Food Insecurity and the Double Burden of Malnutrition in Colombian Rural Households

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Abstract

Background: The Colombian rural areas are vulnerable to household food insecurity and its consequences. Household food insecurity has been associated with child stunting and overweight and obesity (OWOB) in women. However, its relationship with an emerging phenomenon known as the double burden of malnutrition remains unclear.

Objective: This study aimed to examine in Colombian rural households the association between different severity levels of household food insecurity and the presence of the double burden of malnutrition (DBM), defined as the coexistence of a stunted child under five years and an OWOB mother (SCOWT).

Methodology: A cross-sectional study was conducted using data from mother-child pairs living in the same rural household (n=2,350) surveyed by the Colombian National Nutritional Survey (ENSIN) 2015. Household food insecurity status was assessed by using the Latin-American and Caribbean Food Security Scale (ELCSA). The household SCOWT status (child stunting and OWOB mother) was determined using anthropometric data from a mother and her child.

Results: Sixty-two percent of the households were food insecure and SCOWT was present in 7.8% of the households. Moderate (OR: 2.39 – CI: 1.36 - 4.21) and severe (OR: 1.86 – CI: 1.10 - 3.15) food insecurity was associated with SCOWT in an unadjusted logistic regression. Only moderate food insecurity remained significantly associated with SCOWT in a multivariate logistic regression (aOR: 2.41 - IC: 1.24 – 4.68).

Conclusion: The study findings contribute to increase awareness regarding overcoming food insecurity beyond hunger satisfaction to prevent all forms of malnutrition. Moreover, these results highlight the need of implementing rural policies and programs targeting most vulnerable households to SCOWT, particularly in terms of food insecurity.

Key words: food insecurity, double burden of malnutrition, stunting, overweight, obesity, rural areas, Colombia.

Résumé

Contexte : Les zones rurales colombiennes sont sensibles à l'insécurité alimentaire des ménages et à ses conséquences. L'insécurité alimentaire des ménages a été associée au retard de croissance chez l'enfant ainsi qu'au surpoids et à l'obésité (OWOB) chez les femmes. Cependant, sa relation avec un phénomène émergent connu sous le nom de double fardeau de la malnutrition reste incertaine.

Objectifs : Cette étude vise à examiner dans les milieux ruraux colombiens, l'association entre les différents niveaux d'insécurité alimentaire des ménages et la présence du double fardeau de la malnutrition (DBM), défini comme la coexistence d'un enfant de moins de cinq ans souffrant d'un retard de croissance et d'une mère OWOB (SCOWT).

Méthodologie : Une étude transversale a été réalisée, reposant sur des données provenant de couples mère-enfant vivant dans le même ménage rural (n = 2350) collectés par l'Enquête nutritionnelle nationale colombienne (ENSIN) 2015. L'état d'insécurité alimentaire des ménages a été évalué en utilisant l'Échelle de sécurité alimentaire des Caraïbes (ELCSA). Le statut SCOWT du ménage (retard de croissance chez l'enfant et mère en surpoids / obèse) a été déterminé à l'aide des données anthropométriques de l'enfant et de la mère.

Résultats : Soixante-deux pour cent des ménages étaient en situation d'insécurité alimentaire et le SCOWT était présent dans 7,8% des ménages. L'insécurité alimentaire modérée (OR: 2,39 - IC: 1,36 - 4,21) et sévère (OR: 1,86 - IC: 1,10 - 3,15) ont été associées à SCOWT dans une régression logistique non ajustée. Cependant, seule une insécurité alimentaire modérée est restée significativement associée au SCOWT dans une régression logistique multivariée (aOR: 2,41 - IC: 1,24 – 4,68).

Conclusion : Les résultats de cette étude soulignent la nécessité de mettre en œuvre des politiques et des programmes ruraux ciblant les ménages les plus vulnérables au SCOWT, en particulier en termes d'insécurité alimentaire.

Mots-clés : insécurité alimentaire, double fardeau de la malnutrition, retard de croissance chez les enfants, mères obèses en surpoids, zones rurales, Colombie.

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Contribution of Authors

This work was completed thanks to all authors listed in the manuscript. As a first author, I established the research question, reviewed the literature, planned the methodology, designed and executed the statistical analyses, organized and interpret the results, and wrote the manuscript. Dr. Hugo Melgar-Quiñonez supervised this process and shared his knowledge contributing to the development of the research question, interpretation and discussion of results, and revision of the thesis, including the manuscript. Dr. Jennifer Bernal Rivas and Dr. Stan Kubow followed the process and gave advice when required. They also contributed to the revision of the thesis and manuscript. Andrés Suarez assisted with the design and verification of the used statistical methods.

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Abbreviations

BMI	Body mass index
CLACMESA	Latin-American and Caribbean conference for measuring food insecurity
CONPES	Consejo Nacional de Política Económica y Social
CPS	Current Population Survey
DALYs	Disability-adjusted life-years
DANE	Departamento Administrativo Nacional de Estadística
DBM	Double burden of malnutrition
DNP	Departamento Nacional de Planeación
ELCSA	Latin-American and Caribbean Food Security Scale
ENSIN	National Nutritional Survey
FAO	Food and Agriculture Organization
HFSSM	Household Food Security Supplemental Module
HIV	Human immunodeficiency virus
LMIC	Low and Middle-Income Countries
MSPS	Ministerio de Salud y Protección Social
NCD-RisC	Non-Communicable Disease Risk Factor Collaboration
NCDs	Non-Communicable Diseases
OWOB	Overweight and obesity
SCOWT	Coexistence of a stunted child under five years and an OWOB mother
SDH	Social Determinants of Health
UN	United Nations
WFP	World Food Program
WFS	World Food Summit
WHO	World Health Organization

Chapter 1: General Overview

1.1 Introduction

Food insecurity has been strongly related to hunger (Shaw, 2007) and is equally associated with limited access to a diverse and nutritious diet. In contrast, as its definition indicates, *food security* refers to: "A situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 2001b, p. 49). For preventing food insecurity consequences, it is crucial to consider all the aspects included in this definition and recognize that overcoming this phenomenon goes beyond satiating hunger.

Households experience different severity levels when facing the complex phenomenon of food insecurity, which are categorized as mild, moderate or severe. Mild food insecurity refers to worrying about not getting enough food in the future and making adjustments to consume low-quality food or only a few kinds of foods. Further, moderate food insecurity entails the added burden of not getting sufficient food, skipping meals and running out of food. Finally, severe food insecurity involves protracted periods without any food, thus leading household members to experience hunger (Comité científico de la ELCSA, 2012). Since households can experience different severity levels of food insecurity, the consequences of this phenomenon can be diverse. For example, household members can experience diminished mental health as a result of the anxiety caused by not getting enough food (Jones, 2017), or malnutrition, as a result of inadequate dietary intake and dietary diversity (Humphries et al., 2015; Mundo-Rosas et al., 2013; Vega-Macedo et al., 2013). Studies have demonstrated consistent associations between food insecurity and malnutrition, which is mostly reflected among women from high-income

countries as overweight or obese (OWOB), and among children from low and middle-income countries whose growth has been impaired (i.e., child stunting) (Maitra, 2018).

The presence of these two malnutrition conditions, OWOB and stunting, reflect the current state of nutritional transition in the developing world, which is characterized by a decreasing, yet persistent, prevalence of undernutrition, mainly reflected as child stunting, and an increasing prevalence of OWOB (Popkin & Ng, 2007). This nutritional transition is occurring with simultaneous changes in food systems, which ease access to affordable, processed, and unhealthy foods by low-income households, even in rural areas (Popkin & Reardon, 2018). In fact, in rural areas, the OWOB prevalence seems to be growing at a higher rate than in urban settings (Jaacks et al., 2015; Non-Communicable Disease Risk Factor Collaboration [NCD-RisC], 2019), where the prevalence of child stunting has been historically higher, especially in developing countries such as Colombia (Ministerio de Salud y Protección Social [MSPS] et al., 2019).

The increasing OWOB prevalence and the still persistent child stunting prevalence make plausible for these two malnutrition forms to coexist in low and middle-income countries (LMIC). The World Health Organization (WHO) defines this coexistence as the double burden of malnutrition (DBM), which can occur at the population, household, and individual levels (WHO, 2017). According to recent research by Popkin et al. (2020), the most frequent type of DBM occurs at the household level with the coexistence of a stunted child under five years and a mother classified as overweight or obese (SCOWT). Limited research exists regarding the association between SCOWT and food insecurity, especially in Colombian rural areas, which could be vulnerable to both conditions.

According to the World Bank, Colombia is the sixteenth country with the highest income inequality in the world (World Bank, 2019). This inequality is potentially pronounced in rural

areas, as indicated by disproportionate land ownership (Departamento Administrativo Nacional de Estadística [DANE], 2016). Furthermore, as the main locale of Colombia's 50-year armed conflict, rural areas have been especially afflicted by food insecurity (Segovia, 2017). Thus, this study examines the association between different severity levels of food insecurity and SCOWT in the context of Colombian rural areas using nationally representative data.

1.2 Study Rationale

The association of food insecurity with undernutrition and OWOB has been studied independently across different populations. However, new trends in the malnutrition burden have resulted in the coexistence of undernutrition in children, represented as child stunting, and OWOB in mothers within a single household (SCOWT). Although food insecurity is an important underlying determinant for malnutrition (Black et al., 2008), insufficient research explores the magnitude of its association with SCOWT, especially among Colombian rural households. As these areas suffered an armed conflict for more than half a century, affecting their food security (Segovia, 2017), the Peace Accords signed in 2016 by the Colombia government and the largest insurgent armed organization addressed the serious plight of food insecurity and malnutrition (Segovia, 2017). Analyzing the correlation of SCOWT with food insecurity and its different severity levels, using nationally representative nutritional data and a valid and reliable measurement tool such as the Latin-American and Caribbean Food Security Scale (ELCSA), will help to fill the existing research gap and to provide evidence for programs designed to address both conditions and to prevent future SCOWT consequences.

Given that SCOWT comprises a stunted child living with a mother classified as OWOB, households affected by this phenomenon do suffer the possible effects of both malnutrition forms. These effects include increased risk of reduced cognitive development in stunted children

(Dewey & Begum, 2011; Victora et al., 2008), low productivity in adults dealing with OWOB (Goettler et al., 2017), and increased risk for chronic diseases in adulthood for both stunted children (Janghorbani et al., 2012; Stefan et al., 2016; Wittenbecher et al., 2019) and women with OWOB (Abdullah et al., 2010; Dwivedi et al., 2020; Kearns et al., 2014). Moreover, children classified as stunted have increased risk of gaining more fat than lean mass (Martins et al., 2004) and becoming adults with low height (Özaltin et al., 2010). Women with short stature, in turn, have increased risk of delivering stunted children (Özaltin et al., 2010). This array of consequences could potentially lead the afflicted households into a malnutrition and poverty vicious cycle, affecting the local and national economies, as well as the development of rural areas.

Furthermore, since available research has reported discrepancies regarding which food insecurity level has a greater risk for SCOWT (Gubert et al., 2017; Mahmudiono et al., 2018), this study will investigate and clarify this association in Colombian rural households. Clarifying this association will contribute to a better understanding on how the complex food insecurity consequences manifest in diverse ways in accordance to the different severity levels and various contexts in which such a phenomenon occurs.

1.3 Study Objectives

The primary research objective of this research was to assess the association between different severity levels of household food insecurity and the presence of the double burden of malnutrition, defined as the coexistence of a child classified as stunted and a mother classified as overweight or obese (SCOWT) in Colombian rural households, using nationally representative data. The secondary research objective was to identify factors related to the social determinants

of health that might be associated with the presence or absence of SCOWT in Colombian rural households.

Chapter 2: Literature Review

2.1 Food Security

2.1.1 The Origins of the Food Security Concept

Nowadays, even though there is enough food to feed the world population, thanks to advances in agricultural systems and food surpluses, food insecurity still exist (FAO et al., 2019; Shaw, 2007) because inequalities and poverty—especially in the developing world—are still highly prevalent (FAO et al., 2019). Understanding the meaning of food security is essential to grasping its importance. Thus, the following section analyzes the historical development of this concept, which has evolved from discussions of hunger and poverty to its present-day understanding.

Both the determinants of hunger and our understanding of those causes have shifted over time. Hunger refers to "a weakened disordered condition brought about by prolonged lack of food" (Merriam-Webster, 2020., medical definition); hence, being hungry is a physiological symptom that results from a survival need. The first humans experienced hunger when they were not capable of obtaining their food by their own physical means because of weakness, lack of animals to hunt or decreased availability of foods to collect (Gibson, 2012). With the establishment of civilizations, hunger became the result of more than insufficient availability and physical access to food; other constraints to adequate food access arose, such as inequalities and poverty (Gibson, 2012). Poverty is defined as "the state of one who lacks a usual or socially acceptable amount of money or material possessions" (Merriam-Webster, 2020). Although the relationship between poverty and hunger is now widely recognized, for a long period of time hunger was predominantly associated with inadequate food availability rather than a lack of resources to access food. As explained by Gibson (2012), it was not until the 1930s that hunger

was globally recognized to be a consequence of poverty and not just of insufficient food production, a fact that was included in the 1937 League of Nations report. Just as hunger was not recognized to be a consequence of poverty until the mid-20th century, efforts to eradicate its existence were not made until the 20th century.

Before concerted efforts to eradicate hunger could be made, it was first necessary that world leaders commit themselves to such a project. This commitment resulted from the first United Nations (UN) conference on food and agriculture, which was held in 1943—two years before the UN was formally recognized—in response to the humanitarian crisis caused by the two world wars (Gibson, 2012). In this conference, poverty, rather than insufficient food production, was declared as the first cause of hunger and malnutrition, ratifying what was stated in the 1930s (UN, 1943). Moreover, as a result of the UN conference, the Food and Agriculture Organization (FAO) was created in 1945 in Quebec City, with the aim of addressing the global problem of food after the second world war (FAO, n.d.-b). The creation of the FAO was followed by the Universal Declaration of Human Rights in 1948. Article 25 of this declaration included the right to food: "Everyone has the right to a standard of living adequate for the health and well-being of themselves and of their family, including food…" (UN, 1948, p. 5). Recognizing hunger as a worldwide problem solidified the commitment to addressing this problem and led to efforts to eradicate its presence.

The first worldwide actions to eradicate hunger were made by the FAO (Shaw, 2007). John Boyd Orr was the first director of this organization who, to attain the goal of eradicating hunger, proposed consolidating a multidisciplinary board that integrated the fields of agriculture, nutrition, health, trade, and industry. However, this multidisciplinary board was not approved by industrialized countries such as the United States and the United Kingdom (Shaw, 2007).

Therefore, Orr focused on actions such as managing food surpluses, creating reserves for emergencies, and controlling food prices (Shaw, 2007). In the 1960s, Orr was succeeded by Binay Ranjan Sen as the FAO director. While Orr had hoped to address world hunger from a multidisciplinary perspective, Sen prioritized increasing awareness about hunger among governments (Gibson, 2012; Shaw, 2007). To do so, he created the Freedom from Hunger Campaign, which led to the implementation of food aid actions that were consolidated with the creation of the World Food Program (WFP) (Gibson, 2012; Shaw, 2007). Since its creation, the WFP objective has been to provide food aid in emergencies and assistance to improve food access to developing countries (Gibson, 2012; Shaw, 2007). These actions indicate that the importance of poverty and hunger was greatly recognized during the1960s; however, the term "food security" was not yet used.

The term "food security" appeared in 1974 when the world´s food crisis of the '70s took place (FAO, n.d.-a). This worldwide crisis resulted after an extreme food surplus which was followed by a sudden reduction in the availability of food, especially grains, with a simultaneous exorbitant increase in oil prices that affected fertilizer production and transportation (Gibson, 2012). This emergency led to the World Food Conference of 1974, in which as a reflection of that crisis (FAO, n.d.-a), food security was defined as "availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices" (FAO, n.d.-a, para.7). Although poverty was already recognized as a cause of hunger, the definition of food security did not account for the effect of poverty and instead focused solely on world food supply.

Additional efforts were needed to account for the role of poverty in food insecurity. The work of Amartya Sen was crucial to addressing this need. Sen's research on famine highlighted

the importance of having adequate resources to acquire produced food (Sen, 1981). For his important work, Sen was granted the Nobel Prize on Welfare Economics in 1998 (Gibson, 2012). In 1983, the FAO extended the definition of food security as follows: "ensuring that all people at all times have both physical and economic access to the basic food that they need" (FAO, n.d.-a, para. 8). This ammended definition complemented the previous one by recognizing that, in addition to food supply, everyone's access to food is also important. This definition finally considers poverty, referred to as "economic access", as important to food security.

In the decades that followed the FAO's 1983 food security definition, this concept was broadened even further to include, essential aspects for attaining food security. For instance, in 1986 the World Bank report *Poverty and Hunger* recognized that food security also implied having "enough food for an active and healthy life" not just to "the basic food they need" (World Bank, 1986). In this report, the World Bank also made a distinction between chronic and transitory food insecurity. They defined chronic food insecurity as a household continuous impairment to obtain food and transitory food insecurity as a provisional household reduction in the access to food (World Bank, 1986). The concept for the complex phenomenon of food security became more inclusive; however, there were some key aspects that were not yet considered.

Problematically, until the late 1990s the concept of food security did not account for dietary needs. The omission of this key aspect from the food security concept erroneously suggested that food security is attained with any kind or amount of food so that food security only referred to hunger satisfaction. The inclusion of dietary needs in the food security definition was crucial since satisfying dietary needs prevents most forms of malnutrition and is necessary for an active and healthy life. Therefore, the World Food Summit (WFS) expanded in 1996 the

definition of food security including dietary needs, food safety, and food preferences (FAO, 1996). This definition was further enhanced in 2002, when the FAO added "social access" to this concept (FAO, n.d.-a). The result of including dietary needs, food safety, food preferences, and social access to food, led to the multifaceted food security definition that is nowadays most recognized as: "A situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 2001b, p. 49). This definition better reflects the complex nature of food security, as it involves many dimensions. The definition of food security as a multifaced condition emphasizes that food security not only entails having access to enough food to satisfy hunger but also involves having nutritious, culturally adequate, and safe food at all times to prevent all forms of malnutrition.

2.1.2 Pillars and Factors of Food Security

Central to the 1996 WFS and 2002 FAO definitions are the four pillars of food security: 1) availability, 2) access, 3) utilization, and 4) stability over time. Understanding these four pillars, along with the factors that compromise their attainability, is necessary to determine the causes and consequences of food insecurity and so design appropriate interventions.

The first pillar is physical availability of food, which the WFS definition identifies as "sufficient" (Simon, 2012). This pillar depends on an adequate supply of diverse foods in quantity and quality, and it is determined by food production, imports, exports, stock levels and food aid (FAO, 2008a; Gibson, 2012; World Food Programme, 2009).

As clearly stated in the WFS definition, the second pillar, access to food, exists when people have enough financial capacity to regularly acquire the available foods with no physical or socio-cultural obstacles (FAO, 2008a; Simon, 2012). In accordance with Sen´s (1981)

argument, poverty is nowadays recognized as one of the most significant constraints for food access, since it affects the purchasing power of individuals. Moreover, unemployment and the market are factors that affect income and food prices, thus influencing economic access to food (FAO, 2008b).

Food access also depends on physical and social conditions. Physical access can be compromised by factors such as transport facilities and the quality and existence of infrastructure such as roads to obtain food in all areas (Kathuria & Nagpal, 2016; Simon, 2012). Furthermore, social access to food entails factors such as gender, cultural practices and equity among family members (Simon, 2012). Researchers have found that women, especially rural women, are more food insecure than their male counterparts (Sinclair et al., 2019). Maiga (2010) identified HIV as a determinant for food shortages in afflicted households in the Ivory Coast.

Food utilization corresponds to the third pillar of food security, achieved when a person can make the most out of the consumed nutrients, absorbing and utilizing them appropriately, which is then reflected in the nutritional status (FAO, 2008a; Gibson, 2012; Simon, 2012). Therefore, health status is an important factor of this pillar, along with food safety, preparation, and the selection of nutritious foods. Non-nutritional factors such as access to health services, adequate sanitation and clean water also interfere with the utilization of food (Gibson, 2012; Simon, 2012).

In 2007, the Colombian National Council for Economic and Social Policy (Consejo Nacional de Política Económica y Social [CONPES] 113), established the food and nutritional security policy, which incorporates two additional dimensions or pillars: food consumption and food safety. The former implies factors such as education and culture, which affect food selection, and the latter seeks to guarantee that food represents no harm to those who consume it

(DNP et al., 2007).

The fourth and last pillar comprised in the WFS definition refers to the stability of the three previous pillars over the course of time, since food security must be permanent for everyone. This pillar is of crucial importance during crises due to climate changes, political instability, conflict or economic crises (FAO, 2008a; Simon, 2012; Sousa et al., 2019). A striking example is the effect of the COVID-19 pandemic on food insecurity. According to recent studies in the United States, this pandemic significantly affected the stability of food security among households, especially among those with children (Bauer, 2020; Niles et al., 2020).

Insufficiencies in the four food security pillars can result in household food insecurity, which the FAO defines as "uncertain access to sufficient, safe and nutritious food" (FAO et al., 2018, p. 29). Food insecurity is a multifaced phenomenon affecting nations, regions, households and individuals, causing health and well-being issues that will be further discussed in this chapter. The complexity of food insecurity requires in-depth measures to be studied objectively and addressed effectively, including the appropriate tools to measure and monitor its occurrence.

2.1.3 Measuring Food Insecurity

Different measurement methodologies have been used to evaluate food insecurity. Each of these tools involve challenges and advantages when used, and therefore, clear objectives must be determined before selecting them. These methodologies include: 1) The FAO food balance sheets, 2) household income and expenditure surveys, 3) assessment of the adequacy of dietary intake, 4) nutritional status using anthropometric indicators, and 5) experience-based scales (FAO, 2002). Understanding the implications of each of these methodologies is necessary to make an objective selection.

The FAO food balance sheets determine the prevalence of undernourishment at a national

level (Ballard et al., 2013; Cafiero et al., 2014). This method uses information regarding the available energy from foods for human consumption, which results from a balance of imports, the amount of produced food, and exports. This total is subtracted by food loss, waste, food used for livestock and agricultural input, and exports (FAO, 2001a). Thereafter, the nationally available food is calculated and contrasted with the minimum nutritional needs of the population. This indicator generates data regarding undernourishment due to insufficient food available rather than food access (Cafiero et al., 2014). Moreover, it results in useful information for monitoring goals concerning hunger-reduction included in the Millennium Development Goals and Sustainable Development goals (Ballard et al., 2013; FAO, n.d.-d). However, some challenges of this indicator are that it is complex to calculate and depends on the quality of the information generated by the different countries (Cafiero et al., 2014). Moreover, it does not account for food loss at the retail level (Cafiero et al., 2014) and does not give information concerning individuals or households affected directly by food insecurity (Ballard et al., 2013; Pérez-Escamilla et al., 2017).

The second tool to measure food security refers to household expenditure surveys. This tool differs from the first one in that it provides indirect information concerning the household's food availability. However, these types of surveys lack information regarding the intake of the purchased food during a reference period and do not consider products acquired outside the household (Jones et al., 2013). This method also requires complex resources and time to gather information (Ballard et al., 2013).

The third tool measures household´s and individual´s food consumption. These types of tools include the assessment of the adequacy of dietary intake and dietary diversity scores measures (Ballard et al., 2013), which use instruments such as the 24-hour recall diaries, dietary

records, and food frequency questionnaires (Pérez-Escamilla et al., 2017). Dietary diversity scores represent an important tool to measure food insecurity since it is associated with measures of socioeconomic status (Jones et al., 2013). However, its reliability depends on adapting the used food groups according to different cultural contexts (Cafiero et al., 2014). Unfortunately, these instruments are highly vulnerable to recall bias, take time, and need to be applied by qualified interviewers; thus, it is frequent that national representative surveys include limited information from these types of assessments (Pérez-Escamilla et al., 2017).

Nutritional status using anthropometric indicators is an indirect way to measure food intake and its utilization, which are two of the food security pillars. Such indicators include weight for age, weight for height, height for age, and body mass index (Pérez-Escamilla et al., 2017). The nutritional status can be the result of food insecurity; however, it can also be determined by disease and inadequate dietary habits (Jones et al., 2013). Moreover, these indicators require highly trained personal to be taken (Ballard et al., 2013) and are a measure of the consequence of food insecurity more than food insecurity itself.

The instruments referred to so far, give essential information and indicators to measure food insecurity; however, they do not measure directly household experiences regarding food insecurity. The first two tools (The FAO method food balance sheets and household expenditure surveys) focus on the causes of food insecurity; and the last two (assessment of the adequacy of dietary intake and nutritional status using anthropometric indicators), on the consequences of food insecurity (Ballard et al., 2013; Comité científico de la ELCSA, 2012).

There is a fifth method that directly measures people´s experiences regarding food insecurity and hunger. This method consists of food insecurity experience-based scales, which have been implemented since 1995, proving to be easy to use and inexpensive (Comité científico

de la ELCSA, 2012; FAO, 2002). Likewise, evidence has shown that these scales are a valid and reliable tool (Cafiero et al., 2014; Comité científico de la ELCSA, 2012), giving a trustworthy scientific approach for understanding this matter of interest.

Besides determining if subjects are food insecure or not, these food security experience-based scales, also establishes different severity levels of food insecurity. The experience when facing these levels have been validated across countries (Cafiero et al., 2014). Moreover, the use of the Rasch model validates that the subjects with more severe food insecurity levels also experienced the preceding levels, discrepancies in responses with this regard contribute to determining the reliability of this scales using the Item Response Theory (Cafiero et al., 2014). Likewise, when compared with other variables that share the same food security construct, experience scales have generated similar results supporting its reliability (Cafiero et al., 2014).

The origin of the experience´s scales lays in the need of having a tool capable of capturing this multidimensional problem of food insecurity (Ballard et al., 2013). Thus, in the United States, qualitative research was carried out to understand hunger and the process households were facing as they were experiencing food insecurity (Ballard et al., 2013; Radimer et al., 1990). This research uncovered that food insecurity was characterized by different dimensions, first worrying about not having resources to access to enough food, which was followed by making adjustments in diet to make food last, which further lead to a reduction in the amount of food consumed (Ballard et al., 2013; Radimer, 2002; Radimer et al., 1990). In the most severe cases, hunger was experienced by adults and children who did not eat for a whole day or more (Ballard et al., 2013; Radimer, 2002; Radimer et al., 1990). Understanding this process was crucial for the development of the first food security scale.

In 1995, the first questions regarding food security were added to the Current Population Survey in the United States (CPS) (Radimer, 2002). Since then, the Household Food Security Supplemental Module (HFSSM) has been used yearly in USA to measure food insecurity. Furthermore, this module gave the foundation for the replication of modified scales across countries (Ballard et al., 2013; Comité científico de la ELCSA, 2012). These scales consist of measuring the different dimensions that occur as the household experiences food insecurity using the information obtained from the previous research (Ballard et al., 2013). First, the scales ask for the feeling of worrying about not getting enough food, followed by having to make adjustments to the quality of the food eaten. Further, they inquire about reducing the quantity of food and using social acceptability of ways for acquiring foods. Finally, there is focus on when children are affected by food insecurity and household members are experiencing hunger (Ballard et al., 2013; Cafiero et al., 2014; Comité científico de la ELCSA, 2012).

In 2002, the International Scientific Symposium on Measurement and Assessment of Food Deprivation and Undernutrition took place in Rome. With regards to experience scales, such as the HFSSM, the conclusion of the Symposium was that this tool provided important direct data concerning how households experiment hunger and food insecurity and were easy to use and analyze (FAO, 2002). Moreover, based on the HFSSM experience, the Symposium concluded that these tools were valid and useful for different purposes. For instance, the scales had utility for tracking changes in the prevalence of hunger and food insecurity, for analyzing and designing policies, and for specific interventions among populations and zones, but they were not useful for intervening afflicted households directly (Comité científico de la ELCSA, 2012; FAO, 2002).

Latin-American countries were the first to implement the HFSSM or its modified versions (Carmona Silva et al., 2017; Lorenzana & Sanjur, 1999). Countries such as Mexico, Bolivia, and Argentina modified the HFSSM questions to create valid tools for their populations (Fiszbein & Giovagnoli, 2003; Melgar-Quiñonez et al., 2005; Melgar-Quinoñez et al., 2006). There was a tool that preceded the creation of the HFSSM, called the Community Childhood Hunger Identification Project (CCHIP), which countries such as Venezuela used as a guide to creating their own food security scale (Lorenzana & Mercado, 2002; Lorenzana & Sanjur, 1999), which was, in turn, used in Colombia to develop the Lorenzana scale (Álvarez et al., 2006). It has been highly recommended, however, that a homogeneous tool is implemented to measure food insecurity (Carmona Silva et al., 2017; Comité científico de la ELCSA, 2012; Melgar-Quiñonez & Hackett, 2008). Latin-American researchers unified their knowledge and experience towards the development of the Latin-American and Caribbean Food Security Scale (ELCSA). This scale is directly derived from the Colombian Lorenzana and EBIA scales that, in turn, are derived from the CCHIP and the HFSSM, respectively (Comité científico de la ELCSA, 2012).

2.1.3.1 The ELCSA Scale. The first version of the Latin-American and Caribbean Food Security Scale (ELCSA) was the result of the first Latin-American and Caribbean conference for measuring food insecurity (CLACMESA I), which took place in Colombia in 2007 (Comité científico de la ELCSA, 2012). That same year, the scale was implemented for the first time in Haiti, which identified health issues associated with food insecurity after adjusting for socioeconomic and anthropometric indicators (Pérez-Escamilla et al., 2009).

In 2008, the ECLSA scale was implemented at the national level in Colombia in the National Survey of Life Conditions and Mexico in the National Survey of incomes and expenditures (Comité científico de la ELCSA, 2012). A second conference (CLACMESA II)

took place in Brazil in 2009 to discuss these ELCSA implementation experiences (Comité científico de la ELCSA, 2012). Furthermore, in this conference, a harmonization process of the ELSCSA was proposed to implement it in national surveys around Latin-American regions. The first harmonization workshop was held in Mexico and the second one in Colombia. As a result of the first workshop the ELCSA was harmonized and in the second workshop criteria for its internal and external validation were unified (Comité científico de la ELCSA, 2012).

The ECLSA scale has demonstrated to be a valid and reliable tool (Álvarez et al., 2006) that can be used homogeneously across Latin-American countries (Comité científico de la ELCSA, 2012). The measurement of the multifaced aspects of food insecurity using experiences scales such as the ELCSA has led to a better understanding of food insecurity in Latin-America and its associated causes and consequences across the most vulnerable populations.

2.1.4 Food Security in The Context of Colombian Rural Areas

The factors influencing the attainability of each of the food security pillars may vary across populations. For instance, Smith et al. (2017) found that the most common risk factors for food insecurity across 134 countries were low levels of education, weak social networks, and less social capital (i.e., less support from friends when needed). Moreover, in upper-middle-income countries such as Colombia, gender, low income, unemployment, and the number of children also increased the likelihood of being food-insecure (Smith et al., 2017). Such factors are common in populations with lower socioeconomic conditions, such as indigenous people, women, people living below the poverty line, and those that live in rural areas. Thus, populations with such characteristics have an increased risk of food insecurity (FAO, n.d.-c).

Smith et al. (2017) reported that rural areas inhabitants from low and middle-income countries have a higher likelihood of being food insecure. This observation was supported by

Sinclair et al. (2019), who found that rural women had the highest odds of being food insecure than rural men and urban men and women. In Colombia, according to the ENSIN (2015), 64% of rural households were food insecure vs. 52% in urban regions (MSPS et al., 2019). This higher rate of food insecurity in these Colombian rural areas can be derived by distorted factors that alter food security pillars.

According to the most recent data published by the World Bank, Colombia has the sixteenth highest income inequality in the world (World Bank, 2019), which is more pronounced in the rural areas of the country. A striking example is that of land ownership in this country, where 69.5 % of agricultural producers owned just 5.2% of productive land (DANE, 2016). According to the FAO, this is one of the most unequal apportionments of land ownership in Latin-America (DANE, 2016). Moreover, in the rural areas, multidimensional poverty was 2.8 times higher than in urban areas, with 90% of the inhabitants of the scattered rural settlements classifiable as poor or as hovering at the poverty line (Departamento Nacional de Planeación [DNP], 2015). In terms of education, 57.4% of the rural producers had primary school as the highest obtained educational level, and 19.2% did not have any level of formal education (DANE, 2016). Moreover, the percentage of illiteracy was three times higher than in urban areas (DNP, 2015).

Several constraints also negatively affect adequate food production in Colombian rural areas, as 63% of its inhabitants do not have access to loans, technical assistance, land, and/or irrigation (DNP, 2015). Furthermore, only 26% of the residents of the rural areas belonged to an association, e.g., producer organizations (DANE, 2016). Belonging to associations reinforces social networks and social capital so that associated small farmers are less susceptible to suffer food shortages shocks. Industrial mining activity also threatens food security in Colombian rural

areas. Although it contributes to the income of some households, this activity also interferes with food production due to additional demands on resources such as water, land, and workforce (DNP, 2015). To further worsen the situation, armed conflict in Colombia has enormously affected the rural population by compromising the stability of the food security pillars over time (Segovia, 2017).

All the above factors place rural areas in Colombia at a significant disadvantage regarding food security and leaves them extremely vulnerable to food insecurity consequences.

2.1.5 Food Insecurity Consequences

Hadley and Crooks (2012) suggest that the way households cope with food insecurity may determine the type of consequences they suffer. Coping decisions might be mediated by the characteristics and factors affecting a population's food insecurity, which would explain why food insecurity consequences manifest differently across regions and countries. Hereafter, it is important to identify in which context food insecurity occurs and its societal consequences.

The consequences of food insecurity can manifest themselves at the individual, household, and national levels. At the individual level, food insecurity leads directly to distorted food consumption in quantity, quality, and continuity, and to mental health issues such as anxiety, stress, and depression (FAO et al., 2018; Hadley & Crooks, 2012). This altered food consumption and mental state can lead to inadequate dietary intake characterized by excessive consumption of calories and insufficient consumption of diverse nutrients, which are a cause of malnutrition (FAO et al., 2018). Moreover, food insecurity influences the well-being of households (Hadley & Crooks, 2012) that adversely affects communities and populations and so can compromise the productivity and the economy of nations (Comité científico de la ELCSA, 2012). The above relationship might be explained by associations showing that better health

status is related with increased economic growth (Comité científico de la ELCSA, 2012; Spence & Lewis, 2009). Food insecurity consequences are as diverse and complex as food insecurity itself. Hence, the present review focuses on food insecurity health consequences at the household and individual levels, with a further in-depth analysis of malnutrition.

Numerous studies have documented that food insecurity is associated with mental imbalances such as stress, anxiety, and depression, which affect the well-being of households and individuals (Ballard et al., 2013; Cole & Tembo, 2011; Hadley & Crooks, 2012; Jones, 2017; Kolovos et al., 2020; Maes et al., 2010; Weaver & Hadley, 2009; Whitaker et al., 2006). Jones (2017) using data from 149 countries, found that food insecurity levels had a dose-response effect on mental health indices, resulting in poorer mental health status with a higher level of food insecurity. Similar results were found in Mexico, where individuals had an increased likelihood of depression with increased severity levels of food insecurity (Kolovos et al., 2020). Jones (2017) explained that individuals might experience the anxiety of not getting enough food in the future, which more severe cases of food insecurity could exacerbate. Likewise, acquiring foods in unacceptable ways, a coping strategy for food insecurity, might provoke shame and guilt in addition to anxiety (Jones, 2017). Alternatively, the link between mental health and food insecurity may be attributed to inadequate food consumption. Previous research has indicated a positive link between mental disorders and micronutrient deficiencies such as iron deficiency (Corwin et al., 2003; Kaplan et al., 2007). These latter findings suggest that malnutrition, represented as micronutrient deficiencies, is not only a consequence of food insecurity but could also be a mediator to mental health issues. Besides malnutrition, other physical aspects of health are compromised among the food insecure, including infectious diseases, chronic diseases, and HIV (Hadley & Crooks, 2012).

2.1.5.1 Food Insecurity and Malnutrition. According to the WHO, malnutrition "refers to deficiencies, excesses, or imbalances in a person's intake of energy and/or nutrients" (WHO, 2016, para. 1). Deficiencies refer to low height (stunting), low weight (underweight) for a child´s age, or low weight for height (wasting), and deficiencies in vitamins and minerals. In this definition, excesses are reflected by instances of overweight and obesity (WHO, 2016).

The literature establishes a consistent pattern of significant associations between food insecurity and undernutrition, reflected as child stunting (Ali et al., 2013; Bernal et al., 2014; Gordon & Halileh, 2013; Hackett et al., 2009; Hasan et al., 2013; Mahmudiono et al., 2018; Reis, 2012; Saha et al., 2009; Santos & Gigante, 2013; Shamah-Levy et al., 2017; Singh et al., 2014) whereas OWOB is more commonly found among food-insecure women (K. L. Hanson et al., 2007; Jomaa et al., 2017; Martin & Lippert, 2012; Martin-Fernandez et al., 2014; Morales-Ruán et al., 2013; Schlüssel et al., 2013; Shamah-Levy et al., 2013; Velásquez-Melendez et al., 2011).

A review of 120 studies by Maitra (2018) reported that the association of food insecurity with child wasting or overweight was not as substantial as seen with child stunting as found mainly in lower-middle and upper-middle-income countries. Maitra (2018) reported that the positive association between food insecurity and obesity conversely occurred in women, not in men, which was noted in high-income countries. According to this latter review, however, not all studies found a positive association between food insecurity and malnutrition after adjustment for confounders. Maitra (2018) indicated that this lack of association could stem from factors such as conceptual aspects. For instance, besides food access, malnutrition is affected directly by food biological utilization (i.e., nutrient absorption) for which food security experience scales do not account for. Moreover, study design can generate heterogeneous associations, since most available evidence is obtained by cross-sectional studies, which cannot control for unobserved

features. Such unobserved aspects might vary by study context, as the nutritional status is influenced by socio-economic cultural factors such as supermarket access (Drewnowski et al., 2012; L. Yang et al., 2010) and care practices (Galler et al., 1998; Pelto, 2000).

The association between food insecurity and obesity was first reported by Dietz (1995), who suggested that "food choices or physiologic adaptations in response to episodic food shortages could cause increased body fat" (p. 2). Some authors deemed this association paradoxical since food security refers to a lack of food, which was believed to cause underweight exclusively. Nowadays, however, there is a broader understanding of the pathways by which food insecurity can lead to excessive weight gain. Thus, the presumed paradoxical association between food insecurity and obesity is no longer controversial (Frongillo, 2013; Frongillo & Bernal, 2014).

The most direct explanation for the association between food insecurity and malnutrition reflected as child stunting and women's overweight is that food-insecure households have a higher availability of low-cost foods, which are usually dense in energy but not in nutrients (Drewnowski, 2004; Drewnowski & Specter, 2004; Popkin & Reardon, 2018; Rao et al., 2013; Tanumihardjo et al., 2007). Additionally, food-insecure households can have less dietary diversity than their food-secure counterparts (Mundo-Rosas et al., 2013; Vega-Macedo et al., 2013). Further in-depth explanations for the association of malnutrition with food insecurity is discussed below.

2.1.5.1.1 Food Security and Obesity Pathways. Various studies have explained the presence of excessive weight in people with food insecurity through physical and mental mechanisms. For instance, growth failure in fetal life and infancy, which is especially associated with food insecurity in low-income communities (Borders et al., 2007; Chowdhury et al., 2018),

has been correlated with higher visceral fat in adult life (Barrios et al., 2019; Corvalan et al., 2007; Law et al., 1992; Schroeder et al., 1999). According to Martins et al. (2004) this association can be explained since chronic undernutrition in infancy is correlated to metabolic adaptations that further lead to higher fat mass accumulation. These authors found that Brazilian stunted adolescents aged 11 to 15 years showed increased metabolic efficiency reducing fat oxidation. After a three-year follow-up, the growth stunted group had higher fat mass and lower lean mass than those who experienced no growth stunting. In contrast, a cohort study of African stunted children showed found that height at two years of age was not associated with an increased BMI in early adulthood (S. K. Hanson et al., 2018). Such discrepancies may be explained by differences in body composition measures, such as fat mass, lean mass, and BMI since the latter index does not differentiate accurately between fat and lean mass.

Another postulate called the insurance hypothesis refers to physical adaptations to food insecurity. These adaptations consist of increased body fat storage as an adaptative metabolic response to future food insufficiency (Nettle et al., 2017). In addition to these metabolic changes, decreased physical activity has also been positively correlated to food insecurity (Bruening et al., 2018; Gunter et al., 2017; To et al., 2014), which includes lower energy expenditure to the food insecure individuals that increases likelihood of weight gain. A. M. Lee and Cardel (2019) hypothesized that decreased energy expenditure is a protective response that enables energy storage to protect against future food scarcity. On the other hand, Ert and Heiman (2017) have argued that there is insufficient evidence to claim the insurance hypothesis as a single mechanism for the association between food insecurity and excessive body weight. These authors propose two psychological mechanisms involving temporal discounting and the psychology of food scarcity. Temporal discounting consists of behaviors responding to

uncertainty about future food supply such as present overconsumption of available food. Dinour et al. (2007) noted the above behaviors in recipients of food stamps. In order to use food stamps resources within a short time period, the recipients adjusted their diets by consuming more energy-dense low-cost foods rather than a more nutrient-dense diet. In the temporal discounting theory, contrary to the insurance hypothesis, the individual does not account for future uncertain food access (Ert & Heiman, 2017).

The second postulate is the psychology of food scarcity, which refers to offsetting food insufficiency with immediate excessive consumption of cheap, high energy-dense foods (Ert & Heiman, 2017). This postulate also refers to time needed for a healthy diet and physical activity practice, which is usually reduced in women and those living in poverty in high-income countries (Jabs & Devine, 2006). This postulate helps to explain why the association between food insecurity and obesity is mostly seen in women and high-income countries (Ert & Heiman, 2017). Moreover, in middle and high-income countries, access to cheap, ready-to-eat foods is frequent (Drewnowski & Specter, 2004; Popkin & Reardon, 2018; Rao et al., 2013). The psychological reaction to scarcity is also associated with self-control loss (Mani et al., 2013), which can partially explain the association of food insecurity with eating disorders such as binge eating. This eating disorder is characterized by episodes of eating unusually large amounts of food in a specific period, accompanied by an inability to control this behavior (American Psychiatric Association, 2013), which has been positively associated with food insecurity (Rasmusson et al., 2019). Binge eating disorder had been previously associated with intentionally dieting for weight loss; however, more recently this disorder has also been correlated to a situation resulting from a lack of resources (Rasmusson et al., 2019).

Another more straightforward explanation is related to the previously mentioned association between food insecurity and mental health issues. The anxiety and stress resulting from food insecurity often triggers sleep loss, all of which can increase the consumption of cheap energy-dense foods, or comfort foods, inducing excessive weight gain (Dallman et al., 2003; FAO et al., 2018; Frongillo, 2013; Narcisse et al., 2018).

2.1.5.1.2 Food Insecurity and Undernutrition Pathways. As mentioned above, food-insecure households suffer from limited consumption of nutritious and diverse foods (Humphries et al., 2015; Mundo-Rosas et al., 2013; Vega-Macedo et al., 2013). The evidence, however, is contradictory regarding dietary diversity as a mediator of child undernutrition in food-insecure households (Ali et al., 2013). This lack of consistency might be driven by differences between household members regarding food insecurity experiences. For instance, Bernal et al. (2016) found that food insecurity was associated with lower quality of diet only when it was reported by children but not by mothers. Another explanation for the above association is that food insecurity in pregnancy is correlated with poor fetal growth (Borders et al., 2007; Chowdhury et al., 2018) that, in turn, is associated with child stunting (Christian, 2014). Inadequate diet (Na et al., 2016) or psychological factors such as stress (Borders et al., 2007) might mediate the association of food insecurity and impaired fetal growth.

The association between food security and undernutrition cannot be attributable to a single factor since food insecurity is a complex phenomenon. As previously discussed, mental health issues are a consequence of food insecurity, and these issues are also a risk factor for inadequate parental care practices such as reduced breastfeeding duration (Harpham, 2005; McLearn et al., 2006). In India, there is evidence that mental disorders that are common in mothers, increased the occurrence of child stunting and underweight (Harpham, 2005).

Food insecurity is also correlated to decreased child health and increased hospitalizations (Cook et al., 2004), which are a direct cause of undernutrition (Black et al., 2008) since nutrient absorption might be compromised, even if adequate foods are consumed. For instance, Pérez-Escamilla et al. (2009) found that children from food-insecure households in Haiti had increased likelihood of malaria, and Gari et al. (2018) noted that malaria increased the risk of stunting in Ethiopian children. Undernutrition simultaneously reduces immune system response to diseases, inducing a vicious cycle of infectious diseases and malnutrition (Katona & Katona-Apte, 2008; Schaible & Kaufmann, 2007). In such vicious cycle, food insecurity plays a crucial role since it is associated with both infectious diseases, such as malaria, and with malnutrition.

A robust body of evidence supports the association between food insecurity and malnutrition, especially in women of child-bearing age and in children under five years (Maitra, 2018). Although the above associations are not consistent across all studies (Maitra, 2018), it is important to recognize that both food security and malnutrition are complex phenomena. Therefore, methodological aspects should be considered, for instance, including differentiating factors such as cultural and socioeconomic conditions across populations.

The world is nowadays facing changes in malnutrition trends with an outbreak of obesity rates and a reduced, yet in some cases persistent presence of undernourishment (FAO et al., 2019; Maitra, 2018; Popkin et al., 2020). Popkin (2002) has coined the term nutritional transition to describe these trends in malnutrition among different populations.

2.2 Nutritional Transition

According to accumulated evidence, demographic, epidemiological, and nutritional transitions have occurred worldwide, and at a higher rate in developing countries (Herrera & Delisle, 2006; Kapoor, 2002; Popkin & Ng, 2007; Rivera et al., 2004; WHO, 2017). The

epidemiological transition is the result of changes in disease patterns with a shift from infectious to chronic diseases (Omran, 2005). On the other hand, the demographic transition is characterized by a reduction in fertility and mortality rates, resulting in an aging population. Occurring simultaneously or as a subsequent result of the referred transitions, a nutritional transition reflects changes in diet and physical activity, particularly in low and middle-income countries where these changes are reported to increase at higher rates (Popkin & Ng, 2007).

As explained by Popkin & Ng (2007), the nutritional transition has five patterns, which do not necessarily correspond to a specific era in human history, since some of them are still occurring in some populations. The first pattern occurs in hunter-gatherer populations, with a diet "high in carbohydrates and fiber and low in fat" (Popkin, 2002, p. 1) and with a high practice of physical activity, leading to a reduced presence of obesity. The second pattern is characterized by the presence of famine due to decreased food availability, resulting in a reduction of the population height. Although famine persists in the third pattern, this is mainly characterized by a reduction of famine occurrence along with a higher intake of fruits, vegetables, and animal protein, as well as a decrease in overall physical activity. The fourth pattern appears with the presence of obesity and diet-related non-communicable diseases, caused by a diet characterized by high consumption of sugar and fat coupled with less active lifestyles. The last pattern consists of lifestyle changes to prevent the diseases that resulted from the previous pattern. The current nutritional transition is identified by changes from pattern three, a reduction in hunger that is reflected in stunted children, to pattern four, an increase of obesity and non-communicable diseases (Popkin, 2002).

Colombia is one of the many countries facing a nutritional transition, with a decreasing prevalence of child undernutrition and an increasing prevalence of overweight/obesity especially among women of childbearing age (Lamus-Lemus et al., 2012; Parra et al., 2015).

According to the most recent Colombian National Nutritional Survey (ENSIN) 2015, undernutrition in children under five decreased from 26% in 1990 to 10.8% in 2015, which represents a yearly reduction of 0.8%. Meanwhile, the same survey reported an increase in the prevalence of adult overweight and obesity (OWOB), from 49.5% in 2005 to 56.5% in 2015, a yearly increase of 7%. Moreover, by 2015 women had a higher prevalence of OWOB (MSPS et al., 2019). More concerning is that in some countries, rural areas are contributing significantly to the global burden of excessive weight (NCD-RisC, 2019) and Colombia is one of those countries (Jaacks et al., 2015; MSPS et al., 2019). According to the ENSIN survey, by 2015 OWOB was higher among adults from urban areas, when compared to those from rural settings (57.5% vs 52.7% respectively). A different panorama, however, was shown for rural women of childbearing age (13 to 49 years), in which excessive weight was 0.9% higher than in their urban counterparts (50.4% and 49.5%, respectively) (MSPS et al., 2019). Furthermore, Jaacks et al. (2015) reported that in most low and middle-income countries, including Colombia, excessive weight is increasing at a higher rate among rural women. This represents a concern since rural areas are characterized for having higher rates of undernutrition than urban settings. For instance, by 2015, 15.4% of children under five years were stunted in Colombian rural areas and 9% in urban settings (MSPS et al., 2019). The increasing prevalence of excessive body weight worsens the malnutrition load in rural areas, with the coexistence of OWOB and undernutrition.

As previously stated, the independent relationship between food insecurity and OWOB and undernutrition has been widely studied. Much greater gaps in knowledge exist, however,

regarding the relationship between food security and its different severity levels with the coexistence of OWOB and undernutrition, a phenomenon known as the Double Burden of Malnutrition (DBM).

2.3 Double Burden of Malnutrition

According to the World Health Organization, the double burden of malnutrition is "characterized by the coexistence of undernutrition along with overweight, obesity or diet-related NCDs, within individuals, households and populations, and across the life-course" (WHO, 2017, p. 2).

At the population level, the DBM is characterized by the simultaneous occurrence of a high prevalence of undernutrition with excessive weight or diet-related noncommunicable diseases NCDs, which can be presented in communities, regions, or countries (WHO, 2017). Popkin et al. (2020) defined that a country has the double burden of malnutrition if it has a prevalence of wasting of >15%, stunting of >30%, or thinness in women of >20%, and an adult or child overweight prevalence of >20%, >30%, or >40%. Popkin et al. (2020) found that sub-Saharan Africa, South Asia, East Asia, and the Pacific had the highest prevalence of DBM, and between 1990 and 2010 the countries that increased the prevalence of the DBM were the ones with the lowest income quantile. They also identified that the increasing presence of this phenomenon was mainly due to overweight, which is increasing in low-income households in Latin-American countries (Popkin et al., 2020).

The DBM in upper-middle-income countries, such as Colombia, is characterized by an obesity-undernutrition ratio that lays between high-income countries ratio and middle and low-income countries ratio. The former present a higher prevalence of overweight and obesity than undernutrition and the latter a higher prevalence of undernutrition than overweight and obesity

(Min et al., 2018).

At the household level, the double burden of malnutrition exists when one or more household members suffer of different malnutrition types (WHO, 2017). For instance, one or more members presenting wasting, stunting, or thinness coexists with another member classified as overweight or obese (Popkin et al., 2020). Popkin et al. (2020) found that across the LMIC the most common form of DBM at the household level refers to the coexistence of an OWOB mother and a stunted child, which had a wide prevalence range that went from 1.08% in Vietnam to 24.34% in Guatemala.

At the individual level, the DBM manifest itself as a person with excessive weight and anemia, or with stunting and overweight. According to Popkin et al. (2020), the coexistence of stunting and overweight in children under five-year was less than 1% in Colombia and more than 15% in Albania. The individual DBM is also seen across the life-course, so that a stunted child can become an overweight adult (WHO, 2017).

The focus of the present thesis is on the most common household manifestation of the DBM, which is the coexistence of a stunted child under five years of age and an overweight/obese mother (SCOWT). This form of DBM has been studied by several authors, who noted different prevalence levels amongst their studied populations (Freire et al., 2014; Garrett & Ruel, 2005; Gubert et al., 2017; Kroker-Lobos et al., 2014; J. Lee et al., 2012; Mahmudiono et al., 2018; Parra et al., 2015; Sarmiento et al., 2014).

An ecological study found that in 42 countries (27 in Africa, eight in Latin America, and seven in Asia) SCOWT was generally below 10%, with a higher prevalence in Latin American than in African countries (Garrett & Ruel, 2005). By the year 2010, Colombia had a 5% prevalence of SCOWT reported within its populace (Parra et al., 2015; Sarmiento et al., 2014)

compared to 4.2 % reported just ten years prior in 2000 (Garrett & Ruel, 2005).

It is also imperative to consider that regional differences in the occurrence of SCOWT can exist inside of a country, given the high variability in the prevalence of nutritional alterations. For instance, in 2015, the Colombian national prevalence of stunted children under five years was 10.8%. However, in the Colombian department (provincial unit) of Vaupés, this prevalence was far higher than the national level at 27%. The same pattern is presented in the prevalence of OWOB, with a staggering 56.5% of Colombian adults reported as having this condition and with numbers climbing as high as 72.4% in departments like San Andrés y Providencia. (MSPS et al., 2019). Moreover, as previously mentioned and according to the ENSIN 2015 survey, the prevalence of both stunting and excessive weight is higher in rural areas (MSPS et al., 2019). Consequently, it is expected that rural areas have higher SCOWT rates. This is supported by two studies reporting that SCOWT was higher in rural areas, especially in Latin America (Garrett & Ruel, 2005; J. Lee et al., 2012).

2.3.1 Determinants of The Double Burden of Malnutrition

Some biological pathways explain the existence of the DBM. For instance, evidence suggests that when it occurs during an individual´s life course (e.g., undernutrition in early life and excessive weight when grown-up), it might be the outcome of metabolic adaptations. These adaptations consist of storing energy mostly into fat and not into muscle when undernutrition is followed by a period of higher energy intake (Corvalan et al., 2007; Dulloo, 1997; Martins et al., 2004). Some studies reported that stunting was significantly associated with a decreased fat oxidation (Hoffman et al., 2000; Martins et al., 2004), which explains why after a follow-up period of three years, stunted girls had increased body fat and decreased lean mass than their

non-stunted counterparts (Martins et al., 2004). According to Wells et al. (2020), however, this latter effect can be countered with adequate diet and prevention of infections.

Inflammation and microbiota might be playing a role in the existence of the DBM across the life course since both are altered in stunted children and adults with excessive weight (Cuevas-Sierra et al., 2019; Dinh et al., 2016; Pedersen et al., 2016; Tzoulaki et al., 2008). To date, however, there is not enough evidence to support this relationship. Moreover, evidence for the association of dysbiosis and obesity is not yet clear, mainly because of differences in methodological aspects included in the available research (Cuevas-Sierra et al., 2019).

Regarding the biological determinants for the household presence of SCOWT, Wells et al. (2020) reported that children of mothers with OWOB and short stature had increased risk of being stunted, a result that was not seen if the mother was solely overweight. These authors claimed that the mother's previous experience when growing was a determinant for intergenerational transmission of low height. Moreover, Barquera et al. (2007) reported that when mothers had a higher waist-hip ratio, the odds for the child to be stunted were higher, even after controlling for the mother's height. This association might be driven by poorer maternal nutrition in pregnancy, leading to reduced intrauterine growth (Barquera et al., 2007), which is later reflected as child stunting.

When addressing health issues, it is crucial to recognize that besides biological factors, health inequalities can determine the differences in the way these issues manifest across populations (McFarland & MacDonald, 2019). Thus, the Social Determinants of Health (SDH) can contribute to understanding these health inequalities. The WHO defines the SDH as “the conditions in which people are born, grow, live, work and age” (WHO, 2018, para. 1). The most known model of the SDH was proposed by Dahlgren and Whitehead in 1991 (McFarland &

MacDonald, 2019). In this model they present the SDH in different categories: (a) non-modifiable factors, e.g., age, sex, and constitutional factors; (b) individual and lifestyle factors, e.g., diet; (c) social and community networks; (d) living and working conditions, e.g., housing, sanitation, employment, education, food production; and (e) general socioeconomic, cultural and environmental conditions, e.g., rural areas and political stability (Dahlgren & Whitehead, 1991; McFarland & MacDonald, 2019).

Furthermore, to understand the causes of malnutrition, UNICEF proposes a malnutrition framework, which is in line with the model of the SDH. In this framework, inadequate dietary intake and disease are the direct causes of malnutrition, while food insecurity and poverty are among the underlying causes, and the social, political, and economic context encompass its basic causes (Black et al., 2008). The present thesis gives focus on the SDH as this allows the inclusion of various factors that can influence the nutritional health of children and their mothers simultaneously.

There are several factors associated with the presence of SCOWT. For instance, several authors mention inadequate diet as a factor for the coexistence of both overweight/obesity and undernutrition in the same household (Garrett & Ruel, 2005). Such inadequate diet could be represented by both an increased consumption of energy-dense foods and a reduction in the intake of nutrient-rich foods (Bernal et al., 2016; Freire et al., 2014; Kroker-Lobos et al., 2014; Loret de Mola et al., 2014; Min et al., 2018; Tanumihardjo et al., 2007). Furthermore, a study conducted in Indonesia reported an association between intra-household food distribution and the DBM (Wibowo et al., 2015). In association with inadequate dietary intake, are factors such as the living and working conditions that include the socio-economic, cultural, and environmental

factors. These latter conditions should be examined as well in order to address the DBM problem effectively.

Popkin et al. (2020) highlighted the role of food system transformations, in the presence of the DBM, which can be categorized as environmental conditions. These transformations are the result of the world´s economic growth and consist of an increasing availability and access to foods often classified as ultra-processed foods and drinks (Popkin, 2017). According to Monteiro et al. (2018), these ultra-processed foods are "energy-dense, high in unhealthy types of fat, refined starches, free sugars and salt, and poor sources of protein, dietary fibre, and micronutrients" (p. 1). Furthermore, this food system transformations are accompanied by an increase in sedentary time (Ng & Popkin, 2012).

The consumption of ultra-processed foods is associated with excessive weight gain, cardiovascular disease, and all-cause mortality (Hall et al., 2019; Rico-Campà et al., 2019; Srour et al., 2019). The evidence is less clear, however, regarding the impact of their consumption on child growth (Popkin et al., 2020; Pries, Filteau, et al., 2019). Huffman et al. (2014) found that more than 20% of infants 6–8 months in Asia and Africa consumed sugary snacks, and infants were consuming more sugary snacks than fruits, fortified cereals, and eggs. The authors state that consumption of snacks and sugar-sweetened beverages might replace the intake of nutritious foods; however, more research is needed to validate this statement. In a systematic review, Pries, Filteau, et al. (2019) found contradictory evidence regarding the association between the intake of processed foods and reduced early child growth. The authors claim that the heterogeneity in their results might be driven by methodological aspects of the studies, which used diverse definitions of unhealthy foods and incorporated subjects of different age groups. For example, Vakili et al. (2015) showed that regular feeding of junk foods was associated with growth delays

in infants 6 to 24 months old. Conversely, Budree et al. (2017) found no association between such consumption and anthropometric z-scores in 12 month-old children. Pries, Rehman, et al. (2019) found that high consumption of unhealthy snacks foods and beverages was significantly associated with a lower length for age z-score, and this association was partially explained by inadequate diet.

Unhealthy foods are often ready to eat, and they are relatively affordable. Thus, their availability among households in low and middle-income countries represents a concern since vulnerable households could be exposed to the consequences of their consumption (Popkin et al., 2020). Latin-American countries are not exempt from this. According to several studies, there is a rapid transition in the food systems characterized by an increased presence of supermarkets and a higher offer of industrialized foods in Latin-American countries (Popkin & Reardon, 2018; Reardon & Berdegué, 2002). These food systems transformations are occurring at the same time as the nutritional transition, even in rural areas (Popkin & Reardon, 2018; Reardon & Berdegué, 2002).

Among other socio-economic, cultural, and environmental conditions related to the presence of the double burden of malnutrition, some authors mention economic growth, globalization, and urbanization (Herrera & Delisle, 2006; Min et al., 2018; Parra et al., 2015; Popkin & Ng, 2007). On the other hand, Garrett & Ruel, (2005) did not find a significant association between SCOWT and level of urbanization (coefficient 0.003; standard error 0.032; p=0.94), although it was positively associated with the country moderate/middle economic development (coefficient 0.003; standard error 0.001; p=0.01).

Two studies found that a high maternal level of education was a statistically significant protective factor for SCOWT. Mahmudiono et al. (2018) reported this finding in Indonesia (OR=

0.53; 95% CI= 0.34-0.83) and J. Lee et al. (2012) showed similar results in Guatemala (OR= 0.55; 95% CI= 0.30-0.10). Moreover, in Brazil, SCOWT was more likely to happen among households with the lower head of household education levels (OR= 2.54; 95% CI= 1.10-5.89) (Gubert et al., 2017).

Low poverty levels could be associated with SCOWT since this compromises access to nutritious foods (Tanumihardjo et al., 2007). In a Guatemalan study, however, this relationship was significantly more likely to occur among the middle-economic quintile group (OR= 1.74; 95% CI= 1.13-2.67) (J. Lee et al., 2012), which at some extent supports the findings made by Garrett & Ruel (2005), which could indicate that a country's moderate/middle economic development might increase the occurrence of SCOWT.

Poverty is positively related to food insecurity (Tanumihardjo et al., 2007). Therefore, just as middle poverty levels are correlated with the presence of SCOWT, middle food insecurity severity levels could be associated with this phenomenon. There are just a few known studies that have looked into this association. Mahmudiono et al. (2018) showed that in Indonesia mild food insecure households have greater risk of SCOWT (aOR=2.78; 95% CI= 1.54-5.08), followed by moderately food insecure households (aOR=2.53; 95% CI=1.28-4.98), and those classified as severely food insecure (aOR= 2.04; 95% CI= 1.08-3.84). In contrast, a Brazilian study found that this association was only significant for households facing severe food insecurity (aOR= 3.33, 95% CI= 1.41-7.84) (Gubert et al., 2017). The latter study also found an association between food-insecure households and child stunting alone but no association of food insecurity with OWOB in the children's mothers.

2.3.2 Double Burden of Malnutrition Consequences

The consequences of SCOWT can be related to a variety of adverse outcomes resulting from child stunting and OWOB in adults and mothers. For instance, some studies associate stunting with low cognitive development, less schooling, less productivity in adulthood, and low height in adults (Dewey & Begum, 2011; Victora et al., 2008). According to Özaltin et al. (2010), when adult low-height occurs in women, it is related to their children's low birth weight and increased death risk. These authors observed that children born to short mothers (height <145 cm) had increased risk of mortality (RR= 1.397 95% CI= 1.373 – 1.422) even after adjusting for different covariates. The same study found that women with short stature were more likely to have stunted children (RR= 2.132 95% CI= 2.103 - 2.161). Several studies reported a similar finding (Addo et al., 2013; Felisbino-Mendes et al., 2014; Ferreira et al., 2008; Hernández-Díaz et al., 1999; Varela-Silva et al., 2009), indicating that mothers' short height might perpetuate the malnutrition cycle.

Furthermore, the malnutrition cycle can start in utero. Mothers with a stature <145 cm do not have an adequate placental blood flow, which restricts fetus growth, a condition that might persist until adulthood, which is also associated with a decreased intellectual capacity (Dewey & Begum, 2011). Several authors have found an association between stunting in early life and reduced cognitive development (Alam et al., 2020; Grantham-McGregor et al., 2007; Kar et al., 2008; Victora et al., 2008). In a cohort study that included data collected between 2009 and 2017, Alam et al. (2020) found that when stunting started between one and six months of age and persisted until 60 months of age, the child had significantly lower cognitive scores than never stunted children. This lower cognitive capacity might lead to lower productive capacity in adulthood. Furthermore, a systematic review found that overweight and obesity were associated

with productivity loss (Goettler et al., 2017). In this regard, Victora et al. (2008) reported that in Brazil and Guatemala, income was shown to increase with higher height in males.

Stunting in childhood has been associated with excessive weight and the presence of chronic diseases in adulthood as well. According to Wittenbecher et al. (2019), however, more evidence is needed to support and understand the mechanisms of these associations. Among the available evidence, a meta-analysis of cross-sectional and cohort studies found that women with higher height had a lower risk of type 2 diabetes (RR = 0.83 95% CI=0.73, 0.95) (Janghorbani et al., 2012). This latter finding was further supported by Wittenbecher et al. (2019), who found that height was inversely correlated with type 2 diabetes in both women and men. This association might be driven by a potential lower liver fat storage among taller subjects (Wittenbecher et al., 2019). Lower height has been inversely associated with higher cardiovascular risk (Stefan et al., 2016). Furthermore, a Brazilian study found an association of this phenomenon of lower height with maternal hypertension, obesity, and abdominal adiposity (Ferreira et al., 2008). The association of stunting and excessive weight, as explained above, can be due to a decreased fat oxidation rate in stunted children. As reported by Martins et al. (2004), stunted children were more susceptible to gain more fat than lean mass after a three-year follow-up period. Moreover, individuals with low height have reduced energy requirements, which can easily be exceeded inducing excessive weight gain (Sawaya & Roberts, 2003).

The presence of excessive weight during pregnancy also implicates consequences for the offspring such as an increased risk of caesarean delivery, preterm delivery, and macrosomia (Ay et al., 2009; Gaillard et al., 2013; Poston et al., 2011). Since an inadequate diet is a direct cause of overweight and obesity, it will be expected that during pregnancy, the fetus of mothers with

excessive body weight, is not receiving adequate nutrient supply for a healthy growth (Barquera et al., 2007).

Cardiovascular disease is one of the chronic diseases strongly associated with excessive weight (Dwivedi et al., 2020; Lu et al., 2014; Yeh et al., 2019), as well as diabetes. For instance, Kearns et al. (2014) found a positive association between BMI and chronic diseases and that 42% of diabetes in women and 30% of hypertension in men were due to high BMI. A meta-analysis of cohort studies reported that overweight individuals and obese individuals had an increased likelihood of presenting diabetes after controlling for different variables (Abdullah et al., 2010). Moreover, a meta-analysis by González-Castro et al. (2019) found that when obesity was accompanied by diabetes, the risk of depression was higher. Individuals classified as overweight and obese also had increased odds of presenting gastric cancer in a meta-analysis of cohort studies; this risk incremented with higher body mass index (P. Yang et al., 2009).

The concern about excessive body weight and chronic diseases goes beyond their effects on the health and quality of life of individuals and their families. These diseases also represent increased costs for the public health system (Bahia et al., 2012). In Colombia, chronic diseases such as hypertension, type 2 diabetes, cardiac ischemic disease, and lower back pain in descending order, are the highest contributors of disability-adjusted life-years (DALYs) (Gil-Rojas et al., 2019). Moreover, in this country, obesity-related diseases had an annual economic impact of 2.16 billion US dollars (Gil-Rojas et al., 2019).

Given the evidence described above on both OW/OB and stunting, the SCOWT pairs might be exposed to the consequences derived from both conditions. Both stunting and excessive weight have implications to the human capital, economy, development of communities, and household's health and well-being. The fact that these two conditions can be presented

simultaneously within a household represents an increased risk for the children to develop excessive weight since it is very likely that they are growing in an obesogenic environment, perpetuating the malnutrition cycle. Moreover, since stunting and OWOB are also associated with less productivity, the household will be doubly affected, perpetuating the poverty cycle as well.

In conclusion, the available evidence shows that the DBM is affecting predominantly populations vulnerable to poverty, apparently in a more robust way those who are in the middle of the socio-economic class, are affected by food insecurity, and live in rural areas. Studying its causes in the developing world is fundamental to develop strategies to address this problem and reduce its prevalence.

Chapter 3. Manuscript

Food Insecurity and the Double Burden of Malnutrition in Colombian Rural Households

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3.1 Abstract: The Colombian rural areas are vulnerable to household food insecurity and its consequences. Household food insecurity has been associated with child stunting and overweight and obesity (OWOB) in women. However, its relationship with an emerging phenomenon known as the double burden of malnutrition remains unclear. This study aimed to examine in Colombian rural households the association between different severity levels of household food insecurity and the presence of the double burden of malnutrition, defined as the coexistence of a stunted child under five years and an OWOB mother (SCOWT). A cross-sectional study was conducted using data from mother-child pairs living in the same rural household (n=2,350) surveyed by the Colombian National Nutritional Survey (ENSIN) 2015. Household food insecurity status was assessed by using the Latin-American and Caribbean Food Security Scale (ELCSA). The household SCOWT status (child stunting and OWOB mother) was determined using anthropometric data from a mother and her child. Sixty-two percent of the households were food insecure and SCOWT was present in 7.8% of the households. Moderate (OR: 2.39 – CI: 1.36 - 4.21) and severe (OR: 1.86 – CI: 1.10 - 3.15) food insecurity was associated with SCOWT in an unadjusted logistic regression. Only moderate food insecurity remained significantly associated with SCOWT in a multivariate logistic regression (aOR: 2.41 - IC: 1.24 – 4.68). Colombian rural areas are not exempt from the worldwide concern of increasing OWOB rates while stunting is still persistent. These results highlight the need of implementing rural policies targeting most vulnerable households to SCOWT, particularly in terms of overcoming food insecurity beyond hunger satisfaction to prevent all forms of malnutrition.

Key words: food insecurity; double burden of malnutrition; stunting; overweight; obesity; rural areas; Colombia.

3.2 Introduction

Household food insecurity is experienced when there are concerns regarding accessing available food; the food needed for an active and healthy life is insufficient; or when accesing food implicates using socially unacceptable practices (Wunderlich et al., 2006). This complex situation occurs when one or all of the four food security pillars fail to be achieved over time, which include physical availability of food, access to food (economic, physical and cultural), food utilization, and stability of these pillars (FAO et al., 2018).

Since food is produced mainly in the rural areas, it might be expected that such settings would have less food insecure households given that rural areas contribute the most to food production. This scenario, however, seems to be only true for high-income countries (M. D. Smith et al., 2017). In countries with lower economic development levels, rural areas are more inclined to food insecurity than urban centers (Sinclair et al., 2019; L. C. Smith et al., 2005; M. D. Smith et al., 2017). According to the ENSIN (2015), 64% of rural Colombian households were food insecure vs. 52% in urban regions (Ministerio de Salud y Protección Social [MSPS] et al., 2019).

Food security pillars can be readily affected by socioeconomic and cultural dynamic factors seen in rural areas, which may adversely impact one or more of those pillars. For instance, the pillar related to physical availability of food depends on food production. In Colombian rural areas, less than 2% of the inhabitants have access to loans, technical assistance, land, and irrigation, which likely negatively affects adequate food production (Departamento Nacional de Planeación [DNP], 2015). Concurrently, the increased industrial mining activity in Colombian rural areas can threaten food security. Although industrial mining can contribute to the income of some households, food production could be adversely affected due to additional

demands on water, land, and workforce (DNP, 2015). Moreover, Colombian rural areas have higher levels of poverty, low education and illiteracy than urban regions (Departamento Administrativo Nacional de Estadística [DANE], 2016; DNP, 2015). These latter socio-economic factors can compromise the pillars pertaining to adequate access and utilization of food. Additionally, armed conflicts in Colombia have enormously affected the rural population (DNP, 2015) by compromising the stability of food security over time (Segovia, 2017). Taken together, the above factors lead to a significant disadvantage of rural areas of Colombia with respect to food security and so vulnerable to the adverse health and nutritional consequences of food insecurity.

Food insecurity diminishes quality of life and well-being (Ballard et al., 2013; Hadley & Crooks, 2012; Jones, 2017; Wunderlich et al., 2006). Additionally, food insecurity has been associated with the presence of malnutrition reflected in child stunting and maternal overweight and obesity (OWOB) in middle-income and high-income countries, respectively (Maitra, 2018). The latter health issues can be explained by food insecure households having a lower consumption of healthy, diverse, and nutritious foods and a higher consumption of energy dense foods (Drewnowski, 2004; Drewnowski & Specter, 2004; Mundo-Rosas et al., 2013; Tanumihardjo et al., 2007; Vega-Macedo et al., 2013). Such dietary patterns are the result of nutritional transitions occurring in developing countries that are also accompanied by low levels of physical activity (Popkin & Ng, 2007). These nutritional transitions can lead to growth stunting from undernutrition together with increased prevalence of excessive body weight (Popkin, 2002).

In 2015, 10.8% of the children under-five years were reported to be stunted in Colombia (MSPS et al., 2019). Although there has been a remarkable progress in reducing the prevalence

of growth stunting in Colombia, decreasing from a 26% prevalence in 1990, the set millennium development goal to reduce the prevalence to 8% by 2015 was not reached (MSPS et al., 2019). A particular concern was that child stunting was 15.4% in rural areas as compared to a prevalence of 9% seen in urban areas. Thus, growth stunting is still considered an important public health problem in Colombia (De Onis et al., 2019).

There is currently worldwide concern about unbalanced dietary patterns that are implicated in the rising number of persons classified as either overweight or obese in both developed and developing countries (FAO et al., 2019). Although such malnutrition had previously predominantly affected developed countries, this phenomenon is now rapidly rising in developing nations (FAO et al., 2018, 2019). Moreover, the gap in the prevalence of overweight and obesity that used to exist between the rural and urban areas is decreasing (FAO et al., 2019; Jaacks et al., 2015; NCD-RisC, 2019). According to the ENSIN (2015), 49.7% women of childbearing age (13 to 49 years) in Colombia are overweight or obese with a slightly higher prevalence in rural versus urban settings (50.4% and 49.5%, respectively) (MSPS et al., 2019).

The persistent prevalence of undernutrition in the form of stunting and the increasing rates of overweight and obesity can lead to the coexistence of a stunted child, under five years of age, and an overweight or obese mother within the same household (SCOWT). The coexistence of undernutrition together with overweight and obesity has been termed the double burden of malnutrition (WHO, 2017).

Both stunting and OWOB can lead to compromised quality of life and health outcomes since these forms of malnutrition have been associated with an increased chronic disease risk (Dwivedi et al., 2020; Wittenbecher et al., 2019) and impaired cognitive development (Alam et al., 2020). A major concern related to SCOWT is that the above health consequences can affect

mother-child dyads that sharing the same socio-economic environment. On the other hand, this type of double burden might be preventable by interventions addressing underlying household factors.

The association of food insecurity with SCOWT has been studied using nationally representative data in Brazil (Gubert et al., 2017) and in an urban subpopulation of Indonesia (Mahmudiono et al., 2018). The Brazilian study found that severe food insecure households had a higher likelihood of SCOWT (adjusted odds ratios (aOR) = 3.33, CI= 1.41-7.84) (Gubert et al., 2017), whereas all severity levels of food insecurity were associated to this phenomenon in Indonesia (mild food insecure aOR=2.78; 95% CI= 1.54-5.08; moderate food insecure aOR=2.53; CI=1.28-4.98, and severe food insecure aOR= 2.04; CI= 1.08-3.84) (Mahmudiono et al., 2018). The lack of agreement between studies indicates an uncertainty regarding the impact of food insecurity severity levels on the occurrence of SCOWT. To our knowledge, no study has investigated the association of SCOWT with food insecurity in rural households.

The objectives of this research were to use nationally representative data to: (a) assess the association between different severity levels of household food insecurity and SCOWT; and (b) identify factors related to social determinants of health that could be associated with SCOWT.

3.3 Methods

A cross-sectional study was conducted using secondary data from the latest Colombian National Nutritional Survey (ENSIN 2015). This survey incorporated a probabilistic multistage, stratified, cluster sampling design. In this design municipalities were randomized and stratified according to rural and urban areas, in the following stages, blocks were segmented to finally select the unit of analysis, which consisted of households. The ENSIN survey includes representative data for the nation, rural and urban areas, six regions and 32 departments

(provincial units). Detailed information on the sampling design can be found else were (MSPS et al., 2019).

The total sample size for the survey was 44,202 households, from which a subsample that consisted of mothers of childbearing age and their children under five years of age was selected. Firstly, a primary selection of all children under-five years old was conducted (n=12,910). Cases were excluded if they did not have complete anthropometric (n = 526) or food insecurity (n = 67) status data, were not living with their mothers (n = 705), or had implausible height for age values, HAZ < or > 6 z-scores (n = 57). Subsequently, a secondary selection of women of childbearing age (13 to 49 years old) was carried out (n = 42,370), who were then paired with their biologically related previously selected children (n = 9,733). Mothers were excluded if they did not have complete anthropometric data (n = 197), had body mass index (BMI) values lower than 14 kg/m^2 or higher than 45 kg/m^2 (n = 38), were pregnant or were three months postpartum (n = 1,085).

To select a single mother-child pair per household, in case there was more than one eligible mother or when a mother had more than one eligible child, a random selection was performed (1,324 children and 249 mothers excluded). Furthermore, only those households that were located in the rural area were considered, which excluded 6,369 urban households. This resulted in a final subsample of 2,350 households with eligible mother-child pairs.

3.3.1 Outcome and Exposure Variables

3.3.1.1 Household SCOWT Status. The dependent variable was the household SCOWT status, which was constructed using anthropometric data from the mother and the child. Children with height for age below -2SD were classified as stunted, whereas when this index was equal to or above this value, the child was classified as not stunted (MSPS et al., 2016). Mothers were

classified as being overweight or obese (OWOB) when their BMI was equal to or above 25 kg/m^2 (OWOB). Mothers with a BMI below 25 kg/m^2 were classified as normal-weight. In cases where the household had a stunted child together an overweight/obese mother, the household was classified as SCOWT and assigned a value of one. If a household did not have both conditions, a value of zero was allocated. Overweight and obesity were considered together due to the low prevalence of SCOWT among households when only obesity was considered (3%, n = 67). Another consideration for grouping these two weight categories is that overweight (BMI of 25-29 kg/m^2) is also associated with increased chronic disease risk (Kearns et al., 2014; Lu et al., 2014).

Child stunting and maternal OWOB were analyzed as dependent variables to enable a comparison of the factors related to their occurrence with those associated with SCOWT. Hence, the three variables (child stunting, maternal OWOB, and SCOWT) were analyzed as categorical binary variables (having or not having the condition). Therefore, the reference group allowed for the comparison with all other forms of nutritional status classifications, not just with normal pairs. The rationale for this approach was based on the need to compare the presence of SCOWT against all different possible combinations of child-mother nutritional status, not just against normal pairs. Moreover, less than half of the pairs were found to be classified as having normal nutritional status, reducing the power of the analysis. A preliminary analysis excluding underweight mothers did not alter the results. On the other hand, it would have been inaccurate to treat child stunting, maternal OWOB, and SCOWT pairs as categories of one multinomial variable since not all risk factors were shared between each, which would have affected the results from the multivariate logistic regression.

3.3.1.2 Household food security status. With regards to household food security status, the ENSIN survey used the Latin-American and Caribbean Food Security Scale (Escala Latinoamericana y del Caribe de Seguridad Alimentaria - ELCSA). This scale has been validated for Colombia and other countries of the region (Comité científico de la ELCSA, 2012). The ELCSA scale evaluates the experiences of the households with regard to food insecurity through the implementation of 15 different questions (8 for households consisting only of members 18 years old or older and 7 questions for households with one child or more under the age of 18). When the head of the household answers affirmatively to a question a score of one was assigned. On the other hand, a score of zero was allocated if the respondent's answer was negative. A total score was calculated to classify the household as food secure (score of zero), mild food insecure (score of 1 to 5), moderate food insecure (score of 6 to 10), or severe food insecure (score of 11 to 15). Mild food insecure households experience impaired food quality, whereas food quantity is also compromised in moderate food insecure households. Severe food insecure households are those that experience hunger (Comité científico de la ELCSA, 2012).

To better understand the association of SCOWT and food insecurity, 16 categorical covariates that were included in the ENSIN survey were incorporated in the analysis. These covariates were grouped according to the categories of the model of the social determinants of health proposed by Dahlgren & Whitehead (1991). The categories were: (a) social, cultural and environmental conditions; (b) living and working conditions; and (c) individual lifestyle factors (Table 1).

Table 1. Descriptive characteristics of children and mother's pairs according to all covariates.

Social determinants of health categories	VARIABLES	Categories	Total	
			n	% (95% CI)
Social, cultural and environmental conditions	Region	Atlántico	780	24.1 (21.0 - 27.6)
		Oriental	414	23 (19.5 - 27.0)
		Orinoquía and Amazonía	54	3.6 (3.3 - 3.9)
		Central	579	25.3 (23.0 - 27.9)
		Pacífica	521	23.9 (20.4 - 27.8)
Living and working conditions	Head of household economic activity	Unemployed	29	1.4 (1.0 - 2.0)
		Formally employed	335	24.4 (21.0 - 28.1)
		Informally employed	1504	74.2 (70.6 - 77.6)
	Size of the household	2 to 4	1079	48.8 (46.7 - 51.0)
		5 to 6	832	34.7 (32.0 - 37.5)
		7 or more	439	16.5 (15.1 - 17.9)
	Toilet with sewer connection	Yes	1711	81.1 (78.5 - 83.4)
		No	639	18.9 (16.0 - 22.2)
	Wealth index	Below the mean	1177	40 (35.7 - 44.6)
		Above the mean	1173	60 (55.4 - 64.3)
	Educational level head of household	Less than complete primary school	1039	43.4 (37.8 - 49.1)
		Incomplete secondary school	836	33.6 (30.3 - 37.1)
		Complete secondary and more	457	23 (19.4 - 27.2)
	Educational level mothers	Less than complete primary school	515	20 (17.6 - 22.7)
		Incomplete secondary school	1033	41.9 (39.4 - 44.4)
		Incomplete undergraduate	767	37 (34.2 - 39.8)
		Complete undergraduate and more	28	1.2 (0.9 - 1.5)
	Women as a head of the household	No	543	75.5 (73.0 - 77.8)
		Yes	1807	24.5 (22.2 - 27.0)
	Number of children under 5y	1	1931	83.9 (82.0 - 85.6)
		2	385	15.2 (13.6 - 17.0)
		3 or more	34	0.9 (0.7 - 1.3)
Individual lifestyle factors	Race head of household	Afro Colombian	277	9.4 (6.8 - 13.0)
		Indigenous	350	12.5 (8.6 - 17.8)
		None ethnicity identified	1695	78.1 (74.0 - 81.7)
	Multiple birth	No	2317	99.3 (99.0 - 99.6)
		Yes	20	0.7 (0.4 - 1.0)
	Mothers age at birth	13 to 17	291	13.4 (11.5 - 15.5)
		18 to 34	1772	76 (74.1 - 77.8)
		35 to 49	272	10.6 (9.7 - 11.7)
	Preterm birth	Yes	288	13.3 (11.9 - 14.9)
		No	1997	86.7 (85.1 - 88.1)
	Birth spacing	< 24	252	8.8 (7.5 - 10.3)
		>=24	1297	53.4 (51.2 - 55.6)
		Unique child	787	37.8 (35.1 - 40.6)
	Mothers height	< 145	143	5.4 (3.6 - 8.1)
		>= 145	2207	94.6 (91.9 - 96.4)

Raw sample sizes are reported, sample weights were used to compute estimates.

3.3.2 Statistical Analysis

Multicollinearity was tested between all variables using the Variance Inflation Factor (VIF) (Liao & Valliant, 2012), when it was below 2.5 multicollinearity was considered a problem. None of the variables reported a VIF below this value.

Statistical analysis was performed using SPSS version 23.0.0, and more specifically its complex samples module. All the analyses were done using sampling weights, hereafter, the sampling weight of the child was used to analyze the variables SCOWT and stunting, the mother's sampling weight for OWOB, and the household sampling weight for the descriptive characteristics of the households. A 95% confidence interval was set and analyses with a p-value of $p < 0.05$ were considered to be significant. Descriptive characteristics of the sample and their corresponding 95% confidence intervals are also presented.

Pearson chi-squared tests were conducted to evaluate the associations between all independent variables and SCOWT, child stunting and maternal OWOB. Furthermore, a bivariate logistic regression was used to better understand this association. Variables in the Pearson chi-squared test that showed an association with a p-value < 0.25 were included in a multivariate logistic regression (Hosmer et al., 2013). Variables that met this criterium but did not improve the model fit were removed. Subsequently, a first model that included all covariates meeting this criterion was implemented. To better understand the association of SCOWT and food insecurity, a hierarchical logistic regression that included three different models was performed. These models were adjusted for the variables according to the categories of the model of the social determinants of health. Odds ratios (OR) and adjusted odds ratios (aOR) are presented as a result from the logistic regression analyses.

The Colombian National Institute of Health granted ethical approval for the implementation of the ENSIN 2015.

3.4 Results

3.4.1 Descriptive Characteristics

Almost two thirds (62%) of the households experienced food insecurity. Maternal OWOB was present in almost half (49.8%) of the households and child stunting in 16% of households. The presence of SCOWT was found in 7.8% mother-child pairs (Table 2).

Table 2. Household food security and Children and mother's and nutritional status

VARIABLES	Total	
	n	% (95% CI)
Double burden pairs (SCOWT)		
Yes	199	7.8 (6.7 - 9.2)
No	2151	92.2 (90.8 - 93.3)
Child nutritional status		
Height/age		
Stunting	420	16 (14.4 - 17.8)
Risk of stunting	682	29.6 (27.0 - 32.2)
Normal	1248	54.4 (51.2 - 57.6)
Weight/height		
Wasting	28	1.4 (1.0 - 2.1)
Risk of wasting	182	7 (6.0 - 8.3)
Normal	1555	65.2 (62.7 - 67.6)
Risk of overweight	450	20.7 (18.9 - 22.6)
Overweight	107	4.7 (3.9 - 5.7)
Obesity	22	1 (0.6 - 1.6)
Maternal nutritional status		
Underweight	76	3 (2.5 - 3.7)
Risk of underweight	7	0.2 (0.1 - 0.4)
Normal	1058	47 (45.1 - 49.0)
Overweight	788	32.4 (29.9 - 35.0)
Obesity	421	17.4 (15.5 - 19.4)
Overweight + Obesity	1209	49.8 (47.8 - 51.7)

Raw sample sizes are reported, sample weights were used to compute estimates.

Moreover, 2% of the children suffered both stunting and overweight. Almost three quarters of the surveyed heads of households (74.2%) were informally employed and 43.4% did not have a completed primary school educational level (Table 1).

3.4.1.1 Bivariate analysis. As shown in Table 3 almost all covariates used for the analyses were associated with food insecurity. In the overall selected sample of mother-child pairs, there were 37.6% food secure households. However, food security decreased as social-economic conditions increased in inequality. For instance, among those identified as Afro-Colombians and as indigenous people, only 11.5% and 18% households were food secure, respectively. Food security prevalence was lower than 30% within households without a toilet with sewer connection, among mothers with the lowest educational level, and among those who had a height < 145 cm, and households with three or more children under five years of age (Table 3).

The Chi-squared test revealed significant associations ($p < 0.05$) between food security and all dependent variables in terms of maternal OWOB, child stunting and SCOWT. The lowest prevalence of maternal OWOB was found among severe food insecure households, which also had the highest prevalence of child stunting. Child stunting showed a dose response pattern increasing as the severity of food insecurity increased. The association of SCOWT with food security had an inversed U shape curve, i.e., the highest prevalence was found among moderate food insecure households (Figure. 1).

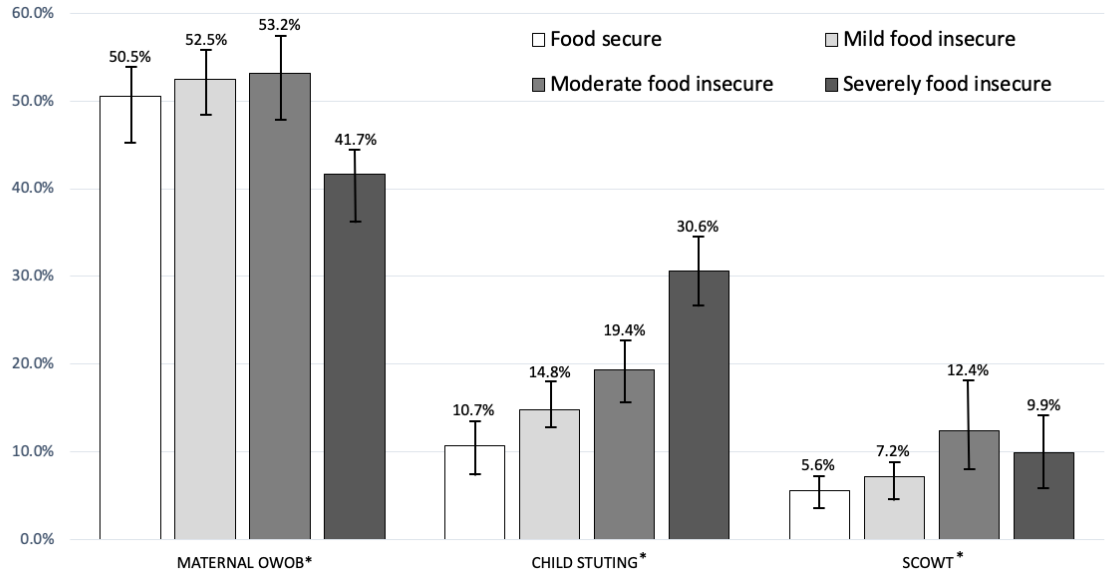
The highest prevalence for both SCOWT and stunting was found in households that had three or more children under five years old, in households with multiple childbirths, and among those households in which the mother's height was < 145 cm. Maternal OWOB showed a

Table 3. Prevalence of food insecurity (by severity levels) across covariates

VARIABLES	Categories	Severe Insecurity		Moderate Insecurity		Mild Insecurity		Food Security		P-value
		n	Row % (95% CI)	n	Row % (95% CI)	n	Row % (95% CI)	n	Row % (95% CI)	
Total		360	9.2 (7.7 - 10.8)	435	15.7 (13.6 - 18.0)	860	37.6 (34.6 - 40.7)	695	37.6 (34.6 - 40.7)	
Region	Atlántico	204	24.3 (21.6 - 27.3)	170	22 (18.2 - 26.5)	266	38 (34.1 - 42.1)	140	15.6 (12.7 - 19.0)	<0.001
	Oriental	12	3.2 (1.7 - 5.8)	67	12.8 (8.9 - 18.2)	177	39.4 (32.8 - 46.4)	158	44.6 (38.7 - 50.6)	
	Orinoquía and Amazonía	6	9 (9.0 - 9.0)	10	18.7 (18.7 - 18.7)	22	42.9 (42.9 - 42.9)	16	29.5 (29.5 - 29.5)	
	Central	39	7.4 (5.3 - 10.1)	87	15.3 (12.0 - 19.4)	202	33.9 (30.4 - 37.6)	251	43.4 (37.2 - 49.7)	
	Pacífica	99	12.3 (7.2 - 20.4)	101	17.2 (13.4 - 21.8)	192	38.3 (31.6 - 45.6)	129	32.1 (24.8 - 40.5)	
Head of household economic activity	Unemployed	8	10 (5.6 - 17.2)	11	41.2 (23.6 - 61.4)	9	45.6 (29.7 - 62.4)	1	3.2 (0.4 - 19.4)	<0.001
	Formally employed	18	3.5 (2.7 - 4.5)	34	6.9 (5.0 - 9.5)	139	36.8 (33.2 - 40.6)	144	52.7 (48.5 - 56.9)	
	Informally employed	222	9.4 (7.5 - 11.7)	299	17.1 (14.6 - 20.0)	550	40.1 (36.2 - 44.2)	433	33.4 (29.2 - 37.8)	
Size of the household	2 to 4	98	6.3 (4.7 - 8.2)	185	13.8 (11.4 - 16.7)	410	35.8 (32.0 - 39.7)	386	44.1 (39.5 - 48.8)	<0.001
	5 to 6	150	9.2 (7.6 - 11.1)	156	16.6 (13.4 - 20.5)	299	41.1 (35.9 - 46.5)	227	33.1 (27.7 - 39.0)	
	7 or more	112	18.7 (14.4 - 24.0)	94	19.5 (15.4 - 24.4)	151	34.9 (29.3 - 40.9)	82	26.9 (21.1 - 33.6)	
Toilet with sewer connection	Yes	151	5.8 (4.8 - 7.0)	283	14.4 (12.1 - 17.0)	680	38.9 (35.6 - 42.2)	597	41 (37.6 - 44.4)	<0.001
	No	209	29.2 (24.0 - 35.1)	152	23.7 (20.0 - 27.8)	180	29.8 (24.1 - 36.1)	98	17.3 (13.4 - 22.1)	
Wealth index	Below the mean	278	19.2 (16.1 - 22.8)	260	21.9 (18.4 - 25.8)	388	35.1 (30.3 - 40.3)	251	23.8 (20.2 - 27.9)	<0.001
	Above the mean	82	4 (3.1 - 5.2)	175	12.6 (10.2 - 15.3)	472	38.8 (34.5 - 43.4)	444	44.6 (40.6 - 48.6)	
Educational level head of household	Less than complete primary school	226	14.9 (11.7 - 18.7)	215	20.3 (16.2 - 25.2)	345	34.4 (30.4 - 38.6)	253	30.3 (24.0 - 37.6)	<0.001
	Incomplete secondary school	90	5.8 (4.2 - 7.9)	144	13.8 (10.7 - 17.6)	327	40.3 (35.4 - 45.3)	275	40.2 (35.1 - 45.5)	
	Complete secondary and more	42	3.4 (2.2 - 5.1)	73	9.9 (7.7 - 12.8)	180	39.2 (32.4 - 46.5)	162	47.5 (40.4 - 54.7)	
Educational level mothers	Less than complete primary school	158	23.7 (19.4 - 28.6)	98	20.8 (16.3 - 26.2)	151	34.1 (27.4 - 41.5)	108	21.4 (16.7 - 27.0)	<0.001
	Incomplete secondary school	136	8.8 (6.7 - 11.4)	202	18.3 (15.5 - 21.5)	385	36.7 (33.6 - 40.0)	310	36.2 (32.5 - 40.1)	
	Incomplete undergraduate	62	3.3 (2.4 - 4.5)	130	11.2 (8.8 - 14.1)	315	41.4 (35.9 - 47.1)	260	44.2 (38.3 - 50.3)	
	Complete undergraduate and more	3	1.2 (0.6 - 2.1)	2	0.6 (0.1 - 3.0)	9	14.1 (4.5 - 36.1)	14	84.2 (63.7 - 94.2)	
Women as a head of the household	No	233	7.1 (5.6 - 9.1)	341	15.3 (13.1 - 17.8)	666	37.8 (34.4 - 41.4)	567	39.7 (35.5 - 44.1)	0.001
	Yes	127	15.3 (12.6 - 18.5)	94	16.9 (13.5 - 20.9)	194	36.8 (31.3 - 42.5)	128	31.1 (25.1 - 37.8)	
Number of children under 5y	1	253	7.9 (6.5 - 9.5)	356	14.9 (12.7 - 17.5)	728	38.2 (34.9 - 41.6)	594	39 (35.7 - 42.4)	<0.001
	2	95	15.5 (12.1 - 19.7)	71	19.4 (15.1 - 24.5)	125	35.1 (29.6 - 41.0)	94	30.1 (23.9 - 37.0)	
	3 or more	12	29.6 (19.1 - 42.9)	8	27.8 (11.2 - 54.1)	7	14.9 (5.8 - 33.3)	7	27.6 (12.4 - 50.5)	
Race head of household	Afro Colombian	87	26.5 (22.2 - 31.3)	65	21.9 (17.7 - 26.7)	97	40.1 (33.1 - 47.6)	28	11.5 (7.6 - 17.1)	<0.001
	Indigenous	134	36 (30.4 - 41.9)	67	20.4 (14.4 - 28.2)	89	25.6 (17.7 - 35.6)	60	18 (13.3 - 23.8)	
	None ethnicity identified	138	4.9 (3.8 - 6.1)	300	14.7 (12.3 - 17.4)	662	38.8 (35.5 - 42.3)	595	41.6 (38.2 - 45.1)	
Multiple birth	No	358	9.2 (7.8 - 10.9)	429	15.7 (13.6 - 18.0)	845	37.6 (34.5 - 40.8)	685	37.5 (34.4 - 40.6)	0.818
	Yes	2	5 (1.0 - 22.2)	3	19.9 (4.2 - 58.4)	8	29.6 (10.6 - 59.9)	7	45.5 (17.8 - 76.2)	
Mothers age at birth	13 to 17	30	10.7 (5.9 - 18.6)	58	15.5 (11.2 - 21.1)	114	33.1 (26.4 - 40.6)	89	40.6 (32.7 - 49.1)	0.115
	18 to 34	276	8.4 (7.2 - 9.7)	318	15.7 (13.3 - 18.4)	645	37.6 (34.0 - 41.4)	533	38.4 (35.2 - 41.6)	
	35 to 49	54	14 (10.1 - 19.1)	55	15.8 (10.5 - 23.2)	93	42.5 (33.7 - 51.8)	70	27.7 (20.4 - 36.5)	
Preterm birth	Yes	69	18.2 (13.3 - 24.3)	46	11.5 (7.6 - 17.1)	95	33.6 (26.4 - 41.8)	78	36.6 (28.2 - 45.9)	<0.001
	No	283	8 (6.6 - 9.5)	374	16 (13.8 - 18.5)	741	38.3 (35.1 - 41.6)	599	37.7 (34.8 - 40.7)	
Birth spacing	< 24	63	15.4 (10.6 - 21.7)	47	24.8 (18.6 - 32.1)	84	37.1 (29.5 - 45.3)	58	22.8 (16.7 - 30.3)	<0.001
	>=24	227	10.5 (9.1 - 12.0)	248	15.7 (13.1 - 18.7)	470	39 (34.4 - 43.8)	352	34.8 (30.2 - 39.6)	
	Unique child	69	6.1 (4.1 - 8.8)	137	13.6 (10.9 - 16.9)	299	35.6 (30.4 - 41.1)	282	44.7 (38.2 - 51.5)	
Mothers height	< 145	45	25.3 (16.0 - 37.5)	24	17 (9.9 - 27.5)	45	36.4 (23.8 - 51.1)	29	21.3 (13.9 - 31.4)	<0.001
	>= 145	315	8.3 (7.0 - 9.8)	411	15.6 (13.5 - 18.0)	815	37.6 (34.6 - 40.8)	666	38.5 (35.3 - 41.7)	

highest prevalence among households in which the mother gave birth at 35 to 49 years old, households in which birth spacing was at or above 24 months, and in households located in the Central region of Colombia (Table 4).

Figure 1. Maternal OWOB, child stunting and SCOWT by food insecurity severity levels



In the unadjusted bivariate analysis, moderate (OR: 2.39 – CI: 1.36 - 4.21) and severe food insecure households (OR: 1.86 – CI: 1.10 - 3.15) presented an increased likelihood of SCOWT when compared to food secure households. The odds for child stunting were higher in households experiencing food insecurity when compared to those with food security, increasing with rising severity of food insecurity (mild OR: 1.45 – CI: 1.02 - 2.06, moderate OR: 2.02 – CI: 1.39 - 2.94, severe OR: 3.70 – CI: 2.64 - 5.17). Conversely, the likelihood of finding households with maternal OWOB was significantly lower in severe food insecure households (OR: 0.60 – CI: 0.47 - 0.78) (Table 5).

Table 4. Maternal OWOB, child stunting and SCOWT according to covariates

VARIABLES	CATEGORIES	SCOWT			MATERNAL OWOB			CHILDREN STUNTED		
		YES (%) (95% CI)	NO (%) (95% CI)	P-value	YES (%) (95% CI)	NO (%) (95% CI)	P-value	YES (%) (95% CI)	NO (%) (95% CI)	P-value
Region	Atlántico	7.6 (6.0 - 9.5)	92.4 (90.5 - 94.0)	0.473	**41.2 (36.9 - 45.6)**	**58.8 (54.4 - 63.1)**	**<0.001**	**21.2 (18.5 - 24.1)**	**78.8 (75.9 - 81.5)**	**0.003**
	Oriental	6.7 (3.8 - 11.4)	93.3 (88.6 - 96.2)		**50 (45.5 - 54.5)**	**50 (45.5 - 54.5)**		**11.9 (8.5 - 16.6)**	**88.1 (83.4 - 91.5)**	
	Orinoquía and Amazonía	5.6 (5.6 - 5.6)	94.4 (94.4 - 94.4)		**49.2 (49.2 - 49.2)**	**50.8 (50.8 - 50.8)**		**21.5 (21.5 - 21.5)**	**78.5 (78.5 - 78.5)**	
	Central	9.3 (7.4 - 11.6)	90.7 (88.4 - 92.6)		**55.4 (52.1 - 58.6)**	**44.6 (41.4 - 47.9)**		**16.5 (13.9 - 19.4)**	**83.5 (80.6 - 86.1)**	
	Pacífica	8 (5.7 - 11.0)	92 (89.0 - 94.3)		**54.2 (49.6 - 58.9)**	**45.8 (41.1 - 50.4)**		**13.5 (9.8 - 18.4)**	**86.5 (81.6 - 90.2)**	
Head of household economic activity	Formally employed	**3.5 (2.1 - 5.8)**	**96.5 (94.2 - 97.9)**	**0.003**	50.3 (45.5 - 55.0)	49.7 (45.0 - 54.5)	0.886	**8.4 (6.6 - 10.7)**	**91.6 (89.3 - 93.4)**	**<0.001**
	Informally employed	**7.7 (6.4 - 9.2)**	**92.3 (90.3 - 93.6)**		50 (47.5 - 52.5)	50 (47.5 - 52.5)		**16 (13.9 - 18.4)**	**84 (81.6 - 86.1)**	
	Unemployed	**5.8 (1.4 - 20.6)**	**94.2 (79.4 - 98.6)**		53.8 (39.8 - 67.3)	46.2 (32.7 - 60.2)		**25.7 (17.6 - 35.8)**	**74.3 (64.2 - 82.4)**	
Size of the household	2 to 4	**4.9 (3.4 - 6.9)**	**95.1 (93.1 - 96.6)**	**<0.001**	49.4 (46.2 - 52.7)	50.6 (47.3 - 53.8)	0.115	**12.2 (10.0 - 14.8)**	**87.8 (85.2 - 90.0)**	**<0.001**
	5 to 6	**9.8 (7.9 - 12.1)**	**90.2 (87.9 - 92.1)**		52.2 (48.8 - 55.5)	47.8 (44.5 - 51.2)		**18 (15.9 - 20.2)**	**82 (79.8 - 84.1)**	
	7 or more	**12.5 (10.2 - 15.1)**	**87.5 (84.9 - 89.8)**		45.9 (41.7 - 50.1)	54.1 (49.9 - 58.3)		**23.2 (19.9 - 27.0)**	**76.8 (73.0 - 80.1)**	
Toilet with sewer connection	Yes	7.7 (6.4 - 9.3)	92.3 (90.7 - 93.6)	0.591	**52.4 (49.8 - 54.9)**	**47.6 (45.1 - 50.2)**	**<0.001**	**14 (12.3 - 15.8)**	**86 (84.2 - 87.7)**	**<0.001**
	No	8.4 (6.4 - 10.9)	91.6 (89.1 - 93.6)		**39.6 (35.5 - 43.9)**	**60.4 (56.1 - 64.5)**		**24.8 (21.6 - 28.3)**	**75.2 (71.7 - 78.4)**	
Wealth index	Below the mean	8.4 (6.9 - 10.0)	91.6 (90.0 - 93.1)	0.465	**43.5 (40.8 - 46.3)**	**56.5 (53.7 - 59.2)**	**<0.001**	**21.6 (18.9 - 24.6)**	**78.4 (75.4 - 81.1)**	**<0.001**
	Above the mean	7.5 (5.9 - 9.5)	92.5 (90.5 - 94.1)		**54.2 (51.0 - 57.4)**	**45.8 (42.6 - 49.0)**		**12.3 (10.4 - 14.6)**	**87.7 (85.4 - 89.6)**	
Educational level head of household	Less than complete primary school	8.9 (7.0 - 11.1)	91.1 (88.9 - 93.0)	0.134	**45.5 (42.8 - 48.2)**	**54.5 (51.8 - 57.2)**	**0.018**	**18.9 (16.5 - 21.5)**	**81.1 (78.5 - 83.5)**	**0.009**
	Incomplete secondary school	8.5 (6.3 - 11.5)	91.5 (88.5 - 93.7)		**54.5 (51.0 - 57.9)**	**45.5 (42.1 - 49.0)**		**14.8 (12.1 - 18.1)**	**85.2 (81.9 - 87.9)**	
	Complete secondary and more	4.9 (2.8 - 8.7)	95.1 (91.3 - 97.2)		**51.5 (44.7 - 58.4)**	**48.5 (41.6 - 55.3)**		**12.2 (9.1 - 16.2)**	**87.8 (83.8 - 90.9)**	
Educational level mothers	Less than complete primary school	**12.5 (10.3 - 15.1)**	**87.5 (84.9 - 89.7)**	**<0.001**	53 (49.3 - 56.6)	47 (43.4 - 50.7)	0.673	**25.6 (22.2- 29.2)**	**74.4 (70.8 - 77.8)**	**<0.001**
	Incomplete secondary school	**8.7 (7.0 - 10.9)**	**91.3 (89.1 - 93.0)**		48.8 (46.0 - 51.7)	51.2 (48.3 - 54.0)		**16.2 (13.8 - 18.9)**	**83.8 (81.1 - 86.2)**	
	Incomplete undergraduate	**4.5 (2.8 - 7.0)**	**95.5 (93.0 - 97.2)**		49.3 (45.8 - 52.8)	50.7 (47.2 - 54.2)		**11.1 (8.9 - 13.7)**	**88.9 (86.3 - 91.1)**	
	Complete undergraduate and more	**4.8 (1.0 - 20.2)**	**95.2 (79.8 - 99.0)**		44.5 (8.5 - 87.4)	55.5 (12.6 - 91.5)		**4.8 (1.0 - 20.2)**	**95.2 (79.8 - 99.0)**	
Women as a head of the household	No	**6.6 (5.4 - 8.1)**	**93.4 (91.9- 94.6)**	**0.002**	49.1 (46.6 - 51.5)	50.9 (48.5 - 53.4)	0.321	**14.4 (12.5 - 16.6)**	**85.6 (83.4 - 87.5)**	**0.001**
	Yes	**11.5 (8.7 - 15.0)**	**88.5 (85.0 - 91.3)**		51.8 (47.4 - 56.2)	48.2 (43.8 - 52.6)		**20.9 (18.0 - 24.2)**	**79.1 (75.8 - 82.0)**	
Race head of household	Afro Colombian	**6.7 (3.8 - 11.4)**	**93.3 (88.6 - 96.2)**	**0.001**	**53.8 (48.4 - 59.1)**	**46.2 (40.9 - 51.6)**	**0.001**	**11.1 (7.9 - 15.2)**	**88.9 (84.8 - 92.1)**	**<0.001**
	Indigenous	**13.7 (10.8 - 17.1)**	**86.3 (82.9 - 89.2)**		**39.6 (33.7 - 45.8)**	**60.4 (54.2 - 66.3)**		**35 (30.2 - 40.1)**	**65 (59.9 - 69.8)**	
	None ethnicity identified	**7.1 (5.8 - 8.6)**	**92.9 (91.4 - 94.2)**		**51.1 (48.8 - 53.3)**	**48.9 (46.7 - 51.2)**		**13.7 (12.0 - 15.5)**	**86.3 (84.5 - 88.0)**	
Multiple birth	No	**7.6 (6.4 - 9.0)**	**92.4 (91.0 - 93.6)**	**<0.001**	49.5 (47.5 - 51.4)	50.5 (48.6 - 52.5)	0.163	**15.8 (14.1 - 17.6)**	**84.2 (82.4 - 85.9)**	**<0.001**
	Yes	**38.7 (16 - 67.6)**	**61.3 (32.4 - 84)**		65.7 (42.0 - 83.5)	34.3 (16.5 - 58.0)		**54.4 (30.3 - 76.7)**	**45.6 (23.3 - 69.7)**	
Sex	Female	**6.5 (4.9 - 8.6)**	**93.5 (91.4 - 95.1)**	**0.049**	48.9 (45.3 - 52.6)	51.1 (47.4 - 54.7)	0.539	**13.5 (11.2 - 16.1)**	**86.5 (83.9 - 88.8)**	**0.005**
	Male	**9.2 (7.6 - 11.1)**	**90.8 (88.9 - 92.4)**		50.6 (47.6 - 53.6)	49.4 (46.4 - 52.4)		**18.5 (16.3 - 20.9)**	**81.5 (79.1 - 83.7)**	
Mothers age at birth	13 to 17	6.3 (3.9 - 10.1)	93.7 (89.9 - 96.1)	0.159	**30.2 (25.4 - 35.5)**	**69.8 (64.5 - 74.6)**	**<0.001**	18.2 (14.0 - 23.3)	81.8 (76.7 - 86.0)	0.41
	18 to 34	7.7 (6.3 - 9.3)	92.3 (90.7 - 93.7)		**50.9 (48.6 - 53.2)**	**49.1 (46.8 - 51.4)**		15.4 (13.7 - 17.3)	84.6 (82.7 - 86.3)	
	35 to 49	10.6 (7.6 - 14.7)	89.4 (85.3 - 92.4)		**66.4 (61.2 - 71.2)**	**33.6 (28.8 - 38.8)**		17.3 (12.6 - 23.3)	82.7 (76.7 - 87.4)	
Preterm birth	Yes	**11.5 (8.1 - 16.1)**	**88.5 (83.9 - 91.9)**	**0.025**	45.6 (40.5 - 50.7)	54.4 (49.3 - 59.5)	0.105	**25.5 (21.2 - 30.2)**	**74.5 (69.8 - 78.8)**	**<0.001**
	No	**7.2 (5.9 - 8.7)**	**92.8 (91.3 - 94.1)**		50.2 (48.0 - 52.5)	49.8 (47.5 - 52.0)		**14.5 (12.7 - 16.4)**	**85.5 (83.6 - 87.3)**	
Birth spacing	Unique child	**3.7 (2.5 - 5.5)**	**96.3 (94.5 - 97.5)**	**<0.001**	**39.6 (36.3 - 42.9)**	**60.4 (57.1 - 63.7)**	**<0.001**	**10.5 (8.6 - 12.8)**	**89.5 (87.2 - 91.4)**	**<0.001**
	>=24	**9.4 (7.7 - 11.6)**	**90.6 (88.4 - 92.3)**		**58.6 (56.2 - 60.9)**	**41.4 (39.1 - 43.8)**		**17.1 (14.8 - 19.8)**	**82.9 (80.2 - 85.2)**	
	< 24	**15.2 (11.9 - 19.3)**	**84.8 (80.7 - 88.1)**		**42.1 (37.5 - 47.0)**	**57.9 (53.0 - 62.5)**		**33 (27.7 - 38.8)**	**67 (61.2 - 72.3)**	
Mothers height	< 145	**23.3 (18.4 - 29.1)**	**76.7 (70.9 - 81.6)**	**<0.001**	56.4 (49.1 - 63.4)	43.6 (36.6 - 50.9)	0.064	**41.1 (35.2 - 47.2)**	**58.9 (52.8 - 64.8)**	**<0.001**
	>= 145	**6.9 (5.8 - 8.3)**	**93.1 (91.7 - 94.2)**		49.4 (47.4 - 51.4)	50.6 (48.6 - 52.6)		**14.6 (13.1 - 16.3)**	**85.4 (83.7 - 86.9)**	
Number of children under 5y	1	**6.3 (5.0 - 7.9)**	**93.7 (92.1 - 95.0)**	**<0.001**	50.7 (48.1 - 53.3)	49.3 (46.7 - 51.9)	0.075	**12.4 (10.7 - 14.3)**	**87.6 (85.7 - 89.3)**	**<0.001**
	2	**14.9 (12.2 - 18.0)**	**85.1 (82.0 - 87.8)**		44.4 (40.1 - 48.7)	55.6 (51.3 - 59.9)		**33.3 (29.0 - 37.8)**	**66.7 (62.2 - 71.0)**	
	3	**31.1 (17.4 - 49.1)**	**68.9 (50.9 - 82.6)**		57 (36.9 - 75.1)	43 (24.9 - 63.1)		**63.1 (46.8 - 76.8)**	**36.9 (23.2 - 53.2)**	

Table 5. Crude and adjusted odds ratio for maternal OWOB, child stunting and SCOWT

VARIABLES	CATEGORIES	SCOWT		MATERNAL OWOB		STUNTING	
		OR (95% CI)	aOR (95% CI)	OR (95% CI)	aOR (95% CI)	OR (95% CI)	aOR (95% CI)
Food security levels	Food secure	1	1	1	1	1	1
	Mild food insecure	1.31 (0.74 - 2.31)	1.12 (0.60 - 2.10)	1.07 (0.90 - 1.28)	1.10 (0.88 - 1.38)	**1.45 (1.02 - 2.06)**	1.26 (0.88 - 1.82)
	Moderate food insecure	**2.39 (1.36 - 4.21)**	**2.41 (1.24 - 4.68)**	1.08 (0.84 - 1.39)	1.17 (0.88 - 1.55)	**2.02 (1.39 - 2.94)**	1.41 (0.86 - 2.33)
	Severely food insecure	**1.86 (1.10 - 3.15)**	1.11 (0.54 - 2.30)	**0.60 (0.47 - 0.78)**	0.80 (0.55 - 1.15)	**3.70 (2.64 - 5.17)**	1.44 (0.80 - 2.62)
Region	Atlántico	1	1	1	1	1	1
	Oriental	0.87 (0.46 - 1.65)	1.07 (0.48 - 2.38)	**1.43 (1.11 - 1.84)**	0.99 (0.75 - 1.31)	**0.50 (0.33 - 0.76)**	1.08 (0.64 - 1.82)
	Orinoquía and Amazonía	**0.72 (0.56 - 0.92)**	1.05 (0.58 - 1.10)	**1.38 (1.16 - 1.66)**	1.05 (0.83 - 1.31)	1.02 (0.86 - 1.21)	1.21 (0.89 - 1.66)
	Central	1.25 (0.88 - 1.77)	1.22 (0.68 - 2.18)	**1.77 (1.42 - 2.21)**	**1.48 (1.15 - 1.89)**	**0.73 (0.56 - 0.95)**	1.19 (0.83 - 1.68)
	Pacífica	1.05 (0.68 - 1.62)	0.80 (0.35 - 1.80)	**1.69 (1.31 - 2.19)**	**1.32 (0.97 - 1.79)**	**0.58 (0.39 - 0.87)**	0.81 (0.46 - 1.41)
Head of household economic activity	Formally employed	1	1	1		1	1
	Informally employed	**2.30 (1.38 - 3.81)**	1.59 (0.92 - 2.76)	0.99 (0.79 - 1.24)		**2.09 (1.54 - 2.82)**	**1.36 (0.98 - 1.89)**
	Unemployed	1.70 (0.39 - 7.37)	1.39 (0.30 - 6.48)	1.15 (0.65- 2.05)		**3.77 (2.29 - 6.21)**	**2.92 (1.74 - 4.89)**
Size of the household	2 to 4	1	1	1	1	1	1
	5 to 6	**2.11 (1.42 - 3.14)**	**2.49 (1.50 - 4.13)**	1.12 (0.91 - 1.37)	1.02 (0.83 - 1.25)	**1.57 (1.24 - 1.99)**	**1.81 (1.29 - 2.53)**
	7 or more	**2.77 (1.80 - 4.25)**	**3.00 (1.67 - 5.41)**	0.87 (0.72 - 1.05)	0.97 (0.78 - 1.20)	**2.17 (1.65 - 2.86)**	**1.72 (1.16 - 2.54)**
Toilet with sewer connection	Yes	1	1	1	1	1	1
	No	1.10 (0.77 - 1.57)	0.62 (.35 - 1.10)	**0.60 (0.48 - 0.75)**	**0.70 (0.53 - 0.93)**	**2.03 (1.64 - 2.52)**	1.23 (0.85 - 1.77)
Wealth index	Above the mean	1		1	1	1	1
	Below the mean	1.13 (0.81 - 1.56)		**0.65 (0.54 - 0.78)**	**0.77 (0.61 - 0.96)**	**1.96 (1.49 - 2.57)**	1.21 (0.79 - 1.84)
Educational level head of household	Complete secondary and more	1	1	1	1	1	1
	Incomplete secondary school	**1.79 (0.91 - 3.55)**	**1.82 (1.05 - 3.17)**	1.12 (0.80 - 1.58)	1.12 (0.76 - 1.65)	1.26 (0.84 - 1.88)	0.89 (0.54 - 1.47)
	Less than complete primary school	**1.87 (1.01 - 3.44)**	1.25 (0.60 - 2.60)	0.79 (0.58 - 1.07)	0.83 (0.55 - 1.26)	**1.679 (1.20 - 2.34)**	0.83 (0.50 - 1.37)
Educational level mothers	Complete undergraduate and more	1	1	1	1	1	1
	Incomplete undergraduate	0.93 (0.16 - 5.22)	0.24 (0.03 - 1.80)	1.22 (0.14 - 10.47)	1.32 (0.20 - 8.95)	2.47 (0.46 - 13.13)	0.69 (0.09 - 5.29)
	Incomplete secondary school	1.90 (0.36 - 10.04)	0.48 (0.06 - 4.07)	1.19 (0.14 - 10.39)	1.52 (0.24 - 9.66)	3.83 (0.74 - 19.71)	1.23 (0.16 - 9.56)
	Less than complete primary school	2.85 (0.55 - 14.71)	0.37 (0.04 - 3.21)	1.41 (0.16 - 12.20)	1.87 (0.30 - 11.50)	**6.82 (1.34 - 34.80)**	0.10 (0.12 - 8.23)
Women as a head of the household	No	1	1	1		1	1
	Yes	**1.82 (1.25 - 2.65)**	**2.11 (1.22 - 3.64)**	1.12 (0.90 - 1.39)		**1.57 (1.22 - 2.02)**	**1.98 (1.43 - 2.76)**
Number of children under 5y	1	1	1	1	1	1	1
	2	**2.60 (1.85 - 3.67)**	**2.71 (1.57 - 4.68)**	**0.78 (0.61 - 0.98)**	**0.7 (0.53 - 0.93)**	**3.53 (2.68 - 4.65)**	**3.61 (2.40 - 5.45)**
	3	**6.72 (2.944 - 15.34)**	**3.42 (1.28 - 9.12)**	1.29 (0.55 - 2.99)	1.28 (0.50 - 3.23)	**12.08 (5.87 - 24.87)**	**4.66 (1.53 - 14.21)**
Race head of household	None ethnicity identified	1	1	1	1	1	1
	Afro Colombian	0.93 (0.50 - 1.75)	1.02 (0.54 - 1.96)	1.12 (0.89 - 1.40)	1.23 (0.93 - 1.65)	0.79 (0.53 - 1.16)	0.68 (0.41 - 1.13)
	Indigenous	**2.07 (1.48 - 2.90)**	**1.53 (1.01 - 2.32)**	**0.63 (0.48 - 0.82)**	**0.69 (0.51 - 0.92)**	**3.39 (2.61 - 4.40)**	**1.96 (1.30 - 2.96)**
Multiple birth	No	1	1	1	1	1	1
	Yes	**7.67 (2.28 - 25.77)**	**3.42 (1.07 - 10.89)**	1.96 (0.74 - 5.13)	2.00 (0.78 - 5.10)	**6.38 (2.27 - 17.91)**	**2.87 (0.10 - 8.25)**
Sex	Female	1	1	1		1	1
	Male	**1.46 (0.10 - 2.14)**	1.45 (0.98 - 2.15)	1.07 (0.86 - 1.33)		**1.45 (1.12 - 1.89)**	**1.45 (1.11 - 1.88)**

Table 5. (continued)

VARIABLES	CATEGORIES	SCOWT		MATERNAL OWOB		STUNTING	
		OR (95% CI)	aOR (95% CI)	OR (95% CI)	aOR (95% CI)	OR (95% CI)	aOR (95% CI)
Mothers age at birth	18 to 34	1		1	1	1	
	13 to 17	0.81 (0.49 - 1.33)		0.42 (0.32 - 0.54)	0.55 (0.38 - 0.79)	1.22 (0.89 - 1.68)	
	35 to 49	1.43 (0.92 - 2.23)		1.9 (1.53 - 2.37)	1.54 (1.19 - 1.98)	1.15 (0.79 - 1.67)	
Preterm birth	No	1	1	1	1	1	1
	Yes	**1.69 (1.06 - 2.70)**	1.64 (0.99 - 2.71)	0.83 (0.66 - 1.04)	0.89 (0.72 - 1.11)	**2.02 (1.52 - 2.68)**	**1.64 (1.15 - 2.35)**
Birth spacing	Unique child	1	1	1	1	1	1
	>=24	**2.68 (1.71 - 4.22)**	**2.02 (1.20 - 3.38)**	**2.16 (1.84 - 2.54)**	**1.88 (1.47 - 2.40)**	**1.76 (1.32 - 2.34)**	1.03 (0.64 - 1.68)
	< 24	**4.62 (2.93 - 7.29)**	0.98 (0.50 - 1.92)	1.11 (0.89 - 1.38)	1.31 (0.94 - 1.81)	**4.19 (3.05 - 5.75)**	0.10 (0.52 - 1.92)
Mothers height	>= 145	1	1	1	1	1	1
	< 145	**4.08 (2.87 - 5.81)**	**3.92 (2.25 - 6.81)**	**1.32 (0.98 - 1.78)**	1.50 (0.97 - 2.33)	**4.09 (3.12 - 5.36)**	**3.31 (1.94 - 5.66)**

Maternal OWOB aOR were calculated controlling for the variables: Region, Size of the household, Toilet with sewer connection, Wealth index, Educational level head of household, Educational level mothers, Number of children under 5y, Race head of household, Multiple birth, Mothers age at birth, Preterm birth, Birth spacing, Mothers height

SCOWT aOR were calculated controlling for the variables: Region, Head of household economic activity, Size of the household, Toilet with sewer connection, Wealth index, Educational level head of household, Educational level mothers, Women as a head of the household, Number of children under 5y, Race head of household, Multiple birth, sex, Preterm birth, Birth spacing, Mothers height

Child stunting aOR were calculated controlling for the variables: Region, Head of household economic activity, Size of the household, Wealth index, Educational level head of household, Educational level mothers, Women as a head of the household, Number of children under 5y, Race head of household, Multiple birth, sex, Preterm birth, Birth spacing, Mothers height

3.4.1.2 Multivariate Analysis. As shown in Table 5, when adjusting for the different covariates, an increased likelihood of SCOWT remained significant only for moderately food insecure households (aOR: 2.41 – CI: 1.24 - 4.68). In the multivariate analysis, child stunting and maternal OWOB were no longer significantly associated with food insecurity. Hierarchical logistic regression analysis confirmed the positive significant association between moderate food insecurity and SCOWT when adjusted for the three different categories of the social determinants of health (Table 6).

Table 6. Adjusted odd ratios for SCOWT by food insecurity severity levels, controlling for social determinants of health

Variable	SOCIOECONOMIC, CULTURAL, ENVIROMENTAL CONDITIONS		LIVING AND WORKING CONDITIONS		INDIVIDUAL LIFESTYLE FACTORS	
	aOR (95% CI)	P-value	aOR (95% CI)	P-value	aOR (95% CI)	P-value
Food security levels						
Food secure	1.000		1.000		1.000	
Mild food insecure	1.37 (0.77 - 2.42)	0.279	1.11 (0.61 - 1.20)	0.735	1.28 (0.70 - 2.36)	0.42
Moderate food insecure	**2.50 (1.42 - 4.42)**	**0.002**	**2.07 (1.07 - 4.01)**	**0.032**	**2.29 (1.32 - 3.97)**	**0.004**
Severely food insecure	**2.03 (1.22 - 3.39)**	**0.007**	1.18 (0.59 - 2.37)	0.638	1.20 (0.64 - 2.26)	0.568

Socioeconomic, cultural, environmental conditions: food security adjusted for region.
Living and working conditions: food security adjusted for head of household economic activity, size of the household, educational level head of household, women as a head of the household, number of children under 5y, toilet with sewer connection.
Individual lifestyle factors: food security adjusted for Race head of household, Multiple birth, sex, Preterm birth, Birth spacing, Mothers height.

Mothers height < 145 cm had the highest adjusted odds for SCOWT, increasing its occurrence by almost four times when compared to mothers that had a height > 145 cm (aOR: 3.92 – CI: 2.25 - 6.81), followed by multiple births (aOR: 3.42 – CI: 1.07 - 10.89), and for households having three or more children under five (aOR: 3.42 – CI: 1.28 - 9.12). These variables were also associated with a highest occurrence of child stunting.

SCOWT was more likely to occur in households with the following characteristics: more than seven members (aOR: 3.00 – CI: 1.67 - 5.41); women as head of the household (aOR: 2.11 – CI: 1.22 - 3.64); an indigenous head of the household (aOR: 1.53 – CI: 1.01 - 2.32); child birth spacing more than 24 months (aOR: 2.02 – CI: 1.20 - 3.38). Although being indigenous increased the presence for both SCOWT and stunting, this characteristic was also associated with a lower likelihood of maternal OWOB. The presence of a toilet without sewer connection and a wealth index below the mean also decreased the likelihood of maternal OWOB.

3.5 Discussion

In this study, the coexistence of child stunting and maternal OWOB was found in 7.8% of the rural households. This finding is higher than a previously reported national prevalence of SCOWT of 5.1% (Sarmiento et al., 2014), and in line with evidence showing that in countries such as Colombia, the rural areas have a higher prevalence of SCOWT (Garrett & Ruel, 2005).

The existence of SCOWT in the rural areas could be explained by the persistent prevalence of stunting. Although stunting has historically been higher than in the urban areas, the increasing presence of overweight/obesity in rural areas has reduced the gap between urban and rural areas (Jaacks et al., 2015; MSPS et al., 2019; NCD-RisC, 2019). This gap reduction is supported by published data from the ENSIN (2015) which showed that in the adult population the difference in the prevalence of OWOB between the urban and the rural areas decreased from 6.5% in 2005 to 4.8% in 2015. More concerning is that by 2015, in women of childbearing age, OWOB was 0.9% higher in rural than in urban areas (MSPS et al., 2019). Jaakcs et at (2015) found that the OWOB prevalence was increasing at a higher rate in rural women aged 19-49 years than in their urban counterparts in most low and middle-income countries, including Colombia. In the present study, rural maternal OWOB was found in almost half (49.8%) of the

households. The current research findings provide further support for rising OWOB rates among rural Colombian women, which needs to be urgently addressed.

According to Dieffenbach & Stein (2012), the coexistence of an OWOB mother and a stunted child is the result of their independent existence in the general population, which can be attributed to the increasing rate of maternal OWOB. This phenomenon was previously hypothesized by Jehn & Brewis (2009), who suggested that SCOWT, overweight, and undernutrition shared the same determinants. It is important to point out, however, that the rising rates of maternal OWOB do not appear to occur evenly across the whole population (Jaakcs et at., 2015). Thus, there seem to be factors that increased the occurrence of SCOWT, which do not show an association solely with overweight and stunting. As such, moderate food insecurity in the present study showed an association with SCOWT but not with stunting and overweight alone.

After controlling for various covariates, the results of the present research support the hypothesis that food insecurity is associated to the double burden of malnutrition in Colombian rural households. The positive association between these two phenomena was also found in Brazil (Gubert et al., 2017) and in Indonesia (Mahmudiono et al., 2018). The Brazilian study, however, found this association only with severe food insecure households whereas the Indonesian study showed the association with all severity levels of food insecurity. Such discrepancies regarding the severity level of food insecurity with respect to SCOWT might be explained by a variety of factors. For instance, Gubert et al., (2017) analyzed nationally representative data of both urban and rural areas in Brazil, while Mahmudiono et al., (2018) used a sample from Indonesian urban settings with high prevalence of underweight. Taken together, the above findings suggest that the coping mechanisms adopted to deal with food insecurity and

its consequences might be due to the differences between urban and rural environments. In rural Colombia, the lack of an association between severe food insecure households and SCOWT could be accounted for by the lower prevalence of maternal OWOB among this severity level. Conversely, the Brazilian study reported that severe food insecure households had a slightly higher prevalence of maternal OWOB than all other food security categories (Gubert et al., 2017). Similar results in Brazil were reported by Conde & Monteiro (2014), who found that both the lowest and the highest household income quintiles had the highest prevalence of obesity. Furthermore, evidence indicates that women with lower socioeconomic status had a higher occurrence of obesity in countries with a higher Gross National Product (GDP) (Monteiro et al., 2004). Thus, one factor that could explain the lower prevalence of maternal overweight in severe food insecure Colombian households when compared to their Brazilian counterparts is the higher GDP in Brazil (The World Bank Group, 2019). Consequently, it is conceivable that severe food insecure households in rural Colombia are experiencing an early stage of the nutritional transition whereby high energy dense foods are not yet highly accessible.

Since severe food insecure households experienced hunger, the present finding of higher prevalence of child stunting together with a lower prevalence of maternal overweight/obesity was expected. Despite lower prevalence of child stunting in mild food insecure households, which experience impaired food quality, these households also showed high presence of maternal OWOB. Accordingly, it appears that SCOWT occurs in moderate food insecure households as these households suffer from both impaired food quality and quantity. This observation is supported by the findings of Lee et al. (2012), who found that the middle consumption quintile increased the likelihood of a household with SCOWT in Guatemala. In moderate food insecure households, the occurrence of child stunting could be explained by a diet

lacking in nutrient density and diversity and insufficient food consumption. Conversely, the presence of maternal OWOB might be due to excessive intake of highly available calorie dense foods specifically by the mothers as only 2% of children were both stunted and overweight. Such differential intra-household food distribution has been observed previously to be associated to the double burden of malnutrition (Wibowo et al., 2015).

There are underlying factors that determine the consumption of unhealthy diets. For instance, food system transformations have been characterized by an increased production and access of energy dense, ultra-processed foods including in rural areas (Popkin & Reardon, 2018). It appears that such processed, carbohydrate-rich foods have become more available to small farmers in Colombian rural areas (NCD-RisC, 2019). Moreover, such changes in food systems and industrialization can also lead to universalization of television and greater sedentarism (Freire et al., 2014), which can contribute to the increasing rates of overweight in rural areas.

3.5.1 Living and Working Conditions Associated to SCOWT

In this study households with low educational levels, with two or more children under five years of age, and with five or more members, had an increased likelihood of SCOWT. These associations have been found in previous studies (Das et al., 2019; Gubert et al., 2017; Kroker-Lobos et al., 2014; Lee et al., 2012; Oddo et al., 2012). Likewise, we found that a female head of household increased the occurrence of this phenomenon, which to the best of our knowledge has not been previously reported. These results highlight the importance of education in promoting healthy growth in children and preventing excessive weight gain in mothers. Moreover, having more children and more household members might increase the difficulty for the parents to provide adequate care practices and could also lead to less available food per family member. On the other hand, where the woman was the head of the household, it is highly probable that,

besides taking care of the usual domestic tasks, the woman needs to work to maintain the family, putting the mother and her child in a more vulnerable position. Taken together, all of the above factors can compromise the personal care practices of the mother, which might contribute to her increased risk of excessive weight gain.

3.5.2 Individual and Lifestyle Factors Associated to SCOWT

Low mother´s height was a significantly strong determinant for SCOWT, which is in line with previous literature (Doak et al., 2016; Oddo et al., 2012). The latter association that might be driven by the significant relationship of lower maternal height with child stunting (Addo et al., 2013; Felisbino-Mendes et al., 2014; Ferreira et al., 2008; Hernández-Díaz et al., 1999; Özaltin et al., 2010; Varela-Silva et al., 2009). Such relationships are suggestive of intergenerational mother to child transmission of low height, which could be influenced by genetics, sharing the same poverty conditions, epigenetic and metabolic changes, and impaired fetal growth due to reduced intrauterine space (Martorell & Zongrone, 2012). Moreover, the strong association of low mother´s height with SCOWT might be also due to the association of low height with overweight (Ferreira et al., 2008; Sichieri et al., 2003), which can be explained by the reduced energy requirements in these individuals that can easily be exceeded (Sawaya & Roberts, 2003). Furthermore, low maternal height is the outcome of chronic undernutrition in infancy, which is associated with overweight later in life, since stunted children seem to be more susceptible to gain more fat than lean mass (Martins et al., 2004).

The SCOWT pairs represent a concern due to their vulnerability to chronic diseases, as these are associated not only with excessive weight, but also with low height (Adair et al., 2013; Ferreira et al., 2008; Reinhardt & Fanzo, 2014; Wittenbecher et al., 2019). This phenomenon can place children at a higher health risk, since they are stunted and more likely to develop

overweight, particularly if raised in an obesogenic environment. Consequently, special attention should be given to this demographic to promote adequate linear growth and avoid excessive weight gain, and so decrease chronic disease risk (Barker et al., 2002, 2010).

In the present study, another factor related to the occurrence of SCOWT was the birth spacing of the target child above 24 months with siblings, which might be determined by the association of this factor with maternal overweight. Weight gain during and after pregnancy should be investigated among this population to better understand this association.

Indigenous households, which had higher odds for SCOWT, were also significantly associated with an increasing occurrence of child stunting and a decreasing occurrence of maternal overweight. This observation, which is in line with findings by Lee et al. (2012), could suggest that the occurrence of SCOWT is a reflection of nutritional transition, which not all indigenous households may be experiencing equally. Further research is needed within indigenous populations to identify specific factors involved for this possible nutritional transition.

The findings of the present research reinforce the need for implementation of rural public health and food security programs to address the social determinants of health to reduce the presence of SCOWT. Likewise, the coverage of such programs should include those households vulnerable to food insecurity, which would contribute to achieve the second Sustainable Development Goal (Zero Hunger) and so reduce all forms of malnutrition, provide opportunities for the countryside transformation and development, and sustaining the Colombian peace. Moreover, additional longitudinal, experimental, and qualitative studies are needed to better understand this association and its causality, including the role of diet to determine dietary patterns within households and taking into consideration intrahousehold food distribution. All

efforts should be taking to avoid the growing prevalence of overweight and obesity and its coexistence with undernutrition, especially in the rural areas, where access to adequate health care is limited.

3.6 Limitations

Although this research provides insight of an understudied issue, causality cannot be established. Moreover, the ELCSA scale questions referred to a period of 30 days, which might not reflect long term interactions between variables. Furthermore, since the ELCSA scale is only answered by one member of the household, individual experiences were not contemplated.

Additionally, there were some variables that could not be included in this research as they were only present in a reduced number of pairs ($n < 1000$), such as breast-feeding, physical activity, and dietary variables, which would have allowed amplifying the analysis of individual factors for the presence of SCOWT.

3.7 Conclusions

Colombian rural areas are highly vulnerable to food insecurity and its consequences, such as SCOWT. The association between different severity levels of food insecurity and SCOWT was significant in moderate food-insecure households. Other factors associated with SCOWT were low mother's height, mothers with multiple births, households with three or more children under five, households with more than seven members, women as head of the household, indigenous head of the household, and childbirth spacing more than 24 months. There is an urgent need to address these factors to prevent the increase of SCOWT in Colombian rural areas.

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Chapter 4. Final Conclusions and Summary

Vulnerable populations, such as food insecure inhabitants of Colombian rural areas, are not exempt from the worldwide concern of increasing OWOB rates. Furthermore, children from these areas have higher stunting rates than urban children. Unsurprisingly, the present research reports that the prevalence of DBM, represented as SCOWT, is higher in rural settings than previously reported in a national study (Sarmiento et al., 2014).

The existence of SCOWT might be driven by the increasing OWOB rates in regions where the child stunting prevalence is still high. This phenomenon, however, does not occur randomly across the population, as the risk is increasing in response to an array of individual factors and social determinants of health, including food insecurity.

This research uncovers that SCOWT is a problem among moderately food insecure households in rural Colombia. Therefore, since moderate food insecurity implicates impaired food quantity and quality, these results reinforce the need to increase awareness regarding the importance of overcoming food insecurity beyond hunger satisfaction to prevent all forms of malnutrition. Consequently, all food security programs should extend their scope, including double-duty actions, i.e., those that simultaneously address undernutrition, obesity, and diet-related non-communicable diseases (Hawkes et al., 2020). These actions are of paramount importance in developing countries and particularly in their rural areas, where food system transformations are rapidly occurring.

Food system transformations could negatively alter diets as they provide access to low-cost ultra-processed foods. Consequently, households with the most vulnerable social-economic conditions can be at greater risk of its effects. According to Popkin et al. (2020), SCOWT might

be one of these effects. The current research results are in line with this assertion since the lowest socio-economic conditions had a higher likelihood of SCOWT.

Besides moderate food insecurity, the living and working conditions that significantly increased the likelihood for SCOWT were low educational levels, the presence of two or more children under five years of age, five or more household members, and having a female head of household. Meanwhile, the individual factors that increased the occurrence of SCOWT were short stature in mothers and an indigenous head of the household.

These results highlight the need to reinforce rural food security and public health programs, in which the living and working conditions must be addressed to improve access to healthy diets, especially among populations more vulnerable to poverty such as indigenous people. These actions should be sustainable to interrupt the intergenerational malnutrition cycle. Furthermore, it is important to recognize the role of family planning programs in reducing the double burden of malnutrition.

Actions developed to fight food insecurity and all forms of malnutrition could contribute to: (a) sustaining Colombian peace; (b) providing opportunities for countryside transformation and development; and (c) reaching the second Sustainable Development Goal (i.e., to achieve zero hunger through food security, improved nutrition, and sustainable agriculture) (UN, n.d.).

Finally, researchers should consider further studies exploring feeding practices and intra-household food distribution in food-insecure households, studying food choices among inhabitants of the Colombian rural areas, and how food system transformations are affecting such populations. Likewise, applied research could substantially contribute to reducing food insecurity and SCOWT through implementing sustainable healthy diets in these areas that due to their close relationship to food production should have the potential means to overcome food insecurity.

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