweight child, wasted child, or stunted child). For the independent variable measuring under-5-year-old child’s age, the months (0—59 months) were grouped to convert the continuous variable into a categorical measure. The age groups included 0—6 months, 6—24 months, 25—36 months, 37—48 months, and 49—59 months. Gender was a dichotomous nominal independent variable, and HL-DBM was a dichotomous dependent variable. Consequently, the nonparametric Chi-Square test was the most appropriate to investigate statistically significant associations between categorical and nominal dichotomous variables. Binary logistic regression was used to measure the strength of the association.

Data Analysis Plan for RQ 5. Research Question 5: What is the association between HL-DBM and the frequency of domestic violence in the neighborhood in South Africa?

The independent variable is the frequency of domestic violence in South Africa’s neighborhoods. The outcome variable is South African households with any one of the three combinations of HL-DBM (i.e., overweight or obese mother with an underweight child, wasted child, or stunted child). Since the independent variable was categorical, and the dependent variable was a dichotomous nominal variable, the Chi-Square test was appropriate. At the same time, binary logistic regression was used to quantify the strength of the association.

Threats to Validity

Whereas validity relates to the degree of accuracy a method measures what it aims to measure (Frankfort-Nachmias & Leon-Guerrero, 2018), internal validity describes the accuracy of the researcher's assertions about the causal associations between the independent and dependent variables. Conversely, external validity refers to the extent to which research results are generalizable to a broader population group than the study population (Babbie, 2017). Due to the cross-sectional nature of this study and the use of a secondary dataset to answer the research questions, common threats included internal and external validity. For researchers to generalize research findings across populations, settings, and time frames, evidence that the results are not limited to a single population is required. This study used a representative sample of South African households and household residents. With the research being cross-sectional, the study's findings were limited to South African homes in 2017 (Salkind, 2010).

Participants have likely matured since the NIDS study is a panel study with repeated data collection with essentially the same CSMs since 2008. Therefore, the observed effect of HL-DBM may not be solely attributed to the independent variables included in this study, compromising the internal validity of the research (Salkind, 2010). Additionally, the likelihood of several CSMs dropping out from the NIDS study resulting in population groups that are systematically different from each other results in a possible threat to internal validity, with the observed effect of HL-DBM attributed to local events or circumstances, rather than the independent variables of interest. In this cross-sectional study, determining the direction of causal influence was unworkable, resulting in the ambiguity of the causal direction and a threat to internal validity (Salkind, 2010). Finally, despite South African having the largest population of people living with HIV, controlling for a positive HIV diagnosis's potential confounding effect was impossible due to limitations with the dataset.

Ethical Procedures

The Wave 5 of the South African NIDS Public Release Dataset will be used to answer this study's research questions. Before data collection commenced in 2017, the University of Cape Town's Human Research Ethics Committee approved Wave 5 of the NIDS survey on December 16, 2016 (Brophy et al., 2018). Ensuring survey respondents' anonymization involved significant effort to remove personal identifier information. Names and contact details are stored separately from the Public Release Dataset, and specific collected variables have restricted access or are released at an aggregated level, e.g., migration. Safeguarding participants' confidentiality entailed limiting access to the data to those who register on the DataFirst platform and completing the short online application to access the Public Release Dataset.

For each of the four questionnaires of the NIDS survey, fieldworkers issued two informed consent forms for each respondent. Further, fieldworkers undertook the informed consent processes in all of South Africa's 11 official languages, and one signed form remained with respondents. Fieldworkers then returned the other informed consent form to the Southern Africa Labor and Development Research Unit (SALDRU) (Brophy et al., 2018). The field survey data was only accepted as valid if accompanied by the related signed informed consent form, with interviews deleted from the dataset when researchers could not locate the associated signed consent form. The primary caregiver signed the consent forms for 15-17-year-old young adult participants, with young adults signing assent forms. Fieldworkers completed the assent forms for anthropometric measurements, supported by the seven to ten-year-old children's willingness to be measured. Based on a review by Walden University's Institutional Review Board (IRB), this study was found to meet the university's ethical standards on June 10, 2021, with an IRB approval number, (i.e., 06-10-21-0754160).

Summary

This section offered a comprehensive description of the research design and rationale of the study design. Further, this section discussed the core elements of the study's methodology, including data and sampling methods, study population, data source, and data storage. This quantitative cross-sectional study used the secondary data generated by the 2017 Wave 5 South African NIDS survey that reached a representative sample of 13,719 households, 13,464 adults (15-years-old and older), and 6,878 children (14-years-old and younger) (Brophy et al., 2018). Based on the G*Power a priori power analysis and informed by previous research proposal, three hundred and sixty-four (364) respondents are needed to achieve a power of 95per cent (Anderson, 2019; LeBlanc & Fitzgerald, 2000; Perugini et al., 2018).

It was impossible to control for the possible confounding effect of a positive HIV diagnosis. Other threats to internal validity were the maturation of respondents during this panel NIDS study, attrition of CSMs to result in systematically different population groups, and ambiguity of the causal direction (Salkin, 2010). Regarding external validity, this study was generalizable to South African households in 2017. Key ethical considerations associated with data collection and human participants were outlined. In addition to describing the data analysis, Section 3 will discuss the study results.

Section 3: Presentation of the Results and Findings

The purpose of this research was to investigate the association between the occurrence of HL-DBM and socioeconomic constructs, maternal characteristics, household characteristics, child characteristics, and the neighborhood characteristics. The research questions were designed to answer (a) how the distribution of HL-DBM varies in South Africa by income step of the household, population group, and type of dwelling; (b) the association between South Africa's prevalence of HL-DBM and maternal marital status, highest level of education, and employment status; (c) the association between South Africa's prevalence of HL-DBM and household food security, minimum dietary diversity for women of reproductive age, primary water source, and type of available toilet; (d) the association between South Africa's prevalence of HL-DBM and the child's age, (i.e., 0—59-months old age range), and gender; and (e) the association between HL-DBM and the frequency of domestic violence in the neighborhood in South Africa. In this study, HL-DBM includes the three common combinations, where household residents comprise overweight or obese mothers and at least one of the mother's under 5-year-old child has signs of undernourishment (e.g., thinness, low weight for age, short for age).

Findings produced from the statistical analyses are expected to support public health professionals as they design comprehensive rather than vertical, programs, policies, and strategies that target malnutrition at the HL. This section includes a description of the data collection, results, and summary findings of the study.

Data Collection of Secondary Data Set

Time Frame and Response Rates

During this study, secondary data from the 2017 Wave 5 of the South African NIDS survey that met most of this study's inclusion criteria were used. NIDS reached a representative sample of 13,719 households, 13,464 adults (15 years old and older), and 6,878 children (14 years old and younger).

Descriptive Demographics of Sample

Of the 13,719 households, only those households with mother–child pairs, where the mother was overweight or obese (i.e., a BMI equal to, or greater than, 25.0kg/m^2) and of reproductive age (i.e., 15–49 years old) and her under 5-year-old child showed signs of thinness, wasting, or stunting were included. After consolidating data across the household, adult, proxy, and child questionnaires, as well as data cleaning, the total sample of households with women of reproductive age and under 5-year-old children were 2,111, of which 314 (14.9%) homes met the criteria for HL-DBM (see Table 2).

Table 2

Distribution of HL-DBM in South African NIDS, 2017

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	1,797	85.1	85.1	85.1
	HL_DBM	314	14.9	14.9	100.0
	Total	2,111	100.0	100.0	

Representativeness of Sample

Quantitative NIDS researchers applied a specific sampling approach to identify a representative sample or a subgroup that reasonably resembles the wider population.

Although NIDS is a longitudinal panel study, this research only used Wave 5 of the panel study, making the study design cross-sectional. NIDS covered South Africa's nine provinces and considered households and individuals as the units of analysis. NIDS targeted private homes and residents in workers' hostels, convents, and monasteries. Using a stratified two-stage cluster sampling strategy across 3,000 primary sampling units, baseline NIDS data were collected from 7,305 households, comprising 28,255 household residents in 2008. The baseline households and household residents would become CSMs. However, due to the attrition of White and Indian CSMs across the primary sampling units in 2017, Wave 5 of the NIDS included a top-up sampling design that used the baseline sampling strategy.

Univariate Characteristics of Sample

With the unit of analysis for this study being households, where the mother was of reproductive age and her child was under 5 years old, the final study population comprised 2,111 households or 15.4% (*N* = 13,719) of the total NIDS household sample size. Within the study population, 14.9% (*n* = 314) of households were identified as having mother–child pairs, where the mother was obese or overweight, and her under 5-year-old child was stunted, thin, or wasted. The independent variables were (a) population group, (b) income step of the household, (c) type of dwelling, (d) maternal employment status, (e) mother's highest level of education, (f) maternal employment status, (g) household food security, (h) household minimum dietary diversity for women of reproductive age, (i) household's main source of water, (j) household's available toilet,

(k) child's age, (l) child's gender, and (m) the frequency of domestic violence in the neighborhood.

Across the study sample, the majority (82.4%, *n* = 1,739) of households were associated with the African population group. Further, most households were within the mid-range income step (48.1%; *n* = 1,016) and were formal houses (87.2%; *n* = 1,841). Of the overweight or obese mothers of reproductive age in the study sample, over half (54.1%; *n* = 1,142) had completed Grades 10–12, were economically inactive (45.2%; *n* = 955) and had never been married (60.1%; *n* = 1,268). Regarding the household characteristics, most homes were food insecure (89.6%; *n* = 1,891) and were found to have poor minimum dietary diversity for women of reproductive age (90.7%; *n* = 1,914).

Additionally, most households in the total study population had piped (tap) water in the dwelling (37%; *n* = 781) and had a flush toilet with onsite disposal (28.7%; *n* = 605) as their available toilet. Among the under-5-old children with signs of thinness, wasting, or stunting, the majority were female (51.4%; *n* = 1, 084) and were within the age range of 7–24 months (33.2%; *n* = 700). Finally, regarding the frequency of domestic violence in the neighborhood, most respondents noted that domestic violence never happens (29.3%; *n* = 618). However, since domestic violence is a sensitive and stigmatized issue, its frequency is likely under-reported. Table 3 presents the univariate characteristics for this study's dependent, independent, and covariates.

Table 3

Frequencies of the Total Study Sample

Independent Variables	Frequency *N* = 2,111	% Sample *N* = 2,111	Frequency of HL-DBM *N* = 314	% HL-DBM *N* = 314
Population group				
African	1736	82.4	263	83.8
Colored	300	14.2	46	14.6
Asian/Indian	31	1.5	2	0.6
White	41	1.9	3	1.0
Income step of the household				
Lowest rung (poorest)	1000	47.4	173	55.1
Mid-range rung	1016	48.1	132	42.0
Highest rung (richest)	72	3.4	9	2.9
Type of dwelling				
Formal housing	1841	87.2	272	86.6
Informal housing	246	11.7	41	13.1
Casual housing	23	1.1	1	0.3
Mother's highest level of education				
Grades 0-9	477	22.6	81	25.8
Grades 10-12	1142	54.1	169	53.8
Certificate/Diploma not requiring Grade 12	322	15.3	50	15.9
Tertiary education	143	6.8	12	3.8
No or other education	27	1.3	2	0.6
Maternal employment status				
Economically inactive	955	45.2	144	45.9
Unemployed	489	23.2	70	22.3
Employed	664	31.5	99	31.5
Maternal marital status				
Married	522	24.7	97	30.9
Living with partner	273	12.9	38	12.1
Widower	20	0.9	3	1.0
Divorced or separated	26	1.2	3	1.0
Never married	1268	60.1	173	55.1
Household food security				
Secure	220	10.4	23	7.3
Insecure	1891	89.6	291	92.7
Household minimum dietary diversity for women of reproductive age				
Good dietary diversity	197	9.3	28	8.9
Poor dietary diversity	1914	90.7	286	91.1
Household's main water source				
Piped (tap) water in dwelling	781	37	107	34.1
Piped (tap) water onsite or in the yard	615	29.1	77	24.5
Communal water source	579	27.4	101	32.2
Natural water source	135	6.4	29	9.2

(table continues)

Independent Variables	Frequency *N* = 2,111	% Sample *N* = 2,111	Frequency of HL-DBM *N* = 314	% HL-DBM *N* = 314
Household's available toilet				
Flush toilet with onsite disposal	605	28.7	82	26.1
Flush toilet with offsite disposal	381	18	47	15
Other toilets	118	5.6	18	5.7
Pit latrine with ventilation pipe	395	18.7	71	22.6
Pit latrine without ventilation pipe	547	25.9	88	28
None	63	3.0	8	2.5
Child's gender				
Male	1025	48.6	164	52.2
Female	1084	51.4	150	47.8
Child's age				
0—6 months	242	11.5	3	1.0
7—24 months	700	33.2	123	39.2
25—36 months	477	22.6	84	26.8
37—48 months	382	18.1	61	19.4
49—59 months	310	14.7	43	13.7
Frequency of domestic violence in the neighborhood				
Never happens	618	29.3	100	31.8
Very rate	515	24.4	69	22
Not common	456	21.6	67	21.3
Fairly common	250	11.8	40	12.7
Very common	257	12.2	35	11.1

Results

Chi-Square and Binary Logistic Regression

Research Question 1

Research Question 1: In South Africa, how does the distribution of HL-DBM (i.e., the combination of maternal and child malnutrition) vary by (a) income step of the household, (b) population group, and (c) type of dwelling?

The statistical assumption was that the dependent variable is a dichotomous nominal variable, and the independent variables (i.e., income step of the household, (b) population group, and (c) type of dwelling) are ordinal variables. All the variables in Research Question 1 are categorical, consisting of two or more independent groups. Hypothesis 1 tested the association between the occurrence of HL-DBM and (a) income step of the household, (b) population group, and (c) type of dwelling. The Pearson Chi-Square results $_{x}$(1)=7.696, p = 0.021 (< 0,05) revealed a statistically significant association between the income step of the household and the occurrence of HL-DBM. However, the Pearson Chi-Square results $_{x}$(1)=3.721, p = 0.293 (> 0,05), as outlined in Table 5**Error! Reference source not found.** and the Pearson Chi-Square results $_{x}$(1)= 2.650, p = 0.266 (> 0,05) described in Table 6, shows that there is no statistically significant association between population group, type of dwelling, and the occurrence of HL-DBM. Therefore, $H_0$1 can only be partially rejected since, despite a statistically significant association between the occurrence of HL-DBM and income step of the household today, there is no statistically significant association between HL-DBM and population group or type of dwelling.

Table 4

Chi-Square Test for HL-DBM and Income Step Of The Household

	Value	df	Asymptomatic Significance (2-sided)
Pearson Chi-Square	7.696 [a]	2	.021
Likelihood Ratio	7.695	2	.021
Linear-by-Linear Association	7.087	1	.008
N of Valid Cases	2088		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 10.83.

Table 5

Chi-Square Test for HL-DBM and Population Group

	Value	df	Asymptomatic Significance (2-sided)
Pearson Chi-Square	3.721 [a]	3	.293
Likelihood Ratio	4.473	3	.215
Linear-by-Linear Association	2.000	1	.157
N of Valid Cases	2111		

a. 1 cells (12.5%) have expected count less than 5. The minimum expected count is 4.61.

Table 6

Chi-Square Test for HL-DBM and Type of Dwelling

	Value	df	Asymptomatic Significance (2-sided)
Pearson Chi-Square	2.650 [a]	2	.266
Likelihood Ratio	3.289	2	.193
Linear-by-Linear Association	0.005	1	.941
N of Valid Cases	2110		

a. 1 cells (16.7%) have expected count less than 5. The minimum expected count is 3.42.

Research Question 2

Research Question 2: What is the association between South Africa's prevalence of HL-DBM and maternal (a) marital status, (b) highest level of education, and (c) employment status?

The statistical assumption was that the dependent variable (the occurrence of HL-DBM) is a dichotomous nominal variable. In contrast, the independent variables (i.e., maternal (a) marital status, (b) highest level of education, and (c) employment status) are ordinal variables. All the variables in Research Question 2 are categorical, consisting of two or more independent groups.

The results of the Pearson Chi-Square test are shown in Table 7, Table 8, and Table 9. With a result of $_x(1)=7.604$, p = 0.107 (> 0,05), there is no statistically significant association between maternal marital status and the occurrence of HL-DBM. Similarly, with a result of $_x(1)=1.272$, p = 0.736 (> 0,05), there is no statistically significant association between maternal employment status and the occurrence of HL-DBM. Finally, with a result of $_x(1)=7.721$, p = 0.102 (> 0,05), there is no statistically significant association between the occurrence of HL-DBM and the highest level of maternal education.

Table 7

Chi-Square Test for HL-DBM and Maternal Marital Status

	Value	df	Asymptomatic Significance (2-sided)
Pearson Chi-Square	7.604 [a]	4	.107
Likelihood Ratio	7.321	4	.120
Linear-by-Linear Association	5.482	1	.019
N of Valid Cases	2109		

a. 2 cells (20.0%) have expected count less than 5. The minimum expected count is 2.98.

Table 8

Chi-Square Test for HL-DBM and Maternal Employment Status

	Value	df	Asymptomatic Significance (2-sided)
Pearson Chi-Square	1.272 [a]	3	.736
Likelihood Ratio	1.425	3	.700
Linear-by-Linear Association	.003	1	.959
N of Valid Cases	2108		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.87.

Table 9

Chi-Square Test for HL-DBM and Maternal Highest Level of Education

	Value	df	Asymptomatic Significance (2-sided)
Pearson Chi-Square	7.721 [a]	4	.102
Likelihood Ratio	8.631	4	.071
Linear-by-Linear Association	5.246	1	.022
N of Valid Cases	2111		

a. 1 cells (10.0%) have expected count less than 5. The minimum expected count is 4.02.

Based on the results outlined in Tables 5 to 7, $H_0 2$ cannot be rejected, meaning that there is no statistically significant association between HL-DBM and maternal (a) marital status, (b) employment status, and (c) highest level of education.

Research Question 3

Research Question 3: What is the association between South Africa's prevalence of HL-DBM and household (a) food security, (b) minimum dietary diversity for women of reproductive age, (c) primary water source, and (d) type of available toilet?

The statistical assumption was that the dependent variable (i.e., the occurrence of HL-DBM) is a dichotomous nominal variable. Conversely, the independent variables, (i.e., household (a) food security, (b) minimum dietary diversity for women of reproductive age, (c) primary source of water, and (d) type of available toilet) are ordinal variables. All the variables in Research Question 3 are categorical, consisting of two or more independent groups.

The Pearson's Chi-Square tests results are shown in Table 10, Table 11, **Error! Reference source not found.**, and Table 13. With a test result of $x(1)=3.789$, $p = 0.052$ (< 0,05), there is a statistically significant association between the occurrence of HL-DBM and household food security. However, with Pearson Chi-Square test results of $x(1)=.075$, $p = 0.784$ (> 0,05), there is no statistically significant association between HL-DBM and minimum dietary diversity for women of reproductive age. Conversely, with a Pearson's Chi-Square test result of $x(1)=11.211$, $p = 0.011$ (< 0,05), there is a statistically significant relationship between HL-DBM and the household's main source of water. Finally, with a Pearson's Chi-Square test result of $x(1)=6.650$, $p = 0.248$ (> 0,05), there is no statistically significant association between HL-DBM and the household's available type of toilet.

Table 10

Chi-Square Test for HL-DBM and Household Food Security

	Value	df	Asymptomatic Significance (2-sided)	Exact Sig (2-sided)	Exact Sig (1 – sided)
Pearson Chi-Square	3.789 [a]	1	.052		
Continuity Correction [b]	3.410	1	.065		
Likelihood Ratio	4.115	1	.042		
Fisher's Exact Test				.057	.029
Linear-by-Linear Association	3.787	1	.052		
N of Valid Cases	2111				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 32.72.

b. Computed only for a 2x2 table

Table 11

Chi-Square Test for HL-DBM and Household Minimum Dietary Diversity for Women of Reproductive Age

	Value	df	Asymptomatic Significance (2-sided)	Exact Sig (2-sided)	Exact Sig (1 – sided)
Pearson Chi-Square	.075	1	.784		
Continuity Correction [b]	.028	1	.866		
Likelihood Ratio	.076	1	.783		
Fisher's Exact Test				.834	.441
Linear-by-Linear Association	.075	1	.784		
N of Valid Cases	2111				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 29.30.

b. Computed only for a 2x2 table

Table 12

Chi-Square Test for HL-DBM and Household Main Water Source

	Value	df	Asymptomatic Significance (2-sided)
Pearson Chi-Square	11.211 [a]	3	.011
Likelihood Ratio	10.766	3	.013
Linear-by-Linear Association	7.293	1	.007
N of Valid Cases	2,110		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 20.09.

Table 13

Chi-Square Test for HL-DBM and Household Available Type of Toilet

	Value	df	Asymptomatic Significance (2-sided)
Pearson Chi-Square	6.650 [a]	5	.248
Likelihood Ratio	6.618	5	.251
Linear-by-Linear Association	2.936	1	.087
N of Valid Cases	2109		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.38.

Statistically significant associations were found between HL-DBM and household (a) food security and (b) main water supply, but no statistically significant association was found between HL-DBM and household (a) minimum dietary diversity for women of reproductive age, and (b) available type of toilet. As such, the $H_0$3 can only be partially rejected due to the statistically significant associations identified between HL-DBM and household (a) food security and (b) main water supply.

Research Question 4

Research Question 4: What is the association between South Africa's prevalence of HL-DBM and the child's age, (i.e., 0—59-months old age range), and gender?

The statistical assumption was that the dependent variable (i.e., the occurrence of HL-DBM) is a dichotomous nominal variable, and the independent variables (i.e., child's (a) age range and (b) gender) are ordinal variables. All the variables in Research Question 4 are categorical, consisting of two or more independent groups.

Table 14 and **Table 15** outline the results of the Pearson's Chi-Square tests related to Research Question 4. With a test result of $x(1)$=42.979, p = 0.000 (< 0,05), there is a statistically significant association between HL-DBM and the child's age. Conversely, with a Pearson's Chi-Square test result of $x(1)$=1.944, p = 0.163 (> 0,05), there is no statistically significant association between HL-DBM and the child's gender.

Table 14

Chi-Square Test for HL-DBM and Child's Age Range

	Value	df	Asymptomatic Significance (2-sided)
Pearson Chi-Square	42.979 [a]	4	.000
Likelihood Ratio	63.239	4	.000
Linear-by-Linear Association	4.898	1	.027
N of Valid Cases	2111		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 36.00

Table 15

Chi-Square Test for HL-DBM and Child's Gender

	Value	df	Asymptomatic Significance (2-sided)	Exact Sig (2-sided)	Exact Sig (1 – sided)

Pearson Chi-Square	.1.944	1	.163		
Continuity Correction [b]	1.777	1	.183		
Likelihood Ratio	1.943	1	.163		
Fisher's Exact Test				.178	.091
Linear-by-Linear Association	1.943	1	.178		
N of Valid Cases	2109				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 152.61.

b. Computed only for a 2x2 table

Based on the results shown in Tables 14 and 15, $H_0$4 can be partially rejected due to the statistically significant association found between HL-DBM and the child's age range.

Research Question 5

Research Question 5: What is the association between HL-DBM and the frequency of domestic violence in the neighborhood in South Africa?

The dependent variable, (i.e., the occurrence of HL-DBM), is a dichotomous nominal variable. In contrast, the independent variable, (i.e., the frequency of domestic violence in the neighborhood), is an ordinal variable. All the variables in Research Question 5 are categorical, consisting of two or more independent groups.

Table 16 shows the results of the Pearson's Chi-Square test. With a result of $x(1)=2.305$, $p = 0.680$ (> 0,05), there is no statistically significant association between HL-DBM and the frequency of domestic violence in the neighborhood. Based on the Pearson's Chi-Square test results, the $H_0$5 cannot be rejected since there is no statistically significant association between HL-DBM and the frequency of domestic violence in the neighborhood.

Table 16

Chi-Square Test for HL-DBM and Frequency of Domestic Violence in the Neighborhood

	Value	df	Asymptomatic Significance (2-sided)
Pearson Chi-Square	2.305 [a]	4	.680
Likelihood Ratio	2.309	4	.679
Linear-by-Linear Association	.328	1	.567
N of Valid Cases	2096		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 37.09.

Logistic Regression

Binary logistic regression was completed to test the association between HL-DBM and (a) income step of the household, (b) population group, (c) type of dwelling, (d) maternal marital status, (e) maternal highest level of education, (f) maternal employment status, (g) household's food security, (h) household dietary diversity for women of reproductive age, (i) household's main water supply, (j) household's available toilet facility, (k) child's age, (l) child's gender, and (m) the frequency of domestic violence in the neighborhood. Based on the results provided in **Table 17**, x^2 = 110.862, p <.001, the binary regression model is statistically significant, and interpretation can proceed.

Table 17

Omnibus Tests of Model Coefficients

		Chi-Square	df	Sig.
Step 1	Step	110.862	36	.000
	Block	110.862	36	.000
	Model	110.862	36	.000

Table 18 provides the Hosmer and Lemeshow test results, where x^2 = 10.329, p >.005, indicating that the model fits the data and can be further interpreted.

Table 18

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	10.329	8	.243

Table 19 shows that the binary regression model explained between 5.2% (Cox and Snell R square) and 9.1% (Nagelkerke R square) of the variance in the occurrence of HL-DBM, as seen in **Table 20**, correctly classified 85.2% of cases. **Error! Reference source not found.** outlines the independent variables compared to the dependent variable, i.e., HL-DBM.

Table 19

Model Summary

Step	-2 Log Likelihood	Cox & Snell R Square	Nagelkerke R Square
1	1643.553[a]	.052	.091

a. Estimation terminated at iteration number 20 because maximum iterations has been reached. Final solution cannot be found.

Table 20

Classification Table [a]

	Observed		Predicted Household-DBM Normal	Predicted Household-DBM HL_DBM	Percentage Correct
Step 1	Household-DBM	Normal	1779	0	100.0
		HL_DBM	310	0	.0
	Overall Percentage				85.2

a. The cut value is .500

For each independent variable, the categories of the variable used as reference are listed in **Table 21**.

Table 21

Reference Categories Used in Binary Logistic Regression

Independent variable	Reference category
Maternal marital status	Never married
Maternal education	No or other schooling
Population group	White
Child's gender	Female
Child's age	49-59 months
Household food security	Food secure
Type of dwelling	Casual dwelling
Household's main water supply	Natural water sources
Type of available toilet	None
Frequency of domestic violence in the neighborhood	Very common
Dietary diversity	Good dietary diversity
Maternal employment	Economically inactive
Income step of the household	Highest rung (richest)

Based on the results presented in **Table 22**, the strongest statistically significant risk factor of HL-DBM is the child's age, with children (a) 0—6-months old (*Exp (B)* = 16.338, $p < .001$), (b) 7—24 months old (*Exp (B)* = 16.435, $p < .001$), (c) 25—36 months old (*Exp (B)* = 14.162, $p < .001$) and (d) 37—48 months old (*Exp (B)* = 11.959, $p < .001$) being more vulnerable to living in a home with HL-DBM. As such, from birth to 6-months-old, a child is 16.338 times more likely to be in a household with HL-DBM, with the likelihood ratio increasing marginally between 7 and 24-months-old to 16.435. As the child ages beyond 24-months-old, the likelihood decreases to 14.162 more likely between the ages of 25—36-months-old and 11.959 more likely between 37—48 months old.

Table 22

Variables in the Equation

Step 1		B	SE	Wald	df	Sig.	Exp (B)	95% CI for EXP (B)	
								Lower	Upper
	Maternal marital status								
	Never married (ref)			11.661	4	.020			
	Married	-.488	.222	4.828	1	.028	.614	.397	.949
	Living with partner	-.408	.652	.391	1	.532	.665	.185	2.388
	Widower	-.518	.642	.652	1	.420	.596	.169	2.095
	Divorced or separated	-.490	.149	10.768	1	.001	.613	.457	.821
	Maternal education								
	No or other schooling (ref)			5.545	4	.236			
	Grades 0-9	-.067	.157	.183	1	.669	.935	.687	1.272
	Grades 10-12	-.002	.210	.000	1	.991	.998	.661	1.505
	Certificate/Diploma not requiring Grade 12	-.640	.353	3.291	1	.070	.527	.264	1.053
	Tertiary education	-1.113	.757	2.160	1	.142	.328	.074	1.449
	Population group								
	White (ref)			3.566	3	.312			
	African	.161	.204	.621	1	.431	1.174	.787	1.752
	Colored	-1.079	.752	2.060	1	.151	.340	.078	1.484
	Asian/Indian	-.517	.648	.635	1	.066	.792	.617	0.015
	Child's gender								
	Female (ref)								
	Male	.161	.204	.621	1	.431	1.174	.787	1.752
	Child's age								
	49—59 months (ref)			24.748	4	.000			
	0—6 months	2.793	.591	22.308	1	.000	16.338	5.126	52.075
	7—24 months	2.799	.596	22.065	1	.000	16.435	5.111	52.852
	25—36 months	2.651	.600	19.490	1	.000	14.162	4.366	45.937
	37—48 months	2.481	.607	16.702	1	.000	11.959	3.638	39.311
	Household food insecurity								
	Food secure (ref)	.203	.259	.611	1	.434	1.225	.737	2.037
	Type of dwelling								
	Casual dwelling (ref)			1.567	2	.457			
	Formal housing	.040	.210	.036	1	.850	1.041	.690	1.569
	Informal housing	-1.287	1.049	1.506	1	.220	.276	.035	2.157
	Household's main water supply								
	Natural water sources (ref)			5.804	3	.122			
	Piped (tap) water in dwelling	-.156	.181	.746	1	.388	.855	.600	1.219
	Piped (tap) water onsite or in the yard	.163	.207	.619	1	.431	1.177	.784	1.767
	Communal water source	.462	.287	2.584	1	.108	1.587	.904	2.786

(table continues)

Step 1		B	SE	Wald	df	Sig.	Exp (B)	95% CI for EXP (B) Lower	Upper
	Type of Available Toilet Facility								
	None (ref)			3.301	5	.654			
	Flush toilet with onsite disposal	-.146	.208	.490	1	.484	.864	.575	1.300
	Flush toilet with offsite disposal	-.035	.325	.012	1	.913	.965	.511	1.824
	Other toilets	.208	.232	.809	1	.368	1.231	.782	1.939
	Pit latrine with ventilation pipe	.017	.223	.006	1	.939	1.017	.657	1.573
	Pit latrine without ventilation pipe	-.316	.438	.519	1	.471	.729	.309	1.722
	Frequency Of Domestic Violence in the Neighborhood								
	Very common (ref)			2.805	4	.591			
	Never happens	-.241	.176	1.888	1	.169	.786	.557	1.108
	Very rare	-.140	.179	.609	1	.435	.870	.612	1.235
	Not common	.046	.213	.046	1	.830	1.047	.689	1.589
	Fairly common	-.179	.222	.652	1	.419	.836	.542	1.291
	Dietary diversity								
	Good dietary diversity (ref)								
	Poor Dietary Diversity	-1.32	.222	.350	1	.554	.877	.567	1.356
	Maternal employment								
	Economically inactive (ref)			.320	2	.852			
	Unemployed	-.093	.164	.319	1	.572	.911	.660	1.258
	Employed	-.035	.154	.050	1	.823	.966	.714	1.307
	Income step								
	Highest rung (richest) (ref)			.074	2	.964			
	Lowest rung (poorest)	18.926	8476.91	.000	1	.998	165765542.91	.000	
	Mid-range rung	18.818	8476.91	.000	1	.998	148715009.164	.000	
	Constant	-22.785	8476.91	.000	1	.998	.000		

a. Variable(s) entered on step 1: Maternal marital status, Maternal Education, Population group, Child's gender, Recoded child's age categorical, Household Food Security, Recoded Type of dwelling, Recoded Household's main water source, Recoded type of available toilet facility, Frequency of domestic violence in the neighborhood, Dietary Diversity, Maternal employment, Income step.

Other statistically significant factors protecting from HL-DBM is the mother's marital status, where being married (*Exp (B)* = .614, $p < .005$) and being divorced or separated (*Exp (B)* = .613, $p < .005$) decreased the likelihood of the occurrence of HL-DBM in the household. Therefore, when the non-pregnant women of reproductive age, (i.e., between 15 and 49 years old), were married, the mother was 38.6% times less likely to be in a home with HL-DBM. Divorced or separated mothers were 38.7% times, less likely times less likely to be in a house with HL-DBM. Other variables were found to have no statistically significant ($p > .005$) association with HL-DBM and did not contribute to the model.

Summary

In Section 3, the study results are presented, including the outcomes of the data collection, descriptive statistics, correlational analyses, and logistic regression analyses. The fifth Wave of the South African NIDS survey data informed the investigation between the dependent variable and several independent variables. The dependent variable was the incidence of HL-DBM, characterized by the co-occurrence of overweight or obese mothers of reproductive age and her undernourished (wasting, stunting, or thinness) under-5-year-old child. Independent variables include (a) income step of the household on the day of the survey, (b) population group, (c) type of dwelling, (d) highest level of maternal education, (e) maternal marital status, (f) maternal employment status, (g) household's main source of water, (h) household's type of available water, (i) household's food security, (j) household's minimum dietary diversity for women of reproductive age, (k) child's age, (l) child's gender, and (m) the frequency of domestic violence in the neighborhood.

Research question 1 sought to examine how the distribution of HL-DBM varied by (a) income step of the household, (b) population group, and (c) type of dwelling. The Pearson Chi-Square results, $x(1)=7.696$, $p = 0.021$ (< 0,05), revealed a statistically significant association between the income step of the household and the occurrence of HL-DBM. Importantly, no statistically significant association was identified between the population group and type of household. As such, in South Africa in 2017, the variance in the occurrence of HL-DBM, as defined in this study, was associated with the income step of the household. However, when binary logistic regression analysis was performed to determine if the association between the income step of the household and the occurrence of HL-DBM would continue to be statistically significant, the association was not statistically significant.

Research questions 2 to 4 investigated the association between the incidence of HL-DBM and (a) maternal characteristics, (i.e., the highest level of education, marital status, and employment status,) (b) household features, (i.e., type of available toilet, the main source of water supply), food security, and minimum dietary diversity for women of reproductive age, and (c) the child's demographic characteristics, (i.e., age and gender). The results of the Pearson's Chi-Square tests revealed a statistically significant association between HL-DBM and (a) household food security, $x(1)=3.789$, $p = 0.052$ (< 0,05), (b) household's main source of water, of $x(1)=11.211$, $p = 0.011$ (< 0,05), and (c) child's age, $x(1)=42.979$, $p = 0.000$ (< 0,05). Therefore, in 2017, the variance in the incidence of HL-DBM, as characterized in this study, was associated with (a) food security, (b) household's main source of water, and (c) child's age. Conversely, no statistically significant associations were found between HL-DBM and maternal characteristics, household type of toilet, household minimum dietary diversity for women of reproductive age, and child's gender.

When binary logistic regression was conducted to determine if the identified statistically significant associations between HL-DBM and maternal, household, and child features continued to be statistically significant, the child's age was revealed as the most vital determinant of HL-DBM, with children 0—6-months old and 7—12-months old being 16.338 and 16.435, respectively, times more likely to be in a home with an overweight or obese mother. Factors found to protect against HL-DBM included maternal marital status, with married mothers of reproductive age were 38.6% less likely to be in a household with HL-DBM. In comparison, divorced or separated mothers were 38.7% less likely to be part of HL-DBM mother—child pairs. Other maternal, home and child characteristics had no statistically significant association with HL-DBM and did not contribute to the model.

Research question 5 attempted to investigate the association between HL-DBM and the frequency of domestic violence in the neighborhood. With a Chi-Square test result of $x(1)=2.305$, $p = 0.680$ (> 0,05), no statistically significant association was found. When using binary logistic regression to determine whether the significance of the association between HL-DBM and the frequency of domestic violence in the neighborhood changed, the association remained insignificant.

In summary, statistically significant risk factors of HL-DBM are the child’s age, with younger children experiencing higher levels of risk than older under-5-year-old children. Further, factors protecting from HL-DBM were married or divorced/separated mothers. Other statistically significant associations included (a) income step of the household, (b) household food security, and (c) household main water source. In addition to summarizing the doctoral study, Section 4 will be used to comprehensively describe the study results and implications for professional practice and social change.

Section 4: Application to Professional Practice and Implications for Social Change

The purpose of this study was to investigate how the distribution of HL-DBM in South Africa varied by income step of the household on the day of survey data collection, population group, and type of household. Further, during the study, other known determinants of HL-DBM were explored in the South African setting: (a) maternal highest level of education, (b) maternal marital status, (c) maternal employment status, (d) household's main water source, (e) household's type of available toilet, (f) household's food security, (g) household's minimum dietary diversity for women of reproductive age, (h) child's age, (i) child's gender, and (j) the frequency of domestic violence in the neighborhood. In this study, HL-DBM was characterized as the household, where occupants include any combination of an overweight or obese mother of reproductive age (15–49 years old) and her under 5-year-old child with signs of thinness, stunting or wasting.

As a summary of the characteristics of the households included in this study (*n* = 314), most households were formal (86.6%; *n* = 272), owned by the African population group (83.8%; *n* = 263), were in the lowest income step (55.1%; *n* = 173). Other key sociodemographic features of the study sample were that most mothers had completed Grades 10–12 (53.8%; *n* = 169), were economically inactive (45.9%; *n* = 144), and were never married (55.1%; *n* = 173). Sampled HL-DBM homes had piped water in the dwelling (34.1%; *n* = 107), had pit latrines without ventilation pipes (28%; *n* = 88), were food insecure (92.7%; *n* = 291), and had poor minimum dietary diversity for women of reproductive age (91.1%; *n* = 286). Of the under 5-year-old children in HL-DBM households, most were male (52.2%; *n* = 164) and within the 7–24-months age range (39.2%; *n* = 123). Lastly, most HL-DBM households were found to have reported that domestic violence never happens in their neighborhood (31.8%; *n* = 100).

Further statistical analyses revealed the child's age as a statistically significant risk factor of HL-DBM, where younger children experienced a considerably higher risk of being in a household with HL-DBM than older children below 5 years old. Conversely, statistically significant protective factors of HL-DBM included married or divorced/separated mothers. Other statistically significant factors associated with HL-DBM were (a) income step of the household on the day of survey data collection, (b) household food security, and (c) household's main water source.

Interpretation of Findings

Of the total NIDS household sample size, 2,111 households, or 15.4% (*n* = 13,719), included a mother and child pair where the mother was of reproductive age and one of her children was under 5 years old. Within the study population, 14.9% (*n* = 314) households were identified as meeting the definition of HL-DBM, an almost 4% increase in South African national prevalence in 2017 compared to Brown's (2018) prevalence finding 11% informed by 2014 cross-sectional survey data. For the rest of this section, the SDH conceptual framework will ground the interpretation of the findings revealed through statistical analyses conducted during this study.

Income Step, Population Group, and Type of Dwelling

Although the univariate characteristics of the sample showed that the majority of the HL-DBM households were identified in the lowest (poorest) income rung (55.1%; *n* =

263) and the Pearson Chi-Square results highlighted a statistically significant association between household income step and HL-DBM, $x(1)=7.696$, $p = 0.021$ (< 0,05), the statistical association did not continue to be significant during the binary logistic regression analysis and, as such, did not contribute to the model. This finding aligns with the overall debate among DBM scholars. Several authors contend that the highest household income rung (Felix-Beltran et al., 2020; Masibo et al. 2020; Patel et al., 2020; Sunuwar et al., 2020) was associated with, and is a risk factor for, HL-DBM, whereas other authors (Mahmudiono et al., 2018; Modjadji & Madiba, 2019) contended that the lowest income rung is associated with, and a risk factor for, HL-DBM. Still, other authors (Sartorius et al., 2020; Senekal et al. 2019) found the middle-income rung to be protective of HL-DBM, putting forward a U-shape social pattern DBM, where the highest and lowest income rungs were found to be associated with higher overnutrition rates.

Regarding population group and type of dwelling, most HL-DBM homes were formal housing (86.6%, n = 272) belonging to the African population group (83.8%, n = 263). In this study, formal housing included (a) dwelling or brick structure on a separate stand or yard or farm, (b) traditional dwelling/structure made of traditional materials, (c) flat or apartment in a block of flats, (d) town/cluster/semi-detached house, (e) unit in a retirement village, and (f) dwelling/house/flat/room in the backyard. However, following the Pearson Chi-Square tests, no statistically significant associations were identified between HL-DBM and population group, $x(1)=3.721$, $p = 0.293$ (> 0,05), and type of dwelling, $x(1)= 2.650$, $p = 0.266$ (> 0,05). Additionally, both population group and type of dwelling remained insignificant during the binary logistic regression and, as such, did not contribute to the model.

These findings are contrary to those of researchers like Brown (2018), who found that mothers belonging to the African population group were associated with an increased risk of HL-DBM. Popkin et al. (2020) and Wells et al. (2020) also recognized an association between population group and malnutrition, noting the continued deficits in birthweight among African Americans, as well as the higher prevalence of obesity among Hispanic and African Americans, compared to those of Americans of European descent. Notably, though researchers identified urban areas as risk factors of HL-DBM (Masibo et al., 2020), others found that the types of dwellings in peri-urban settings (i.e., informal homes, or shacks, rooms or flatlets, and caravans or tents in densely populated regions) were risk factors of HL-DBM (Jones et al., 2018). Finally, a statistically significant association has been established between child undernutrition and rural and tribal dwellings (Sartorius et al., 2020). It is possible that in summarizing the variable, type of dwelling, into three distinct categories, possible associations with specific types of homes were missed.

Importantly, through the lens of the SDH conceptual framework, the lowest income households are more likely to be significantly associated with HL-DBM. This argument is aligned with that of researchers like Popkin et al. (2020). In Popkin et al.'s examination of the number of countries with changes in DBM at the national level between 1990 and 2010, the highest increase in the number of countries with a form of DBM was in the lowest income quartile, with a corresponding decrease in the number of countries with a type of DBM in the highest income quartile. Further, the lowest-income households are more likely to reside in destitute homes in overcrowded and vulnerable peri-urban and urban slum areas with inadequate water and sanitation facilities (Jones et al., 2018). Poor homes are prone to experience economic barriers to known protective factors of HL-DBM (i.e., high levels of maternal education; Mahmudiono et al., 2018; Masibo et al., 2020; Patel et al., 2020), household food security (Drammeh et al., 2019; Gubert et al., 2017), and dietary diversity (Chakona & Shackleton, 2017; Martin-Prevel et al., 2017; Popkin et al., 2020; Wells et al., 2020).

Maternal Marital Status, Highest Level of Education, and Employment Status

Based on the univariate analysis, 53.8% (n = 169) of the mothers in mother–child pairs had completed Grades 10–12 as their highest level of education. Further, 45.9% (n = 144) and 55.1% (n = 173) of the mothers in the study sample were economically inactive and never married, respectively. Despite the Pearson's Chi-Square results not revealing statistically significant associations between HL-DBM and maternal characteristics (i.e., marital status, the highest level of education, and employment status), the binary logistic regression highlighted maternal marital status as protective of HL-DBM. Importantly, compared to the reference category never married, married mothers of reproductive age were 38.3% (*Exp (B)* = .614, $p < .005$, 95% CI [.397-.949]) less likely to be in a home with HL-DBM, whereas divorced or separated mothers were 38.7% (*Exp (B)* = .613, $p < .005$, 95% CI [.457-.812]) less likely to contribute to HL-DBM. Other maternal characteristics remained statistically insignificant in the binary logistic regression and did not contribute to the model.

The finding that married mothers are likely to protect against HL-DBM aligns with previous research in two affluent urbanized settings in South Africa (Senekal et al., 2019) but contradicts a nationally representative cross-sectional study that associated married mothers with increased odds of HL-DBM (Brown, 2018). The lack of a statistically significant association between the maternal highest level of education and HL-DBM found in this study also differs from the same national cross-sectional study that found maternal completion of tertiary education as protective of HL-DBM in South Africa. Low maternal education was additionally identified as a risk factor for undernutrition among children living in LMICs, including South Africa (Mahmudiono et al., 2019; Sartorius et al., 2020).

In LMICs, there is a lack of access to media and education that is associated with HL-DBM (Das et al., 2019), though other research has shown higher odds of HL-DBM significantly correlated with maternal completion of secondary school, compared to no education (Sunuwar et al., 2020). However, in contrast to South Africa's higher-middle-income status, this previous research was conducted on LMICs. Notably, previous research did not explicitly limit their study to mothers of reproductive age (i.e., 15 to 49 years old; Brown, 2018; Mahmudiono et al., 2019; Sartorius et al., 2020). Finally, although the analyses in this study did not find a statistically significant association between maternal employment status and HL-DBM, the specific nuances of the South African context (i.e., cultural barriers and migrant labor) emphasize the need for additional research in this area.

Household Food Security, Dietary Diversity, Primary Water Source, and Type of Available Toilet

Univariate analysis of the sample revealed that 92.7% (n = 291) of HL-DBM households were food insecure, and 91.1% (n = 286) homes were found to have poor dietary diversity. Despite the Pearson Chi-Square test result showing a statistically significant association between HL-DBM and household food security—$x(1)=3.789$, p = 0.052 (< 0.05)—the association did not remain statistically significant to not contribute to the model of the subsequent binary logistic regression analysis. Further, though food security has been associated with dietary diversity (Chakona & Shackleton, 2017), the Pearson Chi-Square test result did not reveal a statistically significant association between minimum dietary diversity for women of reproductive age and HL-DBM, nor did minimum dietary diversity for women of reproductive age contribute to the logistic regression model.

The inconsistent pattern of these findings resembles those in the existing literature. Brown's (2018) study using the 2016 cross-sectional NIDS dataset found that the statistically significant association between food security and HL-DBM did not remain during the logistic regression analyses. Conversely, several studies have associated food insecurity and poorly diverse diets with HL-DBM (Popkin et al., 2020; Wells et al., 2020; with Gubert et al. (2017) establishing food insecurity as a risk factor for HL-DBM in Brazil. In their scoping review of factors associated with HL-DBM, Guevara-Romero et al. (2021) argued an association between HL-DBM and food consumption but noted that only 24 out of 70 eligible journal articles included in their review associated food consumption with HL-DBM. One possible mechanism for the occurrence of HL-DBM in the sampled households may relate to the shift in dietary patterns that underpin the rapid nutrition transition happening in middle-income countries, where households leave their traditional indigenous food to consume energy-rich micronutrient deficient food (Popkin et al. 2020; Prentice, 2018; WHO, 2017). In homes that favor calorific, poorly diverse diets with low micronutrients, the co-occurrence of maternal overnutrition and simultaneous child undernutrition is possible (Mahmudiono et al., 2019).

Regarding the possible association between HL-DBM and water and sanitation facilities, as well as hygiene, over a third of the sample of HL-DBM homes had piped water in the dwelling (34.1%, n = 107), followed closely by homes using communal water sources (32.2%, n = 101). Additionally, though most HL-DBM households (26.1%, n = 82) had a flush toilet with onsite disposal, 22.6% (n = 71) of HL-DBM homes used a pit latrine with a ventilation pipe. However, the Pearson's Chi-Square test revealed only one statistically significant association, which was between HL-DBM and the household's main source of water—i.e., $x(1)=11.211$, $p = 0.011$ (< 0.05)—when binary logistic regression was conducted, the association did not remain statistically significant and did not contribute to the model. However, considerable evidence demonstrates that unsafe drinking water, inadequate sanitation facilities, and poor household hygiene practices are the leading determinants of diarrhea-related under-nutrition among children under 5 years (Dharod et al., 2021; Gizaw & Worku, 2019; Momberg et al., 2020;

Pickering et al., 2019). Therefore, it is possible that acute childhood illnesses, particularly diarrhea, could contribute to the occurrence of HL-DBM.

Child's Age and Gender

Univariate analysis of the sample of HL-DBM households showed that most under-5 children in mother–child pairs with signs of thinness, stunting, or wasting were male (52.2%, n = 164) and within the age range of 7—24 months (39.2%, n = 123), followed closely by the 25–36-month age range (26.8%, n = 84). The only statistically significant association identified using the Pearson's Chi-Square results was the child's age——$x(1)=42.979$, $p = 0.000$ (< 0.05). When binary logistic regression was conducted, based on the reference age category of 49–59 months, the variable child's age was the strongest statistically significant association with HL-DBM. Children 0–6 months old (Exp (B) = 16.338, $p < .001$, 95% CI [5.12-52.075]), 7–24 months old (Exp (B) = 16.435, $p < .001$, 95% CI [5.111-52.852]), 25–36 months old (Exp (B) = 14.162, $p < .001$, 95% CI [4.366-45.937]) and 37–48 months old (Exp (B) = 11.959, $p < .001$, 95% CI [3.638-39.311]) were found to be more susceptible to living in a home with HL-DBM. With marginal differences in the likelihood ratios between the under-5 age categories, children between birth and 6 months old and those between 7 and 24 months old were 16.388 and 16.435 more likely to be in an HL-DBM mother–child pair, respectively. As the child grows beyond 2 years old, the likelihood ratio for children between 25–26 months old is 14.162 to be in an HL-DBM home, whereas for children 37–48-months, the likelihood ratio is 11.959 to be in a mother–child HL-DBM.

The finding that younger under-5 children have substantially higher likelihood ratios of being undernourished in households with HL-DBM is consistent with previous research (Senekal et al., 2019; Tzioumis et al., 2016). A biological reason for this increased vulnerability is that several critical development windows close early across the maternal-neonatal-child health continuum to reduce the sensitivity of specific epigenic effects to environmental determinants (Wells et al., 2020). Though malnutrition occurs across the life course with the causative factors of HL-DBM extending over several generations, early sensitive phases begin in pregnancy, lactation, and breastfeeding, resulting in the mother's phenotype being the vital nutritional determinant of early development (Wells et al., 2020). In other studies, a metabolic capacity-load model was a potential biological driver of mother–child HL-DBM (Wells, 2018).

Associated with adult diets, physical inactivity, psychosocial distress, alcohol and tobacco consumption, contaminated air, and infectious diseases, metabolic load, like allostatic load, stresses the body's capacity to maintain intrinsic homeostasis. Conversely, the metabolic capacity to tolerate increasing metabolic load depends on a collection of traits shaped by intrauterine, neonatal infancy nutritional factors during early development critical windows (Wells, 2018). Using the metabolic capacity-load model across the life course, overweight or obese mothers are likely to have lower metabolic capacity to tackle the challenges related to the metabolic load produced by micronutrient deficient and calorific diets associated with the rapid nutrition transition. As such, sub-optimal maternal metabolic capacity-load compromises fetal growth and increases the risk of neonatal and early childhood forms of undernutrition and early undernutrition has deleterious effects on the child's metabolic capacity-load predisposing later adiposity, overweight, or obesity (Wells et al., 2020).

The Frequency of Domestic Violence in the Neighborhood

Univariate characteristics of the sample of eligible HL-DBM households revealed that most households reported that domestic violence never happened in their neighborhood (31.8%, n = 100), with the lowest proportion of HL-DBM homes noting that domestic violence in the neighborhood was relatively common (12.7%, n = 40). The Pearson's Chi-Square test and the logistic regression did not reveal a statistically significant association between HL-DBM and the frequency of domestic violence in the neighborhood. The frequency of domestic violence in the community did not contribute to the model. Therefore, the null hypothesis could not be rejected.

Though no statistically significant association was identified, growing literature notes the gross under-reporting of incidences of domestic violence in South Africa. From a settings perspective, academics recognize that despite domestic violence against women being a serious social and public health threat, domestic violence in South Africa is generally regarded as a private matter, confined to the boundaries of the home and invisible to the public (Mazibuko & Umejesi, 2019). Indeed, recent submissions by South African civil society organizations to the United Nations' Committee on Elimination of Discrimination against Women (CEDAW, 2021) argued that although the overall high prevalence of domestic violence, the South African government had failed to fulfill its due diligence responsibility to protect women from domestic violence, constituting a systematic contravention of the Convention on the Elimination of All Forms of

Discrimination against Women. Allegations against the South African government include the (a) persistent gender roles that legitimize domestic violence, dissuading reporting of domestic violence, (b) lack of routine statistical data and research, and (c) lack of sensitization of the health and social justice workforce, as well as the public.

Applying the life course approach, understanding the prevalence of domestic violence in the neighborhood generates psychosocial stress, with implications for allostatic and metabolic capacity loads for residents in the community. Several researchers identified violence in the neighborhood as a driver of psychosocial and environmental stress that impact biological pathways, e.g., the immune function and sympathetic response, to contribute to the risk of cardiovascular disease (Gibbs et al., 2020; Hazlehurst et al., 2018). Other academics associated psychosocial and environmental stress with decreased metabolic capacity and allostatic load, leading to overweight or obese mothers having malnourished infants and young children predisposed to later adiposity, overweight, or obesity (Wells et al., 2020).

Key Findings and Related to the Conceptual Framework

Upstream Determinants

The most upstream determinant that influences the downstream levels of risk of, or vulnerability to, HL-DBM in South Africa is the country's neoliberalist socioeconomic policies. With South Africa achieving its democracy in 1994, the country plunged into rapid socioeconomic and political transformation. In a bid to secure continued International Monetary Fund and World Bank financial support, the governing African National Congress political party adopted a predominantly neoliberal welfare state, characterized by austerity measures, globalization, trade liberalization, and a dependency on the markets to redress the social injustices of apartheid (Ndhlovu, 2019; Powers, 2019; Schneider, 2018). Despite South Africa's substantial social grant program that disperses at least one type of social grant, (i.e., family and children, old age, illness, and morbidity, or social protection) to almost 46% of households (Schneider, 2018), the impact of neoliberalism is evident in the shift of the country's estimated Gini coefficient of 0.53 in 1993 to 0.63 in 2014 (World Bank, 2021). Other impacts of neoliberalism are worsening unemployment rates that increased to 26.6% in 2016 from 4.4% in 1994, reduced wage share of gross domestic product dropping to 50.6% in 2010 from 55.9% in 1994. Poor income per capita growth leaves South Africa trailing behind middle-income countries, as well as the world average (Schneider, 2018).

Simultaneously, globalization and trade liberalization have offered entry points for industrialized transnational food systems and corporations that are considered a driving force underpinning the overconsumption of nutrient-deficient calorific food to produce food insecurity and malnutrition across the life course (Baker et al., 2021; Schram & Townsend, 2021;). Adaptive complex food systems reach global, national, and sub-national levels, producing variable access to nutritious, wholesome foodstuff between and within countries. Critically, by their diffuse nature, food systems render themselves mainly invisible to consumers, communities, and decision-makers, with globalization distancing food producers from regulators. Transnational corporations lobby for specific economic policies, (e.g., incentive structures, taxes, trade protection, and anti-competition), which safeguard and perpetuate their interests despite diminishing the capacity of local and indigenous food systems to compete in the free market (Lee et al., 2022). In South Africa's liberalized economy, transnational food corporations deploy aggressive marketing techniques and advertising activities to shape beliefs and influence social norms regarding the suitability of different foods to accelerate the adoption of westernized diets as part of the nutrition transition (Baker et al., 2021).

Midstream Determinants

Against this broader context, this cross-sectional study associated (a) income step of the household on the day, (b) household food security, and (c) household's main source of water with variance in the occurrence of HL-DBM in South Africa in 2017. Though these statistically significant associations did not remain during binary logistic regression to contribute to the model, the associations found during the Pearson's Chi-Square tests correspond to similar findings that explain HL-DBM in other studies. Socioeconomic status, or in this study, the income step of the household, is a well-established determinant of health and health inequity (Brown, 2018; Sartorius et al., 2020; Wells, 2018) that influences access to other mid-stream determinants of health, (e.g., housing, employment, water supply, food security, dietary diversity, and sanitation services).

Regarding the relationship between income step of the household and HL-DBM, researchers use the metabolic capacity-load model to unpack the social gradient in nutrition outcomes and notes that along the social ladder and amongst both genders, those born into higher income levels were taller and had higher ratios lean muscle mass (Wells et al., 2020; Wells, 2018) than those born into comparatively poor homes. Even when those individuals born into poverty moved up the social ladder later in life, their height remained approximately 4cm shorter than their counterparts, highlighting the critical nature of the intrapartum, perinatal, neonatal, and infant stages of growth. Significantly, since nutrition scientists linked metabolic capacity with height and lean muscle mass at birth, the social gradient remains as individuals grow older due to the inherent capacity amongst wealthier newborns to maintain homeostasis despite the metabolic load (Wells et al., 2020; Wells, 2018). Conversely, impoverished newborns remain shorter and have lower metabolic capacity such that changes in diets or the adoption of cheap westernized nutrient-dense and micronutrient-deficient diets lead to overweight and obesity (Wells et al.,2020).

Household income usually also determines access to clean water sources and sanitation services. Academics note the few encouraging developments since adopting a neoliberal political economy in 1994, including establishing a basic social security system and providing essential services for people, e.g., water, housing, and healthcare (Schneider, 2018). Whereas these improved social developments are evident in South Africa's middle-class expansion, the disturbingly high unemployment rates of 26.6% in 2016 have underpinned the rapid urbanization into vulnerable peri-urban informal settlements (Weinmann & Oni, 2019) in the employment search. Informal settlements, where houses do not offer tenure security to residents, feature unregulated homes, inadequate or absent essential services, poor supply of healthcare services, and other government amenities.

In South Africa, several informal settlements meet the criteria of urban slums in that several housing settlements are characterized by (a) derelict houses, (b) limited access to piped water, (c) limited or no access to sanitation, (d) land that is insufficient to support subsistence farming, and (e) security of tenure (Weimann & Oni, 2019). In considering the interaction between the setting of informal settlements and population health outcomes, (a) poor housing have poor ventilation and elevated levels of indoor pollution to produce chronic illness, (b) household financial pressure produces increased psychosocial stress within the family, (c) vulnerable locations collapse due to natural disasters, reinforcing poverty and deprivation, (d) lack of clean piped water and sanitation services result in recurrent episodes of childhood diarrhea leading to undernutrition, and (e) high crime or gender discrimination levels in the community produce additional psychosocial stress (Weimann & Oni, 2019). However, considering researchers' work on the metabolic capacity-load model, features of informal settlements may increase the metabolic load, with simultaneous decreases in metabolic capacity to produce overweight and obese adults and stunted, thin, or wasted young children with increased levels of adiposity (Wells et al., 2020).

Though South Africa's school feeding program called the National School Nutrition Program attempts to reduce hunger, nutrient deficiencies and improve education and health outcomes (Mostert, 2021), household income determines access to high-quality, comparatively more expensive nutritious food for under-5-year-old children. Nutrition scientists contend that low-income households substitute healthy fresh food options with cheaper and calorie-dense ultra-processed foods with poor dietary diversity. Low-income households tend to consume high volumes of starch staples, (e.g., maize, bread, and rice, with a low intake of fruit, vegetables, and legumes). Increased supply of per capita macronutrient dense food in South Africa collides with urbanization, unemployment, poverty, and settings to produce and sustain patterns of HL-DBM.

Finally, despite the lack of a statistically significant association between HL-DBM and maternal marital status, binary logistic regression revealed that married, divorced, or separated marital status were statistically significant protective factors of HL-DBM. Relative to the reference category 'never married', married mothers of reproductive age were 38.3% (*Exp (B)* = .614, $p < .005$, 95% CI [.397-.949]) less likely to be in a home with HL-DBM, and divorced or separated mothers were 38.7% (*Exp (B)* = .613, $p < .005$, 95% CI [.457-.812]) less likely to contribute to HL-DBM. Compared to never married, those mothers in marital unions may have access to higher household incomes and subsequently better access to housing, water supply, and sanitation services, as well as purchasing power for good-quality nutritious food to protect against HL-DBM (Christian & Dake, 2021). Conversely, divorced or separated women who have the agency and resources to leave their partners might have higher education, employment, earning capacity to enable access to better quality food and households, and protection against HL-DBM.

Downstream Determinants

According to the SDH conceptual framework, interacting upstream and midstream determinants influence downstream factors, including genetic predisposition, age, gender, and ethnicity that influence individual agency and the willingness to participate in risky health behavior (Donkin et al., 2017). Statistical analyses in this study revealed the child's age as being the most statistically significant association of HL-DBM. Binary regression results further showed marginal variations in the likelihood ratios between under-5 age categories and the incidence of HL-DBM, with the youngest age groups of birth to 6-months and 7-months to 24-months having the highest likelihood ratios. However, these findings align with the biological explanations of intergenerational vulnerability that reduce the maternal metabolic capacity to produce obesity in the mother and nutrient deficiencies and undernourishment of her child during pregnancy, breastfeeding, and infant feeding (Wells et al., 2020; Wells, 2018). As such, critical development windows in the reproductive, maternal, neonatal, and child health continuum close without adequate nutrition to produce largely stunted children with high levels of adiposity and compromised metabolic capacities. Using the life course perspective, without the genetic predisposition to catch up with their taller counterparts with higher lean muscle ratios, these undernourished children develop into overweight or obese adolescents and adults to perpetuate the cycle of deprivation and disadvantage (Fintel & Richter, 2019).

Summary of Key Findings and Interpretation

Post-apartheid South Africa has addressed previously entrenched disadvantages by implementing one of the most extensive social grant programs in the global South (Schneider, 2018). Further, the democratic government has progressed access to housing, clean piped water, sanitation services, and education. However, South Africa's early adoption of a neoliberalist political economy, with subsequent deterioration in socioeconomic inequity (World Bank, 2021), employment rates, the wage share of gross domestic product, and income per capita growth, serves as the most distal determinant of household income and access to nutritious food, piped water supply, and sanitation services (Schneider, 2018). Simultaneously, powerful industrialized transnational food corporations have transformed the sovereign food system with trade liberalization and globalization. Additionally, aggressive marketing methods and advertising activities have accelerated the nutrition transition, (i.e., the shift from wholesome indigenous diets to calorie-dense micronutrient-deficient food) (Baker et al., 2021; Schram & Townsend, 2021).

Within this broader context, statistical analyses conducted during this study revealed the variance in the incidence of HL-DBM, as defined in this study, was statistically significantly associated with the income step of the household, household food security, and the household's main source of water. Although these associations were not statistically significant during binary logistic regression, they highlight essential midstream associations with HL-DBM. Differences in household income produce a social gradient. Individuals born in higher-income households are taller across the gradient and between genders. They have higher lean muscle ratios than their poorer counterparts, who are usually stunted and have high levels of adiposity (Wells et al., 2020). Using the metabolic capacity-load model to explain the differences, Wells (2018) contends that individuals born into rich environments tend to have the higher metabolic capacity and can maintain homeostasis, (i.e., body weight), despite changes to metabolic load, (i.e., consuming higher food quantities, alcohol, tobacco, high levels of psychosocial stress, and air pollution). Conversely, those born into impoverished homes start life in a nutrient-deficient perinatal environment that diverts available nutrition on developing vital organs to produce stunting and adiposity in infancy which cannot be reversed when critical development windows close. Therefore, individuals born into poverty tend to have compromised metabolic capacity and develop into overweight or obese adults.

Household income also determines access to food and piped clean water. However, South Africa's disturbingly high unemployment rates coincide with rapid urbanization and the formation of vulnerable peri-urban urban slums, characterized by inadequate or absent infrastructure and access to essential services, e.g., water and sanitation services (Weinmann & Oni, 2018). Critically, informal housing in peri-urban slums has (a) poor ventilation and high levels of indoor air pollution that contribute to chronic illness, (b) increasingly high levels of the household financial pressure that produces elevated levels of psychosocial stress, (c) increased vulnerability to natural disasters that perpetuate poverty and deprivation, (d) inadequate clean piped water and poor sanitation services that lead to recurrent episodes of childhood diarrhea and undernutrition, and (e) elevated levels of neighborhood crime and gender discrimination that produce increased psychosocial stress (Weinmann & Oni, 2018). Low-income households usually consume a largely starchy diet, rich in maize, bread, or rice, with little to no vegetables, fruit, or legumes (Sartorius et al., 2020). Using the metabolic capacity-load model to understand the interactions of the features of peri-urban slums and HL-DBM, it is evident that mothers living in these settings are likely to experience higher levels of metabolic load and weakened metabolic capacity that ultimately leads to overweight or obese mothers and undernourished children in the same household (Wells et al., 2020; Wells, 2018).

Though maternal marital status was not found to have a statistically significant association with HL-DBM, binary logistic regression showed that married mothers and divorced or separated mothers had statistically significantly lower likelihood ratios of being in a home with HL-DBM than mothers who never married. Academics contend that married mothers may have access to higher household income levels, resulting in better household access to nutritious and diverse foods, housing, clean water supply, and decent sanitation services that protect their children from undernutrition and HL-DBM (Christian & Dake, 2021). Equally, mothers who exercise individual agency to divorce or separate from their partners are likely to have higher education, employment opportunities, and earning capacity that facilitate access to housing, clean piped water, high-quality sanitation services, and nutrient-dense foods.

Limitations

Whereas the findings of this study advance the understanding of the determinants of HL-DBM, it is critical to acknowledge the study's limitations. With the use of cross-sectional data produced by a representative sample of South African households in 2017, external validity, (i.e., the ability to generalize these findings across populations, settings, and periods), is compromised (Frankfort-Nachmias & Leon-Guerrero, 2018) such that the results are limited to South African homes in 2017 (Salkind, 2010). The NIDS is a panel survey, starting in 2008, with repeated rounds of data collection from CSMs. They might have matured or dropped out of the sample to produce systematic changes to the study's population groups. The resultant observed effects of HL-DBM can be attributed to specific events or circumstances instead of the independent variables included in this study (Salkind, 2010) to compromise the study's internal validity. Using secondary cross-sectional data for this research makes determining the direction of causal influence impossible, producing ambiguous causal direction and limitations to the study's internal validity.

Weaknesses in the dataset made it impossible to control several potential confounding effects of maternal or child disability, pregnancy, breastfeeding or lactation, HIV status, tuberculosis status, frequency of maternal alcohol consumption, household consumption of tobacco products, and other types of drugs, and household cooking fuel. An essential additional limitation to this study involved dealing with households with more than one child with signs of undernutrition. Several HL-DBM homes had more than one under 5-year-old child with thinness, wasting, or stunting signs. To move the study forward, a single child was included in the household mother—child pair with the highest markers of

- Stunting: length-for-age or height-for-age less than two standard deviations below the median length-for-age or height-for-age of the WHO Multicenter Growth Reference Study Group (2006) child growth standards),
- Thinness: weight-for-age less than two standard deviations below the median weight-for-age of the WHO Multicenter Growth Reference Study Group (2006) child growth standards, and,

- Wasting: weight-for-height or weight-for-length of less than two standard deviations below the median of the WHO Multicenter Growth Reference Study Group (2006) child growth standards.

Therefore, a fundamental limitation of this study is its inability to describe the dynamics of HL-DBM with mother—child pairs, where more than one child in the household shows signs of undernutrition.

Notably, despite presenting a reasonable a priori power sample size estimate that targeted 364 households to detect a medium effect size. The *OR* = 1.5 at the 5% level of significance with 95% power, this study's sample was 314. Therefore, the actual sample size fell short of the target sample, making it impossible to avoid Type I and Type II errors (Perugini et al., 2018). However, since power is the probability of correcting identifying the alternate hypothesis, power is only meaningful when considered before completing the statistical analyses (Anderson, 2019; Perugini et al., 2018;). Other researchers contend further that a null hypothesis outcome, irrespective of the critical α, will fundamentally not have adequate post-hoc power (Gaskill & Garner, 2020). However, rather than implying that the null hypothesis was true or that the investigation was underpowered, it merely infers that the null hypothesis cannot be rejected, as was the case for most of the research questions in this study.

Recommendations

Although every attempt to control for potential confounding effects was made, limitations in the secondary dataset made controlling for the possible confounding effects of HIV status impossible. Given that South Africa has the highest number of people living with HIV globally (UNAIDS, 2021) and mothers living with HIV are more likely to have low birth weight children (Sartorius et al., 2020), HIV status is an essential contextual risk factor that needs to be considered in future studies on HL-DBM. In addition to TB status and its link to adult and childhood malnutrition and household food insecurity (Balinda et al., 2019), maternal alcohol and tobacco consumption was recently associated with an increased likelihood of their infants being undernourished (Modjadji & Pitso, 2021). With alcohol and tobacco consumption amongst women of reproductive age ranging from a high of over 50% in South Africa's Western Cape Province to a low of 0.07% in Limpopo Province, controlling for the potential confounding effects of maternal alcohol and tobacco consumption, or including these as variables of interest, is recommended in future studies of HL-DBM. As transnational food corporations continue to pursue aggressive marketing tactics and advertising activities, it will be crucial to understand the commercial determinants of HL-DBM (Lee et al., 2022).

Finally, based on an improved understanding of the biological drivers of HL-DBM, it will be increasingly important to understand the association between settings, the prevalence of neighborhood crime, domestic violence, psychosocial stress, and HL-DBM since these are already established factors influencing metabolic capacity and load (Weinmann & Oni, 2019; Wells et al., 2020). With the recent Convention on the Elimination of All Forms of Discrimination against Women (2021) report in response to allegations from South African civil society organizations regarding the government's failure to fulfill its due diligence responsibility to protect women from domestic violence, resulting improved accountability mechanisms and an enabling environment for reporting and managing domestic violence might allow for better exploration of the associations of HL-DBM and the frequency of domestic violence in the neighborhood. Applying a life-course approach, it will be increasingly important to consider cohort monitoring or longitudinal studies that unpack and reveal the intergenerational effects of compromised biological systems that perpetuate cycles of malnutrition (Wells et al., 2020).

Implications for Professional Practice and Social Change

In this section, the potential implications of this study and its findings for the professional practice of public health practitioners, researchers, and theorists and describe how this study will positively impact social change are considered.

Professional Practice

Since downstream determinants of HL-DBM are largely genetically predisposed (Popkin et al., 2020) and focus mainly on the biological metabolic capacity-load model (Wells et al., 2020; Wells, 2018), public health nutritionists need to appreciate how midstream and upstream determinants intersect with downstream determinants to produce intergenerational HL-DBM. As such, vertical programs, policies, strategies, governance structures, and funding streams that target specific types of malnutrition, either overnutrition or undernutrition, are increasingly inappropriate (Hawkes et al., 2020). Using the metabolic capacity-load model, interventions targeting undernutrition amongst those children with compromised metabolic capacity are likely to result in early overweight or obesity (Hawkes et al., 2020).

With the growing acknowledgment that both extremes of malnutrition have equivalent drivers, public health practitioners are calling for double-duty actions that address early life nutrition, diet diversity, and food security, the policy and regulatory environment around food systems, socioeconomic factors, housing, maternal nutrition education, and high-quality water supply and sanitation infrastructure, as well as improved household hygiene practices (Hawkes et al., 2020; WHO, 2017). Addressing these fundamental determinants of HL-DBM requires a multisectoral approach and combined efforts of the National Departments of (a) Health, (b) Basic and Higher Education, (c) Social Development, (d) Agriculture, Land Reform, and Rural Development, (e) Public Works and Infrastructure, (f) Justice and Constitutional Development, (g) Women, Youth, and Persons with Disabilities, and (h) International Relations and Cooperation, as well as (i) National Treasury. With overall oversight, governance, and coordination responsibilities, the National Department of Health will need to engage other departments and National Treasury to develop health-in-all policies or healthy public policy that address the shared drivers of all forms of malnutrition (Hawkes et al., 2020).

Methodological

This study allows researchers to use other datasets, either primary or secondary data, to expand investigations of the associations and determine the direction of causal influence that establishes risk and protective determinants of HL-DBM. In addition to considering all malnourished children in the HL-DBM home, other methodological opportunities include controlling for or having as variables of interest, (a) maternal HIV status, (b) TB status of both the mother or her children, (c) disability or chronic illness of the mother or her child, (d) pregnancy, lactation, or breastfeeding, (e) maternal alcohol and tobacco consumption, (f) the peri-slum setting, and (g) exposure of the mother or her child to domestic, interpersonal, or other types of violence. To advance the understanding of the metabolic capacity-load model, there is an opportunity for public health researchers to conduct quasi-experimental or experimental longitudinal studies that track cohorts of overweight or obese women of reproductive age throughout their pregnancy and until their child reaches adolescence. Within nutrition interventions, monitoring and evaluation systems could be used to conduct cohort monitoring to understand the adverse spillover effects of vertical malnutrition programs to advocate and inform shifts to double duty efforts.

Theoretical

Scientists used a narrative review to identify the socio-ecological correlates of DBM in developing countries (Mahmudiono et al., 2019), and others used a scoping review to identify factors associated with HL-DBM (Guevara-Romero et al., 2021). However, regarding the complex situation of an overweight or obese mother in the same household as her undernourished child and without the financial capability, or purchasing power, to have the required nutrients in the home, questions regarding how the mother could be overweight or obese in the scenario remained (Guevara-Romero et al., 2021; Mahmudiono et al., 2019;). Whereas mothers in the household may be consuming higher volumes of relatively cheaper macronutrient-dense foods, researchers have offered an intriguing biological reason in the metabolic capacity-load model across the life-course (Wells et al., 2018; Wells, 2018).

Children born to overweight or obese mothers are likely to have compromised metabolic capacities linked to increased maternal load, (i.e., overconsumption of calorific food, alcohol misuse, tobacco use, chronic illness, psychosocial stress, and air pollution). Compromised childhood metabolic capacity is evident in increased levels of adiposity during infancy and childhood stunting that once critical development windows close, does not reverse, such that even if a child born into an impoverished household moves into higher household income quintiles, they remain approximately 4cm shorter than their counterparts who started life in wealthier homes (Wells, 2018). Weakened metabolic capacity results in insufficient ability to maintain homeostasis, with an increased likelihood of weight gain in adolescence and adulthood with changes to metabolic load.

Empirical

In addition to anthropometry being used to determine the low birth weight, stunting, or wasting during infancy or childhood, undernutrition can also be investigated by assessing the stores of circulating concentrations of nutrients that represent dietary adequacy (Wells et al., 2020). In so doing, monitoring micronutrient adequacy as children age out can be a clear marker of their metabolic capacity and load. Another important marker of early childhood undernourishment is the ratio of lean muscle mass. Academics found that those children born into wealthier homes had higher proportions of skeletal muscle and maintained body weight homeostasis comparatively better than those born into poor homes with signs of stunting and increased levels of adiposity (Wells, 2018).

Positive Social Change

Aligned to Walden University's ethos of positive social change, this study advances the knowledge base and understanding of the drivers of all forms of malnutrition to inform improved public health practice, including the adoption of double-duty interventions. The methodological and empirical implications offer public health researchers and on-the-ground implementers opportunities to expand the nutrition research agenda and strengthen malnutrition measurement, monitoring, and management. Through strategic dissemination activities at public health and nutrition conferences, the findings of this study can raise awareness and inform advocacy efforts among civil society organizations for a multisectoral approach to nutrition that addresses all forms of malnutrition. Finally, through the publication of this study on Walden University's ProQuest platform and other potential publications, this study's results can generate momentum to tackle the root causes of the complex phenomenon of HL-DBM.

Summary

Whereas the topic area of HL-DBM is a growing area of interest in public health, very few studies have explicitly considered HL-DBM across the reproductive, maternal, neonatal, and child health continuum by limiting their study population to overweight or obese women of reproductive age and their undernourished, (i.e., wasted, stunted, or thin), under-5-year-old child. In addition to considering all types of undernutrition, the study sought to investigate the association between HL-DBM and the frequency of domestic violence in the neighborhood. Though statistically significant associations were found between known midstream determinants of HL-DBM, including (a) income step of the household, (b) household food security, (c) household's main water supply to explain variances in HL-DBM in the study population, these determinants did not remain statistically significant during binary logistic regression and did not contribute to the model. However, binary logistic regression did reveal the maternal marital status of being married and divorced, or separated, compared to never married, as a mid-stream factor that decreases the likelihood ratios of HL-DBM. At a proximal determinant of HL-DBM, a child's age had a statistically significant association with HL-DBM. Binary logistic regression revealed that when compared to 49—59-month-old children, there were marginal variations in likelihood ratios as children aged out from 0 to 6-months to 25—37—48-months-old, such that younger age categories had increased likelihood ratios of being in an HL-DBM.

These results highlight a specific scenario where an unemployed overweight or obese woman of reproductive age with inadequate household income and inadequate household infrastructure does not have the purchasing power to obtain nutritious food and depends on ultra-processed macronutrient-dense food. The psychosocial stress arising from financial stress, chronic illness produced by low-quality housing in peri-urban slums, and inadequate access to sanitation services and clean water supply, in addition to consuming calorific ultra-processed cheaper foods, increases her metabolic load. Her maternal phenotype becomes a vital nutritional determinant of the early development of her child during pregnancy, lactation, and breastfeeding. As the several critical development windows close, the sensitivity of specific epigenic effects to environmental determinants results in compromised metabolic capacity in infancy, which is evident in stunting, low birth weight, and increased levels of adiposity. As the child grows older, they may experience undernourishment related to poor water supply, inadequate sanitation services, insufficient household hygiene practices, and consuming micronutrient-deficient foods. Applying a life course perspective, the child's reduced metabolic capacity will not endure the social and environmental stressors that produce increased metabolic load, resulting in overweight or obesity in adolescence and adulthood.

With increasing recognition that both forms of malnutrition share common root causes, there are growing calls for simultaneous multisectoral action on all types of malnutrition. For example, during pregnancy, mothers should be supported to consume healthy diets, including supplementation with food or micronutrients in food-insecure households (Hawkes et al., 2020). During the postnatal period, mothers should be supported to continue consuming nutritious foods while they provide their children with optimal breastfeeding and complementary food practices, including food or micronutrient supplementation for children younger than two years old. Until 5 years old, all infants and children should be monitored and managed for severe acute malnutrition to limit their effects on growth.

In addition to this study developing the HL-DBM knowledge base, it also offers opportunities for public health practitioners to strengthen their practice and researchers through recommendations for an HL-DBM research agenda. Through strategic dissemination and publication, this study's results can raise awareness and build momentum for advocacy of healthy public policy that tackles the double-entry points for HL-DBM across the life course.

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