Overweight and obesity in elementary schools in three villages of El Progreso, Guatemala

by

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Abstract

Introduction: Childhood obesity is a principal concern worldwide. There is limited information in Guatemala on risk factors for obesity in relation to school environments. The purposes of this study was to characterize the food environment around schools, and to assess if the prevalence of overweight and obesity in children is associated with schools.

Methods: A cross-sectional study was conducted in four rural public schools within three villages of El Progreso, a Department of Guatemala. Anthropometric measures and sociodemographic information for 398 schoolchildren and their mothers was collected in 2018. Environmental audits of food outlets and food advertisements were completed for a 500 meter buffer around schools. One-way ANOVA was used to compare schools for overweight and obesity and variables regarding the food environment. Fisher's Least Significant Difference post hoc tests were used to examine differences by schools. Last, a logistic regression was used to examine the mean differences between schools on overweight and obesity, adjusted for household income, child sex, and maternal education and age.

Results: The overall percentage of overweight and obesity, ranged from 8.5% to 38.8% among the four schools. ANOVA showed a statistically significant difference between schools for overweight and obesity ($p=0.039$) and in the distance of food outlets ($p=0.001$) and food advertisements ($p<0.001$). The Fisher's LSD test showed that school 2 had significantly lower prevalence of overweight and obesity than school 1 (M=-0.17, 95%CI: -0.31, -0.03), and school 3 (M=-0.197, 95%CI: -0.34, -0.06). Logistic regression showed that schools are associated with overweight and obesity ($p=0.043$), when adjusting for household income, child sex, and maternal

education and age. A higher percentage of food outlets within 100 meters was found around school 1 (45.9%), followed by school 3 (42.6%), while a higher percentage of food advertisements was found within 300 meters of school 2 (50.0%). Overall, poor quality unhealthy foods were predominant and proximal to schools.

Conclusion: More research is needed on obesity prevention in Guatemala—especially in rural communities—to enhance the creation and implementation of health and nutrition policies that promote healthy food environments around elementary schools.

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Chapter 1 - Literature Review

The double burden of malnutrition (DBM) is a reality worldwide and has increased in recent decades (1). The DBM refers to the presence of overweight or obesity and undernutrition in one population group often within one household (2). Popkin, Corvalan, and Grummer-Strawn (2020) indicate that the prevalence of DBM is principally high in sub-Saharan Africa, east and south Asia, and the Pacific, while improvements have been observed in the Middle East, North Africa, and Latin America (2).

Even though most countries have seen a decrease in childhood stunting, the prevalence of overweight and obesity has increased, especially among women of reproductive age (2). It appears that the obesity epidemic started in high-income countries between the years 1970 and 1980. However, since then, it has begun to affect many low- and middle-income countries, both adults and children, particularly in urban settings. But rural areas have also been affected by this epidemic (3).

The World Health Organization (WHO) states that childhood obesity is one of the biggest public health challenges of the century. In 2016, more than 41 million children under five years of age were classified as overweight by Body Mass Index (BMI) worldwide (4). Global childhood overweight and obesity have increased in recent years, and Latin America is no exception. The Pan American Health Organization (PAHO) estimated that the prevalence of overweight in children in Latin America and the Caribbean (LAC) increased from 6.2% in 1990 to 7.5% in 2018. This prevalence corresponds to approximately 4 million children less than five years of age who suffer from overweight in the Region. Despite efforts to prevent overweight and obesity in the LAC, the prevalence of overweight is higher than the global rate, which is 5.9% (5). Children who have been overweight and obese since the early stages of their lives, are

more likely to continue suffering from overweight or obesity during adulthood, and they are more prone to develop noncommunicable chronic diseases like cardiovascular diseases, type 2 diabetes, hypertension, and cancer at younger ages as compared with normal weight status (4).

The driving factors for this epidemic are an interaction between behavioral and environmental factors across different levels of the socioecological model. The diet patterns of the region started to change in 1980 (6). Around this same time, there was an increase in ultra-processed food consumption, along with a reduction in physical activity (6). Changes in transportation systems, aspects of employment, food demand and supply, foreign investment, infrastructure, and urbanization are among some other factors that could have contributed to this phenomenon (6, 7). The various environments that exist within a country or community can help to moderate the effects of the obesity epidemic because they hold opportunities to promote or exclude behaviors that play important roles in obesity prevention (3). To change individual behavior, it is necessary to address the context in which people live and make decisions. For this reason, it is necessary to create healthy food environments (8-10).

All the economic, political, and physical circumstances that determine patterns of dietary intake, weight, and some other related health outcomes are defined as the food environment (11). The International Network for Food and Obesity/non-communicable diseases Research, Monitoring and Action Support (INFORMAS) defines healthy food environments as the places where beverages, meals, and foods that are part of a population diet meet the national dietary guidelines, are accessible, available and widely promoted (10). In contrast, unhealthy food environments promote unhealthy diets that are high in energy-dense foods, leading to unhealthy weight gain and non-communicable diseases (10).

As described by Swinburn and colleagues (2013), food environments have four main components (Figure 1) that are influenced by the food industry, governments, and society. Furthermore, there are interactions between these components at different levels, through science funding, policymaking, agenda-setting, and lobbying. The private food industry creates almost all the food supply in communities. The food industry also determines a considerable proportion of food availability, quality, and price, promoting the consumption of mostly processed and ultra-processed foods. Additionally, the food industry also influences beliefs and social norms related to food. Governments can impact food prices, health promotion, social marketing, and social norms by creating policies, laws, or regulations that indicate how both public and private sectors should operate. The cultural norms that are related to food are established by the traditions, and religious and cultural practices of every society. Individual habits and preferences, household income, and level of education also determine people's diets (10, 11).

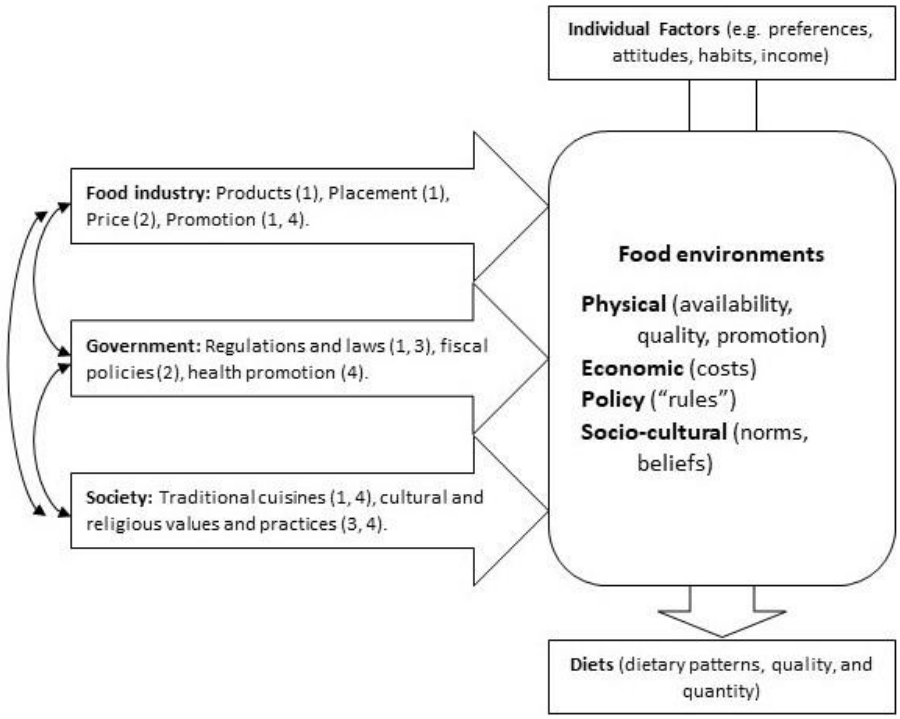

Figure 1 Food environments and their main components. Adapted from Swinburn, et al. 2013. (10: p.3)

The International Network for Food and Obesity/non-communicable diseases Research, Monitoring and Action Support (INFORMAS) designed a framework (Figure 2) to understand and study the food environment, dividing it into seven categories that independently influence dietary patterns, nutritional status, and other health outcomes (10, 11).

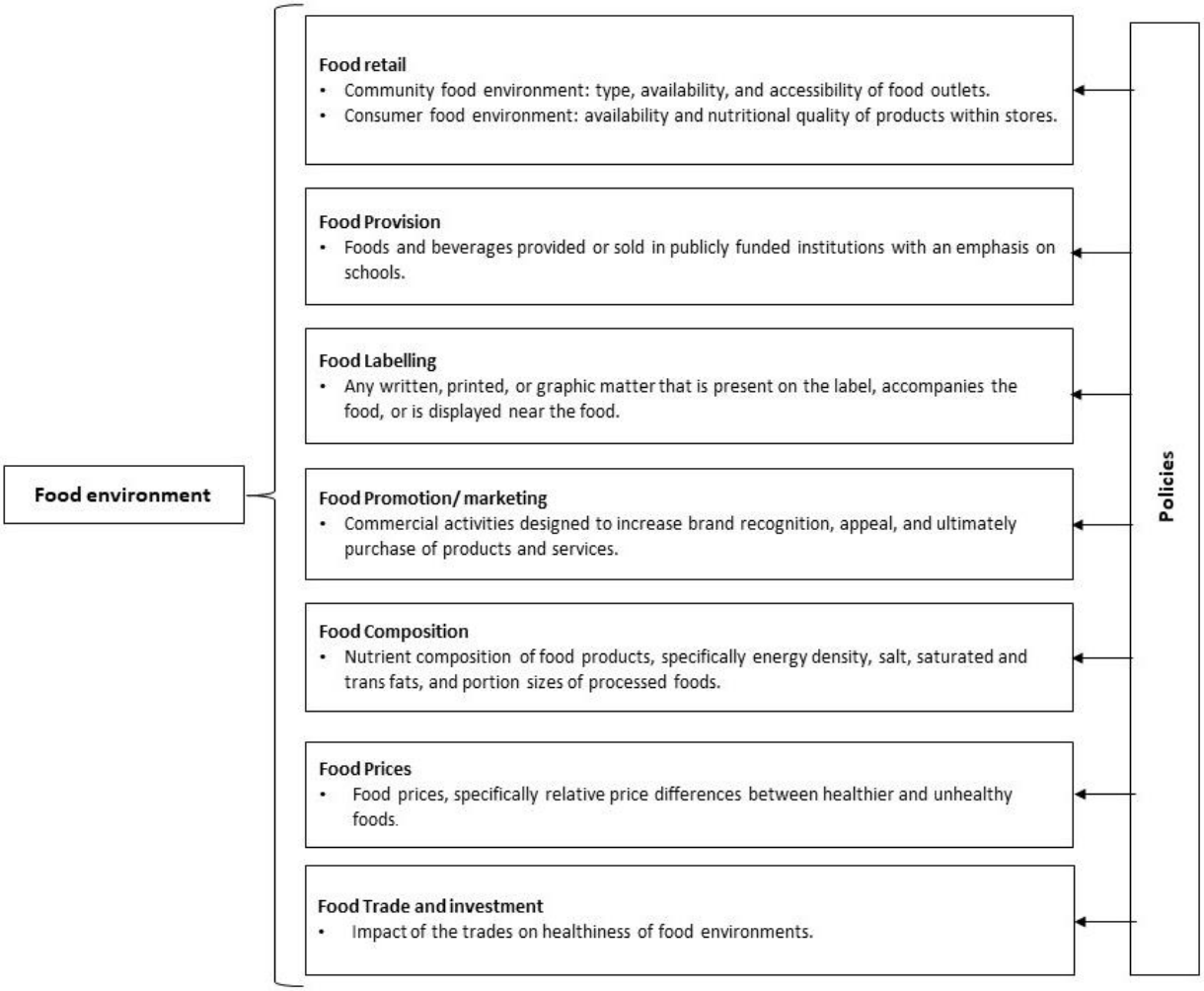

Figure 2 Food environment framework. Adapted from Perez-Ferrer, et al. 2019. (11: p. 3448)

The food environment determines the food options that are available for people in general (12). However, if the environment promotes the intake of high-energy, and low nutrient foods, it can be considered like an obesogenic environment, likely to increase obesity risk (13). Several

studies have shown that less healthful diets and adolescent overweight are related to environments with closer proximity to and availability of lower cost fast-food outlets. Powell et al. suggested that an increase of 10% in the costs of a fast-food meals is associated with 3% increases in the probability of eating more fruits and vegetables, decreases of 0.4% in body mass indexes (BMI), and decreases of 5.9% in the probability of having overweight (14).

Dietary changes have been observed in national, local, school, and household food environments (15). Children spend a great proportion of their time in school. Therefore, schools can help to promote healthy eating habits to children and create healthy food environments by teaching and students to practice lifelong skills for active living and healthy eating (16).

Guatemala

Guatemala is a pluricultural and multilingual country located in Central America. It is privileged because it has a variety of vegetation, rivers, volcanos, lakes, flora, and fauna. It is easy to farm vegetables, legumes, and fruits which serve national consumption and exportation. Unfortunately, due to excessive increases in the population, poverty is rising, especially in rural areas. As a result, it is harder for people to satisfy their necessities like health, food, education, drinking water, food, among others, causing a higher risk of suffering infectious and deficiency diseases (17). According to the VI National Survey of Maternal and Child Health 2014-2015 the national rate of stunting children in Guatemala is 47 percent, and the worse cases are in children between 18 and 23 months of age. Five of every10 kids are short for their age (17). The stunting prevalence in Guatemala is the highest in Latin America, and the second highest rate in the world (18).

In most countries of Latin America, overweight and obesity have rapidly increased, and are related to radical changes in physical activity and dietary patterns as well as obesogenic

environments (18). According to a study published by Mazariegos et.al. where they analyzed data from the Guatemalan 2014–2015 National Maternal and Child Health Survey (ENSMI), the national prevalence of overweight and obesity among children was 4.9%, while the prevalence among adolescent girls was 28.4%, and 56.6% for women of reproductive ages (19). The Guatemalan 2015 World Health Survey to Schoolchildren reported that 29.39% of schoolchildren had overweight and 8.40% had obesity (20). Past studies have found a higher prevalence of DBM in indigenous populations compared with non-indigenous, and at both household and individual levels (18).

Guatemala and the school food environment

Guatemala has seen a rapid increase in the casetas (food kiosks) since the early 1970s, due to changes in political climate (21). Casetas are usually offer products mainly influenced by multinational companies that reflect a more urban idea. Urban residents have changed from traditional foods to more western foods like fried chicken, chips, and sodas (21). Even though it is common to see more traditional foods at a household level, at schools is more common to find fast food from casetas. The food kiosks are located inside the school grounds and are one of the four sources of food for children in public elementary schools (21).

A second source is the refacción or snack. It is a school program that provides food to children at no cost. The program began in 1959 and was used to provide rations of powdered milk and wheat to students. In 1986, the program grew and started to provide fortified cookies to all students from rural and urban schools (21). Since then, the program has been modified a few more times. In 2017, a new law regulating food in schools was approved. With this new law, The Ministry of Education (MINEDUC) assigned a minimum of four quetzales (Q.), approximately

0.51 dollars per day, for each student attending public schools, in order to provide a daily meal that includes all groups of foods (22).

The other two food sources in schools come from foods that are brought from home or purchased on the street. Usually, mothers provide packed school snacks for children (21). However, today, it is more common for children to buy food from the school casetas or street vendors because modern life has led to parents having less time to prepare food for their kids (21).

Schools have been identified as valuable places to implement interventions for childhood obesity. However, there are few school-based interventions implemented in LMICs, and Guatemala is no exception. To date, there is limited research literature published related to the school food environment in Guatemala. Reports, action plans, and educational materials encouraging the improvement of the food environment are among the literature that has been published in Central America related to the subject, but only a few have been put into action (21).

The study conducted by the INCAP Research Center for the Prevention of Chronic Diseases (CIIPEC) and the Human Nutrition Division of the John Hopkins Bloomberg School of Public Health evaluated the school food environment in low-income Guatemalan elementary schools and considered the potential impact on both overweight/obesity and undernutrition. This study showed that Guatemalan elementary schools offer limited options of fruits and vegetables, and a wide range of energy dense snacks and sugar sweetened beverages. Research has shown that availability of energy dense foods and sugar sweetened beverages leads to increased consumption of these type of products (21). In Guatemala, children have shown preference for energy dense snacks because they enjoy the flavor and are used to eating them (23). In order to

prevent the continued increase in the prevalence of childhood obesity, there is a need for policies focused on improving nutrition within school food programs (21).

The food environment around schools

Food outlets

The food environment in school neighborhoods has changed in the last few years. Governments and health institutions have identified schools as critical environments for health promotion. However, in Latin America, most efforts have been focused on research describing the food environment within schools. In comparison, the food environment around the school has been understudied (24). Results of research conducted in the United States have suggested that the consequences of the obesogenic environment are worse in neighborhoods where unhealthy products are more accessible for children (25). In the majority of cases less healthy foods and beverages are conveniently available outside the school ground and are frequently allocated within a short walking distance (26).

As previously mentioned, food outlets are considered determinants of health outcomes and dietary behaviors. Evidence that has emerged in some developed countries regarding the association between food environments and health outcomes has led to implementing initiatives to improve the food environment. For example, in Detroit, Michigan, a zoning code forbade the construction of fast-food restaurants within 500 feet of all elementary, junior, and senior high schools. Another example is the “Green Food Zones” in South Korea. This initiative restricts the sale of unhealthy foods within a 200 meter radius around schools (27). However, only limited research has been conducted related to the food environment around schools in Latin America.

One study used the 2010 Goods and Service Inventory (GASI) to evaluate the food environments in an 800 meter buffer around schools in three school neighborhoods in

Guadalajara, Puerto Vallarta, and Mexico City (24). GASI is an instrument used to record the places where goods and services can be obtained, like fast-food chains, supermarkets, grocery stores, convenience stores (28). Research assistants recorded the number of food outlets found within the buffer area. The results showed a lower number of supermarkets and grocery stores in Guadalajara and Puerto Vallarta. While in Mexico City a higher number of grocery stores and supermarkets in the school neighborhoods were found (24). While this study did a good job of describing the food environment around schools, it did not examine the connection between the food environment around schools and the nutritional status of children.

During 2012–2013, a cross-sectional study was conducted in Cuernavaca and Guadalajara, Mexico, in 60 elementary schools. These cities were chosen because there is a high prevalence of overweight and obesity in schoolchildren (31.8% in Cuernavaca- and 37.0% in Guadalajara) (26). The study aimed to characterize the association between the local food environment around elementary schools and childrens' body mass index (BMI). Researchers collected information regarding the environment within a 100 meter buffer around school gates, and used anthropometric measures to determine the BMIs. Food outlets were classified into three categories: mobile food vendors, food stores (convenience stores, super, and minimarkets), and food establishments like fast-food restaurants, cafeterias, restaurants, temporary street food stands, and other establishments (poultry markets, bakeries, ice cream). Results showed a higher number of mobile food vendors near public schools as compared with private schools. They also found positive associations between the number of mobile food vendors and mean BMI of schoolchildren. The authors compared whether there were differences between public and private schools. Even though they found more retail food sources within public schools, BMIs were not statistically different(26).

According to Elbel et al. (2020), previous research has explored associations between food environment and childhood overweight/obesity, and has not found many statistically significant relationships. The authors mentioned that the available studies where there were statistically significant results, showed correlations between obesity and proximity to fast-food restaurants. However, these studies had limitations, such as the consideration of only short distances (0.1 miles or 160 meters). Many of these studies have only evaluated urban areas, and only a few have considered the food environment around childrens' homes. Based on these limitations, the authors decided to examine access to food outlets around childrens' homes in New York City and whether there was an association with childrens' BMIs (29). The sample consisted of 3,507,542 students enrolled in grades Kindergarten to 12th. The authors measured the childrens' BMIs and the food outlets, classifying them as healthy or unhealthy within a buffer of 0.1 miles or less around the residences. Overall, the kids who lived closer (<0.025 miles) to fast-food restaurants, were 37% more likely to have overweight or obesity. When evaluating corner stores, similar results were found. Children who lived closer to corner stores had poorer weight outcomes as compared with children who lived further away. On the other side, researchers did not find statistical significance when examining associations between distance from supermarkets and wait-service restaurants and obesity because children and adolescents visit 3 times less this type of places as compared to fast-food restaurants (29).

Another study conducted by the same authors in New York City from 2009–2013 with a sample of 1,114,010 student-year observations, evaluated the relationship between food outlets and the risk of obesity among adolescents. It is more common that adolescents have more freedom of motion as compared with younger children. Also, they assumed older students had more money to purchase from food outlets near their schools. For those reasons, the authors

chose to evaluate adolescents from 9th to 12th grades in public schools. The authors measured the exposure to food outlets like restaurants, corner stores, wait-service restaurants, and supermarkets in a buffer of 0.5 miles around schools. To determine the nutritional status of adolescents, they used BMI percentiles. The results showed that 89% of students could find the nearest food outlet within <0.25 miles of schools, and most of these food outlets (54.5%) were fast-food restaurants or wait-service restaurants. However, authors observed statistical significance in that students were more likely to have obesity if they attended schools located nearest to corner stores (16.2%; 95% CI: 16.0, 16.4) compared to fast-food restaurants (15.2%; 95% CI: 15.0, 15.3) and wait-service restaurants (15.5%; 95% CI: 15.2, 15.8) (30).

On the other hand, researchers did not find a difference between corner stores and supermarkets, probably because of insufficient variation in childrens' closeness to supermarkets. These results are consistent with the authors' previous work, where they found that close distances to corner stores and fast-food restaurants around students' residences had a positive association with childhood obesity. Even though both food outlets sell less healthful options and more energy-dense and nutrient-poor products, adolescents may visit corner stores more frequently, thus potentially increasing unhealthy snacking behaviors among students (30).

In 2015, the Department of Epidemiology at Johns Hopkins Bloomberg School of Public Health conducted a systematic review identifying studies from the United States and Canada that evaluated the association with obesity and local food environments. Besides examining this relationship, the authors wanted to assess the quality of the studies that had been published (31). The search of the published literature included both print articles and studies published online from January 1st, 1990, to December 31st, 2013. There were71 studies that met the inclusion criteria, but only 22 that included children. Another finding was that the quality of the

information varied broadly. Of the 22 studies, 21 showed associations between individual food outlets and obesity. Seven studies found at least one positive association between the availability of convenience stores and obesity, no negative associations were found, and the rest of studies showed null associations. However, when assessing the fast-food outlets, the results were more ambiguous, three studies found a positive association between fast-food and obesity, and three studies found negative associations. In low-income areas, fast-food availability was more consistently related to obesity as compared with supermarkets and convenience stores. There was no evidence of a relationship between childhood obesity and the availability of supermarkets. But the authors of the systematic review found some evidence of a positive association between childhood obesity and the availability of convenience stores. Despite the recent increase in the volume of research related to the topic, the evidence that examines associations between obesity and the food environment has not strengthened. It could be related to the fact that the studies have many inconsistencies. For example, there is no clear definition of rural or urban areas, and many studies did not mention whether they controlled for potential confounders (31).

Holsten conducted a systematic review to examine the association between obesity and the consumer food environment. The review included seven studies, and five showed a significant association between consumer food environment and obesity. However, several limitations were discussed, all had cross-sectional designs, and most of the studies analyzed secondary data that limited the collection of data about the variables under study. Also, some data sets were too large, which made difficult a small-scale analysis. In addition, multiple databases had different data collection periods that could led to erroneous assumptions of the dynamic of the food environment and BMI. Another area of concern is that some of these studies did not provide a clear explanation of how confounding variables, such as

sociodemographic characteristics or physical activities, were controlled for. Only two studies evaluated children, and these studies limited their measurements of the food environment to the environment inside schools, not around schools (32).

A cohort study using data from the US Early Childhood Longitudinal Study (1998–2007) examined the relationship between childhood obesity and residential food environments. The authors found that reduced exposure to full-service restaurants, beverages stores, retail bakeries, and fruit/vegetable markets was in general obesogenic, but the statistical significance varied by gender and urbanicity of the residence. This study divided the homes as urban, suburban, and rural and found an increased obesity risk when there was less exposure to fruit/vegetable markets in urban children, beverage stores in suburban kids, and healthy food stores in rural children. They also found a positive association with obesity in girls when exposure to full-service restaurants was high (33).

Another cohort study in Sweden followed-up for six years with 484,677 boys and 459,810 girls aged 0–14 years. The results showed increase odds of childhood obesity if children lived in neighborhoods with more access to fast-food outlets (34). Even though, these were cohort studies and contributed to the evidence related to food environment and childhood obesity, they did not evaluate the food environment around schools.

Another systematic review from Canada found only 17 studies related to retail food outlets. Only four assessed children or adolescents. All the articles had cross-sectional designs, and only eight of them evaluated the association of food environments and BMI. Relative measures of exposure to unhealthy food outlets were associated with a BMI six times higher compared to those who were expose to healthier food outlets. However, the authors found several limitations in the studies. Besides the cross-sectional nature of all the research studies,

the weight and height were frequently self-reported. Also, there is no standard for validating food outlets datasets in Canada, which is an important aspect the authors mentioned because there is no information about the opening and closure of food outlets, which can influence the measures (35). Neither of these systematic reviews discussed information about the food environments around schools, and both included few studies in children.

A multi-country cross-sectional study that included 10,008 adults between 16–66 years of age, from 14 cities and ten countries intended to evaluate the relationship between neighborhood-built environment and proximity of food outlets, with overweight and obesity. The participants' self-reported closeness to three types of food outlets (supermarkets, other food/grocery stores, and restaurants). But due to variations across countries, the food environment was measured by the perceived proximity of food outlets. Results showed that Hong Kong was the country with the lowest proportion of overweight and obesity in both men and women, while Cuernavaca, Mexico had the highest proportion. Another finding was that living farther away o restaurants was related to less likelihood of overweight and obesity in males. For women, the only significant association was found in the distance to public transportation stops, where living close to public transportation stops was associated with higher BMI (36).

A systematic review protocol has been registered, and the authors plan to explore the association between local food environments and obesity in four countries: UK, Ireland, Australia, and New Zealand (37). However, the results have not been published yet. But there is no mention of anything related to the food environment around schools in the protocol.

Several studies in the United States assess the relationship between food environments around schools and childhood overweight and obesity. A study conducted using data from California found a lower prevalence of obesity among boys than girls. The same study found that

obesity was higher among Hispanic kids, followed by black children, then white children and the lowest prevalence was among Asian kids (25). Another study that followed-up children in Baltimore, where 87% percent of the sample were black kids and 46% were male, low income and lived-in urban areas, suggested that if healthy food outlets were found along the school path (100 meter buffer), the lower was the BMI (38). Aligned with these results, another study conducted in California found that adolescents who had access to fast-food restaurants near their schools were more likely to have overweight or obesity. These results were only significant for fast-food restaurants (39). A study conducted with information from adolescents in the United States found that higher availability of chain supermarkets was significantly related to lower BMI in adolescents. In contrast, the increased availability of convenience stores was significantly associated with higher BMI in the same sample. They found a stronger association between supermarket availability and weight status among African American adolescents compared to Hispanic or white adolescents. Another finding in this research is that in households where the mothers worked full time, adolescents had higher BMIs (40).

An ecological study from California, found that the existence of convenience stores within 10-minute walking distance from schools was related to obesity in adolescents. On the other hand, no association was found when assessing the rates of obesity with closeness to schools of fast-food restaurants and supermarkets (41). In contrast with the results mentioned above, a cross-sectional study with 7,020 low-income pre-school children in Cincinnati, Ohio, did not find any relationship between weight status and the proximity to fast-food restaurants. Most of the kids were black (76%) compared to 23% of white children. This study focused on the residential food environment. However, an important aspect that needs to be considered is

that children from this age usually do not have money to buy food for themselves, and they depend on their parents to buy food (42).

A second study done in California evaluated the number of fast-food outlets within 400 meters and 800 meters of high schools, middle schools, and elementary schools. They found a higher presence of fast-food restaurants near high schools, and the lowest was among elementary schools. They also found an association between neighborhood income and fast-food restaurants. There were more fast-food restaurants in the areas where the lower-income schools were located. This study did not test for associations with weight status. However, the results could indicate a relationship between household income and less healthy food environments (43). Another study found that one-third of the schools across the United States have the presence of a fast-food restaurant or convenience store within walking distance (0.5 miles or 805 meters). Results were similar to other studies when they compared the lowest-income school neighborhoods and the highest-income, finding that poorer areas are exposed to more fast-food restaurants and convenience stores. On the contrary, they found less availability of fast-food restaurants in African American neighborhoods regardless of the income level (44).

Despite the research that has been conducted thus far related to food outlets and their relationship with obesity, mixed results are the most prevalent. According to Wilkins et al. 2019, 75% to 80% of the literature has presented null associations. One possible cause of the heterogeneity of the results might be the variations in the methodologies that have been used to measure the retail food environment. The variation in the measurement methods has limited the execution of meta-analysis. Numerous authors have cited the variation in the measurement methods as an obstacle to adapt the evidence into policies. Another aspect that needs to be considered in the variation of the results is the variation of food outlet definition. Some studies

have defined fast food outlets as only fast-food chains: However, other authors include fast-food chains and non-chain traditional food outlets, cafes, and sandwich shops. Little is known about the impact of the difference in the definitions on the relationship between overweight and obesity (45).

One more methodological aspect that has been discussed as a limitation when considering this body of evidence, is the retail food outlet metric. Studies have applied metrics of outlet count, count per population, count per area, presence/absence, the ratio of fast-food outlets to total outlets, among others. Direct comparisons are complicated because measures with different units are frequent hindering the opportunity to combine results in meaningful ways, despite the strong associations that have been found (45).

In a study conducted with adults in Yorkshire, England, authors mentioned that to determine whether there is a relationship between the retail food environment and obesity, the measures used are fundamental (45). Another study conducted in Yorkshire followed up a cohort for three years. They wanted to evaluate determine whether there was an association between the residential food environment and change in BMI within the cohort. Their results showed no relationship between neighborhood food environment and change in the weight status. Self-reported BMI remains one of the most common limitations found in the studies. The lack of information related to other environments like workplaces and the number of times the food outlets were determined have also been mentioned as limitations (46). In a third cross-sectional study done in Yorkshire, the authors wanted to evaluate the association between weight status and fast-food availability. They found that this association varies by age and saw a little increase in the BMI in those with more availability of fast-food outlets. However, the most relevant finding from the study, according to the authors, is that there is no statistical difference in

associations between obesity and fast-food outlets (47). Another cross-sectional study from England found no relationship between the number of food outlets and weight status in children in any food environment (home, school, commute) (48).

An article related to childhood obesity in Mexico mentioned the importance of controlling the environmental factors around schoolchildren. However, they only gathered information about the food environment inside schools and briefly discussed Mexican cultural aspects like kids often buy food in the street when meeting with friends or accompanied by one or both parents. In interviews realized with the mothers, they mentioned how convenient and easy it is to buy and eat street food (49). A study conducted in Tijuana, a US-Mexico border city, evaluated the availability of food for school children in three different settings (home, school, and vicinities). They found that the more availability of fruits and vegetables, the higher the consumption. Nonetheless, this study did not assess the relationship between the nearness of food stores and children's weight status (50).

A study conducted in Brazil was unable to be part of this literature review because, even though it studied the relationship between food environments and school children obesity, it was written in Portuguese only the abstract was in English. Another study conducted in a city in the South of Brazil found no relation between fast-food outlets, supermarkets, mini markets, bakeries in the residential environments, and childhood obesity (51).

A systematic review reviewed the evidence related to food environments in Australia. The evidence included studies related to diet, obesity, socioeconomic, and geographic disparities. In total, 60 studies were examined. However, the large methodological designs used made it difficult to synthesize the evidence and reach a conclusion. The results showed that there is some evidence related to the existence of socioeconomic and geographic position disparities and food

environment in Australia. In general, they found inconsistencies in the association between food outlet environments and obesity (52).

Food marketing

The nutritional status of children can be affected by the environment around schools. For example, the influence of marketing, the availability of food outlets, and the active transportation opportunities are some elements that can affect physical activity and food choices. Some studies conducted in Latin America are focus on TV advertising of dense foods and sweet sugary beverages and marketing inside the schools. Thanks to these studies, some advances have been made. The healthy school guidelines were introduced in Mexico in 2010. They stated that marketing inside schools was forbidden. Despite these efforts, the application of these guidelines has been less effective in the schools located in the poorest areas of Mexico, recommending that special efforts should be made to protect more vulnerable groups of the obesogenic environment. On the other side, advertising around schools has been less studied, and it is more difficult to describe and regulate (53). Advertisement in the form of billboards or posters is a relatively cheap method of marketing. They have a high impact because people tend to watch the same message regularly. In spite, several studies have examined the association between obesity and food outlets density around schools. Fewer studies have studied the advertisements of food and beverages around schools (54). In 2006, in the United States, $3.83 billion were spent on outdoor marketing. The top 25 advertisers that allocated around $76.5 million were companies that sell candies, food, and beverage (54).

Companies like Kellogg Co., which sells sugared cereals, spent $1.7million in outdoor advertising, while Pepsi Co. and Coca-Cola spent together 30.5 million dollars, during 2006. The considerable large budgets dedicated to outdoor advertising could indicate that people are

exposed to a vast amount of outdoor food and beverage marketing, especially unhealthy beverages and foods. These repetitive exposures predominantly around schools could be influencing passive learning as children and adolescents could see these advertising several times a day. For example, when coming and going from school, or depending on the time spent outdoors (54).

One study conducted in two Mexican cities characterized the presence of food and beverage advertisements around schools. It also examined whether the advertisements of food and drinks targeted to children followed the PAHO marketing recommendations of food and non-alcoholic beverages. The authors selected school doors as centers and measured 100 meters of diameter from there. In these buffer zones, they checked out for markets, restaurants, cafeterias, convenience stores, and all kinds of commercial advertisements of food and beverages. All the posters, banners, paintings on the walls, flags inside and outside of stores, stickers, and billboards in the selected areas were considered advertisements. The ads were also classified as sugar-sweetened beverages, sodas, and juices; sweet snacks; chocolates and candies; dairy products and milk; salty snacks; water; ice cream; and other types of foods. The results of the study showed that 50.7% of the advertisements were for sugar-sweetened beverages. The second most advertised products were the sweetbreads and snacks with a 15.8%, followed by the candies and chocolates with a 9.4%. They observed 3.2% of bottled water advertisements. The results of the food products advertised around public and private schools were similar. Only 29.9% of the ads presented some promotion, and the printed posters were the most common medium employed with 97.1%. In this study, they also found a significant difference in the compliance of the food and beverage marketing and the PAHO recommendations of marketing directed to children. Only 18.8% of the advertisements followed the PAHO recommendations.

The authors also found that children from public schools were more prone to be exposed to the marketing of food and beverages than children from private schools, which are usually located in more affluent and more protected neighborhoods (53).

Researchers in Texas have started to pay special attention to the obesity pandemic because one in three kids have overweight or obesity. 46% of Hispanic children suffer from obesity in contrast to non-Hispanic white children, and scientists have suggested that the marketing of unhealthy food and beverages is a contributing risk factor. Moreover, evidence indicates that the food market is more likely to target vulnerable groups like low-income and minority youth (54). The Outdoor Measuring and Evaluating the Determinants and Influences of Advertising (Outdoor MEDIA DOT) study was designed to describe the quantity of food and beverage advertisements around 0.5 miles of 47 Central Texas schools. A total of 824 advertisements were found. One of the findings was that urban schools were more exposed to ads when compared to suburban schools. Besides providing evidence related to food marketing around schools, this study had as objective to provide a useful and standardized tool to gather detached information about food and beverages around the schools (55). Another study wanted to investigate the prevalence of outdoor food and beverage advertising among middle and high schools with the Hispanic population. They used the data collected in the Outdoor MEDIA study and identified which schools had predominantly Hispanic students. Results showed that schools with more than 60% of Hispanic students had a significantly higher number of establishments, price promotion, and total food and beverage advertisements within 0.5 miles around schools. Adolescents who attended these schools were exposed, on average, to 60 more food and beverage advertisements compared to schools with fewer Hispanic students. Most of the advertisements were calorie-dense, low-nutrient, and high-fat foods or beverages. Even though

these results are meaningful, the sample size was too small, and no association with childhood obesity was done (54).

A cross-sectional study conducted around 500 meter walking distance from schools in Auckland, New Zealand, categorized bus stop food and beverage advertisements into recommended for marketing and not recommended. The authors found that 12.8% of the ads were not recommended for marketing. They also found that a higher proportion of advertisements were near private schools or in higher-income areas. A possible explanation was the presence of many bus stops because these schools were in urban areas. Also, the proportion of advertisements increased as the distance from schools increased (56). Another study conducted across New Zealand schools found that the number of unhealthy food advertisements was significantly higher within walking distances around schools with higher socioeconomic status. The majority were from sugar-sweetened beverages and fast food (57). A third study from New Zealand found 1408 outdoor advertisements around ten schools in urban and rural areas in a one-kilometer buffer. More than half (61.5%) of the ads were for food. Soft drinks were the most prevalent advertisements (21.6%). Then, 16.22% of frozen confectionery and 11.4% savory snacks represented the more prevalent advertisements. In total, 70.2% of the food ads were classified as unhealthy food (58).

A study from Canada found similar results. At least one food or beverage advertisement was found within a 400 meter buffer around schools, and 90% were from unhealthy foods. Secondary schools were more exposed to these advertisements than elementary schools (59). A study from Australia found 9151 advertisements around 40 urban and suburban schools. Of these 9151 ads, 25% were for food, and 80% were from not recommended foods, 15% were from coffee or tea, and only 5% were from recommended foods. Soft drinks consisted of 24% advertised food,

making it the most frequently advertised. Followed by 22% of alcoholic beverages, 15% were from coffee, and 14% of ice cream. The results also showed that the areas closest to schools (<250 meters) had a double density of unhealthy food advertisements compared to the farthest areas (60). Although these studies measure the advertisements around schools, neither makes an association with children's weight status.

A study conducted in a city in Northern England explored the prevalence of outdoor food advertising and the nutrition content divided by socioeconomic status. In total, 1371 advertisements were found, and only 15% (211) were from food. A higher amount of propaganda was found in the less affluent area. Results also showed that the healthiest food was publicized in the middle tertile. On the other hand, they found that the less healthy food was advertised in the most affluent tertile. Overall, this study found that almost half of the food advertising space was from food and drinks high in fat, sugar, and salt. None of the advertisements were for fruits or vegetables. One limitation mentioned in this study was that many marketing products were from seasonal products related to the Christmas period because the data was collected between October and December. It also mentions as a limitation that this study cannot be classified as cross-sectional because it did not represent a true cross-section at one point in time (61).

One systematic review and meta-analysis assessed randomized trials to see if there were effects of unhealthy food and beverage marketing on children's dietary intake and dietary preferences. The authors identified 29 studies, and 17 were included in the meta-analysis of diet preferences and nine in the meta-analysis of dietary intake. The studies included information on almost 6000 children aged 2–18 years. The results showed that during or shortly after exposure to unhealthy food advertisements, dietary caloric intake increased significantly. Similar results showed that children who were exposed to unhealthy food marketing had an increased chance of

selecting the advertised foods or beverages. Authors suggested that children younger than eight years are more susceptible to the impact of food and beverage advertising in terms of quantity and quality of calories consumed (62). In a study conducted on children from public schools in Guatemala, similar results were found. Children tended to prefer the taste of foods that comes inside packages with famous cartoons. Also, younger children were more likely to show this trend (63).

A study conducted in a city in Guatemala evaluated the type of food advertising inside and around public schools. It also assessed if there was an association between child-oriented snack food advertisements and closeness to schools. They evaluated all the food stores within 200 meters around four schools (two preschools and two primary schools) and all the food stores inside the schools. They found 321 snack food advertisements in 55 stores. The results showed that 37% were from sugar-sweetened beverages, and 30% of them were soft drinks (64). These results are similar to studies conducted in countries as New Zealand (57). The findings showed that only 29% were child-oriented advertisements. They are defined as child-oriented ads if the packages had promotional characters, premium offers, children's movie tie-ins, sports references, or the world child. Atoles are traditional fortified cereal-based drinks consumed frequently among Guatemalan children. From the beverage propaganda, all the atoles were child oriented. Breakfast cereals were the foods with the highest proportion of child-oriented advertisements (94.1%), followed by ice cream and frozen desserts (71.4%). The authors also found more child-oriented propaganda in stores located closer to the schools (<170 meters) (64). Another study conducted using the same sample of advertisements analyzed 106 packages of food found in 55 stores. The results showed that the most common advertising technique was promotional characters (92.5%) that appeared in front of the package (65). Another study in Guatemala that

evaluated the duration and nature of unhealthy food advertisements targeted to children in television channels found that 85% of the ads were non permitted to be marketed to children. Results also showed that these advertisements were six times more likely to appear for all programs and channels than allowed food advertisements (66).

Conclusions

The literature review showed how the prevalence of overweight, and obesity is increasing rapidly, and that is also a problem in developing countries like Guatemala.

Most information regarding overweight and obesity in schoolchildren is focused on the food environment inside the schools. However, fewer studies have examined the association between overweight and obesity in children and the food environment around schools.

According to the literature, many factors influence the weight status of children. That is one reason why mixed results have been found. Different techniques have been used to measure the food environment, and there is no consensus yet, on which is the best way to do it. One of the most common exposures that were evaluated is the neighborhood food environment. Nevertheless, the studies mainly focus on the adult population, urban areas, and food outlets. There is less information related to food marketing and childhood obesity. Still, associations have been found between marketing targeted to children and food choices. There is some information about the effect of marketing on the front-of-package of snacks and television in children. Little is known about how food advertisements along childrens' walking paths to schools and potential impact on their food choices as well as their nutritional status.

There are few high-quality studies, and most of the available evidence comes from cross-sectional analyses. Further, few of the high-quality studies controlled for important covariates

like SES, gender, and PA. These variables are known to have independent effects on obesity and may also be associated with the food environment

The majority of the studies included in this review were conducted in developed countries, which means that developing countries like Guatemala are underrepresented in the available evidence related to food environment and obesity in children. The current study will contribute with evidence about the prevalence of overweight and obesity among children in rural communities in Guatemala. Ultimately, the current research may inform the creation and implementation of health and nutrition policies that target the obesogenic environment around schools.

Chapter 2 - Manuscript

Introduction

Childhood obesity is one of the biggest public health problems of this century. During 2016, more than 41 million children under five years of age were overweight (4). According to the Pan American Health Organization (PAHO), in Latin America and the Caribbean (LAC) region, there are approximately four million children, less than five years of age who suffer from overweight (5). Children who suffer from overweight and obesity are more prone to develop noncommunicable diseases like type 2 diabetes mellitus, hypertension, cancer, and cardiovascular diseases at younger ages (4).

Since 1980 the eating patterns of Latin America and The Caribbean region started to change. There was an increase in ultra-processed food consumption, accompanied by a decrease in physical activity. Some driving factors that have contributed to the obesity epidemic are the changes in transportation systems, aspects of employments, food demand and supply, foreign investments, and urbanization (6). All the environments that interact within a community can help create interventions to moderate or reduce the effects of the obesity epidemic (3). The food environment can be defined as all of the physical, economic, and political conditions that determine dietary patterns and some diet-related health outcomes (11).

The International Network for Food and Obesity/non-communicable diseases Research, Monitoring and Action Support (INFORMAS) defined healthy food environments as places where foods and beverages that shape the population's diet are accessible, available, and fulfill the dietary guidelines (10). The food environment regulates the food options that people have access to (12). An obesogenic food environment encourages the consumption of high-energy and low nutrient foods and beverages (13). For this reason, it is necessary to create healthy food

environments (10). During recent years, dietary changes have been seen in national, local, school, and household environments (15). Schools are considered favorable environments for promoting healthy eating habits and creating healthy food environments by teaching and practicing healthy eating and long-life skills for active living (16).

Like most Latin American countries, Guatemala has seen accelerated growth in the cases of overweight and obesity, especially in women of reproductive age (18). According to the last National Maternal and Child Health Survey (ENSMI), the national prevalence of overweight and obesity in children younger than five years was 4.9% (19). The prevalence among adolescent girls was 28.4% and for women of reproductive age was 56.6% (19). The 2015 World Health Survey for Schoolchildren reported a national prevalence of overweight of 29.39%, and 8.40% for obesity (20). This survey evaluated the nutritional status of students from seventh to nineth grades (20).

The school food environment inside schools has not been adequately studied in Guatemala. One study found that Guatemalan elementary schools offer limited fruits and vegetables, and a high number of energy-dense snacks and sugar-sweetened beverages (21). Research has shown that more availability of ultra-processed foods is related to higher consumption (21). A study conducted in Mexico showed that children prefer energy-dense snacks because they enjoy their flavor (24). A study conducted in Guatemala evaluated the influence of food marketing on schoolchildren and found that children prefer foods with a cartoon character on the front of the package (65). These studies are examples of how the food environment around children influences food consumption in children. Research on the obesogenic food environment has received little attention in developing countries (26). Moreover, not much is known about the effect of the food environment that surrounds

schoolchildren. Many unhealthy foods are available outside the school area and within a short walking distance from the school gate (26). Children's food marketing has also been an issue of concern around schools (53).

In many developing countries, evidence based-policies that target food environments are emerging (19). Guatemala, to this date, has no national policies that regulate the type of food sold to children outside the schools, nor the type of advertisements they are exposed to on their way to schools (19). However, recently, the Guatemalan Government and academic institutions have supported a Law Initiative for "Healthy Food Promotion" that includes mandatory front-of-pack warning labels, the prohibition of advertisements and sales of ultra-processed products that target children and adolescents, and the addition of nutritional education within the school curricula (19).

Attention is needed in schoolchildren in rural communities as compared with more urban settings. There is almost no information available on how the obesity epidemic has impacted schoolchildren, or about the food environment that surrounds the schools. One of the objectives of the current study was to characterize the food environment that surrounds public elementary schools in rural communities. The other goal was to determine if the prevalence of overweight and obesity is associated these schools.

Methods

Study Design

This cross-sectional study, approved by the Institution Review Board (IRB) of the Institute of Central America and Panama in December of 2017 and the IRB of Kansas State University in November 2020, was conducted in three villages in El Progreso Guatemala. Two of the villages were located in the Municipality of Sanarate; San Miguel Conacaste and San Juan

las Flores; and the third one, Santo Domingo Los Ocotes part of the Municipality of San Antonio La Paz. Data were collected from February to May 2018.

These villages were selected because, since the inception of the Oriente Longitudinal Study, in 1969, they have experienced demographic, social, and economic changes, including improvements in access to roads and transportation, the non-agricultural employment opportunities have increased, and schooling access has improved.

Sample Selection

San Miguel Conacaste (school 1) and San Juan las Flores (school 2) have one elementary public school that operates in two shifts, one in the morning and one in the afternoon. Santo Domingo Los Ocotes has two elementary public schools with only a morning shift (schools 3 and 4). For that reason, four schools were evaluated. The average enrollment of each school was of approximately 200 students.

A letter to the schools' principal was sent to schedule a meeting for authorization to work inside the school, explain the objectives of the study, and ask for collaboration from the schools. After the principals´ permission was obtained, the rosters of students were requested from the teachers. A random selection using Microsoft Excel was determined to recruit boys and girls from first to sixth grades in each school and shift. Approximately 11 children from each class were necessary for reaching approximately 400 students in total, therefore double that number of students per class were invited to participate, with an expected response rate of 50%. The parents of the selected students were invited to attend an informative meeting at the school. In this meeting, the objectives and procedures of the study were explained, and the informed consent form was handed out. Parents who authorized their children to participate completed the informed consent, and the research team asked for verbal assent from each child. Children with

incomplete sociodemographic or anthropometric data were excluded from the study analysis, leading to a final sample size of 398 children between 6 to 15 years of age.

Two research assistants were trained to collect socioeconomic and demographic information as well as anthropometric measures, food frequency questionnaires, and food environment measures.

Measures at the individual level

Sociodemographic information

The children´s mother or guardian answered a survey about the sociodemographic profile of the family. The survey contained information about the mother's age and educational level, parents' occupations, and housing conditions of the children. Tertile variables of mother's education level and household income were created to evaluate socioeconomic status. For both variables tertiles were define as low tertile (Tertile 1=1), middle tertile (Tertile 2 =2), and high tertile (Tertile 3 =3).

Anthropometric measures

Anthropometrics were measured using standardized and validated methods. Body weight was measured using digital scales (Tanita, Model HD-51), and the height was measured using portable stadiometers with 1-mm precision (Seca, Model 213). Waist circumference was measured using a circumference measuring tape (Seca, Model 201). Each measure was taken in duplicate, and later the results were averaged.

Z scores of the Body mass index (BMI) (Kg/m^2) for age were calculated using software for assessing the growth of children and adolescents (WHO Anthro Plus). BMI for age Z scores less than ±5SD were considered plausible. WHO cutoff points for BMI Z scores for sex and age were used to classify the nutritional status of children. Overweight was defined as ≥1SD and

<2SD above the mean, and obesity was defined as ≥2SD above the mean for BMI for age. Underweight was define as a Z score of ≤-2SD below the mean, while severe underweight was define as a Z score of ≤-3SD below the mean for BMI for age. Normal weight was defined as a Z score >-2SD and <1SD between the mean for BMI for age. Stunting was defined as Z score of ≤-2SD below the mean for Height for age according to the WHO growth charts.

Central obesity was calculated using the waist-to-height ratio (W/Hr). A cutoff point of ≥0.5 was used to define central obesity. BMI and central obesity were converted to categorical variables for the logistic regression and one-way analysis of variance (ANOVA) analyses.

Measurements of the food environment at community level

Maps were generated using the application of Google Earth and choosing the main door of the schools as the center of the circular buffer. The circular zones of 100 meters, 200 meters, 300 meters, 400 meters, and 500 meters around schools were created using the QGIS version 2.14 (https://qgis.org/en/site/).

Advertisements outside the schools

The advertisements were defined as all the posters, banners, signs, paintings on walls, boxes, or bottles used as marketing tools outside stores, in the streets, houses, bus stops outside schools, in the designated buffer areas. All the advertisements of ultra-processed and processed foods and beverages (except alcohol) around 500 meters of the schools were recorded.

Using the REDCap 7.5.2 web application (https://www.project-redcap.org/), the research assistants captured the characteristics of each food advertisement, like brand name, size, type, where was it located, and the X and Y coordinates. Researchers created layers to georeferenced each area and the number of ads located within 500 meters around the school. Then, to count

how many times each advertisement was repeated in the same place, the advertisement was multiple by the number of times it was repeated.

Ads were classified using the WHO nutrient profile model (Appendix A). The WHO nutrient profile is a model that determines if a food product may or may not be marketed to children (67). In addition to the original categories, three more were added: coffee or tea, spices, and others; because during pilot test, researchers found that these food products were advertised frequently, and did not fit in any other category. Finally, researchers evaluated whether the ads were in line with the WHO nutrient profile model criteria. Notably, no food advertisements were found inside the schools.

Food Outlets outside the schools

Food outlets were defined as all corner stores, mobile food vendors, convenience stores, and food establishments (fast-food restaurants, ice cream shops, temporary street food stands, cafeterias, diners, bakeries, poultry and meat markets, markets, fruit, and vegetable stores). Even though the mobile food vendors and temporary street food stands could be mistaken, the difference is that mobile food vendors sell their products outside the school gates and only can be found at the beginning and at the end of the school hours (26).

All the food outlets that were found within a 500 meter diameter around schools were located using the REDCap web application. The X and Y coordinates of each food outlet were recorded, layered, and geolocated in the villages using the QGIS application. Then each food outlet was classified according to the type of food sold. The category of healthy food included fruits and vegetables, poultry, meat market, and included the mobile street vendors that sold fruits or vegetables. In contrast, all the corner stores, fast food chains, ice cream shops, bakeries, and cafeterias were classified as unhealthy food outlets.

Statistical Analysis

The children's BMI variable was recoded to a dichotomous variable. Children with obesity were assigned to a category (obese weight status =1) and the rest of the children to another (non-obese =0). Two new variables were created; one categorical variable to classify the children with central obesity (central obesity =1, no central obesity =0), and another one to categorize the children with overweight and obesity (overweight and obesity =1, non-obese =0). The categorical variable overweight and obesity was the dependent variable, and the explanatory variable was the school in the logistic regression analysis. Moreover, variables as mother's age and educational level, household income, and child's sex were entered into the model as control variables.

Frequencies were generated for each explanatory variable. Advertisement's frequencies were determined for type, size, and compliance with the WHO nutrient profile. Additionally, frequencies were generated for the type of food outlets found around schools.

A one-way analysis of variance (ANOVA) was conducted to determine whether the means of the schools differed in the means of overweight and obesity and the food environment. Where there were statistically significant differences, post hoc Fisher's Least Significant Difference tests were conducted to determine which schools differed from one another.

A logistic regression analysis was used to determine the association of the prevalence of overweight and obesity with schools. The number of schools determined the degrees of freedom available in the model because it was the primary unit of analysis. The model was adjusted according to the child's sex, mother's age and level of education, and household income. A P value ≤ 0.05 was defined as a statistically difference between schools, and also to determine

association between the prevalence of overweight and obesity with schools. IBM SPSS Statistics 27 was used for all the statistical analyses.

Results

In total, 398 children enrolled at four different schools participated in the study. The prevalence of overweight and obesity was 32.4% among the three villages. As presented in Table 1, 18.6% of the children were overweight, and 13.8% were obese. Two in ten children have overweight, and one in ten children suffers from obesity in these communities. Of the total participants, 51% were boys, and 49% were girls. The ranged age was from 6 to 15 years. Even though this study was focused on children with overweight and obesity, it is worth mentioning that undernutrition is still present in these communities and 3.8% of the children had underweight or severe underweight. In addition, 14.6% had stunting. According to their education level, a higher number of mothers were found in the lowest tertile (36.9%). The majority of children with overweight and obesity were in the lowest tertile according to their household income (61.3%).

Table 1 General characteristics of the sample population in four schools, El Progreso, Guatemala, 2018

	n (%)
Schools	
School 1	144 (36.2)
School 2	62 (15.6)
School 3	147 (36.9)
School 4	45 (11.3)
Sex	
Female	195 (49.0)
Male	203 (51.0)
Age (years)	
6	22 (5.5)
7	53 (13.3)
8	60 (15.1)
9	71 (17.8)
10	62 (15.6)
11	68 (17.1)
12	43 (10.8)
13	11 (2.8)
14-15	8 (2.0)
Nutritional Status	
Undernutrition	2 (0.5)
Severe undernutrition	13 (3.3)
Normal weight	254 (63.8)
Overweight	74 (18.6)
Obesity	55 (13.8)
Stunting	58 (14.6)
Tertiles Mother's education	
Tertile 1	147 (36.9)
Tertile 2	124 (31.2)
Tertile 3	127 (31.9)
Tertiles Household income	
Tertile 1	244 (61.3)
Tertile 2	96 (24.1)
Tertile 3	58 (14.6)

Table 2 shows the percentage of overweight, obesity, and central obesity per school. Two of ten children had overweight in three schools, and two out of ten children had obesity in two schools. However, the percentage of children with central obesity was higher than the percentage

of overweight and obesity. In three of the four schools, four of ten children had central obesity, twice the number of children with overweight according to their BMI. The majority of children with overweight and obesity were in the lower tertile according to their socioeconomic status. (See Appendix B)

Table 2 General characteristics of the obesity indicators and the food environment in four schools, El Progreso, Guatemala, 2018

	School 1	School 2	School 3	School 4
Overweight and obesity indicators	n (%)	n (%)	n (%)	n (%)
Overweight	28 (19.4)	6 (9.7)	32 (21.8)	8 (17.8)
Obesity	22 (15.3)	5 (8.1)	23 (15.6)	5 (11.1)
Central Obesity	59 (41.0)	9 (14.5)	59 (40.1)	17 (37.8)

The total of food outlets found around the schools was 185. Table 3 shows that schools 1 (34.1%) and 3 (34.6%) had the higher percentages of the total of food outlets as compared with schools 2 and 4. Most of them were found within 100 meters around the schools (33.0%). (See Appendix C)

Only 10.81% of the food outlets provided healthy food. School 3 had a lower percentage of less healthy food outlets (82.8%) when compared to the other schools.

Table 3 Characterization of food outlets by schools

	School 1	School 2	School 3	School 4
	n (%)	n (%)	n (%)	n (%)
Food outlets	63 (34.1)	38 (20.5)	64 (34.6)	20 (10.8)
Healthy food outlets	5 (7.9)	3 (7.8)	11 (17.2)	1 (5.0)
Unhealthy food outlets	58 (92.1)	35 (92.1)	53 (82.8)	19 (95.0)

As shown in Table 4, 45.9% of the food outlets were found within 100 meters around school 1, and 42.6% were found within 100 meters around school 3. Schools 2 and 4 had lower percentages of food outlets within 100 meters. In school 2 a higher percentage of food outlets

(32.7%) was found within 300 meters compared to the other schools. In the case of the school 4, a higher percentage of food outlets (24.5%) was found within 200 meters. (See appendix C)

Table 4 Characterization of food outlets by schools and distance

	School 1	School 2	School 3	School 4
Distance	n (%)	n (%)	n (%)	n (%)
100 meters	28 (45.9)	4 (6.6)	26 (42.6)	3 (4.9)
200 meters	18 (36.7)	10 (20.4)	9 (18.4)	12 (24.5)
300 meters	10 (20.4)	16 (32.7)	18 (36.7)	5 (10.2)
400 meters	5 (33.3)	2 (13.3)	8 (53.3)	0 (0.0)
500 meters	2 (18.2)	6 (54.6)	3 (27.3)	0 (0.0)

A total of 299 food advertisements were found in the villages. School 2 had a higher percentage of food advertisements (34.8%) when compared to the other schools (Table 5). Overall, in all schools, the advertisements that did not meet the WHO criteria were predominant. However, school 2 also had a higher percentage (33.2%) of food advertisements that did not meet the WHO criteria for advertisements. Some advertisements were not categorized, and two did not apply to the categorization.

Table 5 Characterization of advertisements by schools

	School 1	School 2	School 3	School 4
	n (%)	n (%)	n (%)	n (%)
Food advertisements	57 (19.1)	104 (34.8)	66 (22.1)	72 (24.1)
Meet WHO criteria	9 (27.3)	11 (33.3)	6 (18.2)	7 (21.2)
Do not meet WHO criteria	45 (18.9)	79 (33.2)	57 (23.6)	57 (23.9)
Cannot be classified	3 (11.5)	12 (46.2)	3 (11.5)	8 (30.8)
Not apply	0 (0.0)	2 (100.0)	0 (0.0)	0 (0.0)

As table 6 shows, similar to the food outlets, the highest number of food advertisements were found within 300 meters (50.0%) in school 2. Contrary to the food outlets, in school 1, the lower percentage of food advertisements (14.1%) were found within 100 meters. School 3 showed similar patterns to the food outlets 48.2% of the food advertisements were found within

100 meters. On the other hand, school 4 showed a higher number (38.4%) of food advertisements within 200 meters. (Appendix D)

Table 6 Characterization of food advertisements by schools and distance

	School 1	School 2	School 3	School 4
Distance	n (%)	n (%)	n (%)	n (%)
100 meters	12 (14.1)	7 (8.2)	41 (48.2)	25 (29.4)
200 meters	15 (20.6)	25 (34.3)	5 (6.8)	28 (38.4)
300 meters	18 (17.7)	51 (50.0)	14 (13.7)	19 (18.6)
400 meters	6 (23.1)	15 (57.7)	5 (19.2)	0 (0.0)
500 meters	6 (46.2)	6 (46.2)	1 (7.7)	0 (0.0)

Table 7 shows the means and standard deviation by schools. Table 8 displays the ANOVA results. There was a statistically significant difference between schools for overweight and obesity ($F(3,394) = 2.823$, $p=0.039$), and central obesity ($F(3,394) = 5.172$, $p=0.002$). However, schools were not statistically different for BMI/age and obesity.

Additionally, there was a significant difference of the schools on the proximity of food outlets ($F(3,181) = 5.455$, $p=0.001$) and on the proximity of food advertisements ($F(3,295) = 22.449$, $p<0.001$). However, there were no statistical difference between schools and the healthiness of food outlets and food advertisements.

Likewise, there was a statistically significant difference between the association of the healthiness of food outlets and 100 meters distance ($F(1,183) = 10.909$, $p=0.001$). However, there was no statistically significant difference in the association effect of the distance on the healthiness of food advertisements. (Data not shown)

Table 7 Means results on the variables of obesity and food environment by schools, in three villages, El Progreso, Guatemala, 2018

				95% Confidence interval for the mean	
	Schools	**Mean**	**Sta. Deviation**	**Lower Bound**	**Upper Bound**
Obesity indicators					
BMI/age (Z-score)	School 1	0.51	1.406	0.28	0.74
	School 2	0.04	1.162	-0.24	0.34
	School 3	0.49	1.361	0.27	0.71
	School 4	0.12	1.343	-0.27	0.52
Overweight and obesity	School 1	0.35	0.478	0.27	0.43
	School 2	0.18	0.385	0.08	0.28
	School 3	0.37	0.486	0.30	0.45
	School 4	0.29	0.458	0.15	0.43
Obesity	School 1	0.15	0.361	0.09	0.21
	School 2	0.08	0.275	0.01	0.15
	School 3	0.16	0.365	0.10	0.22
	School 4	0.11	0.318	0.02	0.21
Central Obesity	School 1	0.41	0.493	0.33	0.49
	School 2	0.15	0.355	0.05	0.24
	School 3	0.40	0.492	0.32	0.48
	School 4	0.38	0.490	0.23	0.53
Food Outlets					
Healthiness	School 1	0.08	0.272	0.01	0.15
	School 2	0.08	0.273	-0.01	0.17
	School 3	0.17	0.380	0.08	0.27
	School 4	0.05	0.224	-0.05	0.15
Distance	School 1	196.83	110.670	168.95	224.70
	School 2	289.47	118.069	250.67	328.28
	School 3	226.56	125.030	195.33	257.79
	School 4	210.00	64.072	180.01	239.99
Food Advertisements					
WHO criteria	School 1	1.89	0.451	1.78	2.01
	School 2	2.05	0.546	1.94	2.15
	School 3	1.95	0.369	1.86	2.05
	School 4	2.01	0.459	1.91	2.12
Distance	School 1	263.16	123.392	230.42	295.90
	School 2	288.46	93.796	270.22	306.70
	School 3	178.79	111.652	151.34	206.24
	School 4	191.67	78.274	173.27	210.06

Table 8 ANOVA results on the variables of obesity and food environment by schools, in three villages, El Progreso, Guatemala, 2018

	df	Mean Square	F	Sig.
Obesity indicators				
BMI/age (Z-score)	3	4.736	2.61	0.051
Overweight and obesity	3	0.612	2.823	0.039
Obesity	3	0.106	0.887	0.448
Central Obesity	3	1.161	5.172	0.002
Food Outlets				
Healthiness	3	0.137	1.427	0.236
Distance	3	70469.034	5.455	0.001
Food advertisements				
WHO criteria	3	0.331	1.479	0.220
Distance	3	228603.737	22.449	0.000
Healthiness of Food outlets				
100 meters distance	1	2.300	10.909	0.001

Tables 9, 10, 11, and 12 display pairwise comparisons of the schools means using Fisher's Least Significant Difference (LSD). The results of table 9 shows that school 2 had statistically significant lower mean for central obesity compared to school 1 (*M*=-0.26, 95%CI: -0.41, -0.12), school 3 (*M*=-0.25, 95%CI: -0.40, -0.12), and school 4 (*M*=-0.23, 95%CI: -0.42, -0.05). Also, school 2 had statistically significant lower means for the variables overweight and obesity and BMI for age compared to school 1 (*M*=-0.17, 95%CI: -0.31, -0.03) and school 3(*M*=-0.19, 95%CI: -0.34, -0.06). School 2 also had statistically significant higher means of the distance of food outlets. Showing that food outlets were farther away than school 1 (*M*=92.64, 95%CI: 46.59, 138.71), school 3 (M=92.64, 95%CI: 16.98, 108.84) and school 4 (*M*=79.47, 95%CI: 17.52, 141.43). Food advertisements had statistically higher means in school 2 compared to school 3 (*M*=109.67, 95%CI: 78.42, 140.93) and school 4 (*M*=96.795, 95%CI: 66.35, 127.24).

Table 9 Mean differences for school 1

Dependent Variable	Schools		Mean Difference	Std. Error	Sig	95% CI	
						Lower bound	Upper bound
BMI/age (Z-score)	School 1	School 2	0.46	0.20	**0.024**	0.06	0.86
		School 3	0.01	0.15	0.909	-0.29	0.32
		School 4	0.38	0.23	0.093	-0.06	0.83
Overweight and obesity	School 1	School 2	0.17	0.07	**0.017**	0.03	0.31
		School 3	-0.02	0.05	0.622	-0.13	0.08
		School 4	0.05	0.07	0.463	-0.10	0.21
Obesity	School 1	School 2	0.07	0.05	0.170	-0.03	0.18
		School 3	-0.00	0.04	0.928	-0.08	0.08
		School 4	0.04	0.05	0.481	-0.07	0.16
Central Obesity	School 1	School 2	0.26	0.07	**<0.001**	0.12	0.41
		School 3	0.00	0.05	0.880	-0.10	0.12
		School 4	0.03	0.08	0.693	-0.13	0.19
Healthiness of food outlets	School 1	School 2	0.00	0.06	0.995	-0.13	0.13
		School 3	-0.09	0.05	0.095	-0.20	0.02
		School 4	0.02	0.08	0.713	-0.13	0.19
Distance of food outlets	School 1	School 2	-92.64	23.34	**<0.001**	-138.71	-46.59
		School 3	-29.73	20.17	0.142	-69.54	10.06
		School 4	-13.17	29.17	0.652	-70.73	44.38
WHO criteria for food advertisements	School 1	School 2	-0.15	0.07	0.050	-0.31	0.00
		School 3	-0.06	0.08	0.485	-0.23	0.11
		School 4	-0.11	0.08	0.156	-0.28	0.05
Distance of food advertisements	School 1	School 2	-25.30	16.63	0.129	-58.03	7.43
		School 3	84.37	18.24	**<0.001**	48.46	120.28
		School 4	71.49	17.89	**<0.001**	36.28	106.70

Table 10 Mean differences for school 2

Dependent Variable	Schools		Mean Difference	Std. Error	Sig	95% CI	
						Lower bound	Upper bound
BMI/age (Z-score)	School 2	School 1	-0.46	0.20	**0.024**	-0.86	-0.06
		School 3	-0.44	0.20	**0.029**	-0.84	-0.04
		School 4	-0.07	0.26	0.769	-0.59	0.44
Overweight and obesity	School 2	School 1	-0.17	0.07	**0.017**	-0.31	-0.03
		School 3	-0.19	0.07	**0.006**	-0.34	-0.06
		School 4	-0.11	0.09	0.222	-0.29	0.07
Obesity	School 2	School 1	-0.07	0.05	0.170	-0.18	0.03
		School 3	-0.07	0.05	0.148	-0.18	0.03
		School 4	-0.03	0.06	0.653	-0.16	0.10
Central Obesity	School 2	School 1	-0.26	0.07	**<0.001**	-0.41	-0.12
		School 3	-0.25	0.07	**<0.001**	-0.40	-0.12
		School 4	-0.23	0.09	**0.013**	-0.42	-0.05
Healthiness of food outlets	School 2	School 1	0.00	0.06	0.995	-0.13	0.13
		School 3	-0.09	0.06	0.145	-0.22	0.03
		School 4	0.02	0.08	0.736	-0.14	0.20
Distance of food outlets	School 2	School 1	92.64	23.34	**<0.001**	46.58	138.71
		School 3	62.91	23.27	**0.008**	16.98	108.84
		School 4	79.47	31.39	**0.012**	17.52	141.43
WHO criteria for food advertisements	School 2	School 1	0.15	0.07	0.050	0.00	0.31
		School 3	0.09	0.07	0.210	-0.05	0.24
		School 4	0.03	0.07	0.638	-0.11	0.18
Distance of food advertisements	School 2	School 1	25.30	16.63	0.129	-7.43	58.03
		School 3	109.67	15.88	**<0.001**	78.42	140.93
		School 4	96.79	15.47	**<0.001**	66.35	127.24

Table 11 Mean differences for school 3

Dependent Variable	Schools		Mean Difference	Std. Error	Sig	95% CI	
						Lower bound	Upper bound
BMI/age (Z-score)	School 3	School 1	-0.02	0.15	0.909	-0.32	0.29
		School 2	0.44	0.20	**0.029**	0.04	0.84
		School 4	0.36	0.22	0.108	-0.08	0.82
Overweight and obesity	School 3	School 1	0.02	0.05	0.622	-0.08	0.13
		School 2	0.19	0.07	**0.006**	0.06	0.34
		School 4	0.08	0.07	0.283	-0.07	0.24
Obesity	School 3	School 1	0.00	0.04	0.928	-0.08	0.08
		School 2	0.07	0.05	0.148	-0.03	0.18
		School 4	0.04	0.05	0.442	-0.07	0.16
Central Obesity	School 3	School 1	-0.01	0.05	0.880	-0.12	0.10
		School 2	0.25	0.07	**<0.001**	0.12	0.40
		School 4	0.02	0.08	0.770	-0.14	0.18
Healthiness of food outlets	School 3	School 1	0.09	0.05	0.095	-0.02	0.20
		School 2	0.09	0.06	0.145	-0.03	0.22
		School 4	0.12	0.07	0.127	-0.03	0.28
Distance of food outlets	School 3	School 1	29.73	20.17	0.142	-10.06	69.54
		School 2	-62.91	23.27	**0.008**	-108.84	-16.98
		School 4	16.56	29.11	0.570	-40.89	74.01
WHO criteria for food advertisements	School 3	School 1	0.06	0.08	0.485	-0.11	0.23
		School 2	-0.09	0.07	0.210	-0.24	0.05
		School 4	-0.05	0.08	0.462	-0.22	0.10
Distance of food advertisements	School 3	School 1	-84.37	18.24	**<0.001**	-120.28	-48.46
		School 2	-109.67	15.88	**<0.001**	-140.93	-78.42
		School 4	-12.87	17.19	0.455	-46.72	20.97

Table 12 Mean differences for school 4

Dependent Variable	Schools		Mean Difference	Std. Error	Sig	95% CI Lower bound	95% CI Upper bound
BMI/age (Z-score)	School 4	School 1	-0.38	0.23	0.093	-0.83	0.06
		School 2	0.07	0.26	0.769	-0.44	0.59
		School 3	-0.36	0.22	0.108	-0.82	0.08
Overweight and obesity	School 4	School 1	-0.05	0.07	0.463	-0.21	0.10
		School 2	0.11	0.09	0.222	-0.07	0.29
		School 3	-0.08	0.07	0.283	-0.24	0.07
Obesity	School 4	School 1	-0.04	0.05	0.481	-0.16	0.07
		School 2	0.03	0.06	0.653	-0.10	0.16
		School 3	-0.04	0.05	0.442	-0.16	0.07
Central Obesity	School 4	School 1	-0.03	0.08	0.693	-0.19	0.13
		School 2	0.23	0.09	**0.013**	0.05	0.42
		School 3	-0.02	0.08	0.770	-0.18	0.14
Healthiness of food outlets	School 4	School 1	-0.02	0.08	0.713	-0.19	0.13
		School 2	-0.02	0.08	0.736	-0.20	0.14
		School 3	-0.12	0.07	0.127	-0.28	0.03
Distance of food outlets	School 4	School 1	13.17	29.17	0.652	-44.38	70.73
		School 2	-79.47	31.39	**0.012**	-141.43	-17.52
		School 3	-16.56	29.11	0.570	-74.01	40.89
WHO criteria for food advertisements	School 4	School 1	0.11	0.08	0.156	-0.05	0.28
		School 2	-0.03	0.07	0.638	-0.18	0.11
		School 3	0.05	0.08	0.462	-0.10	0.22
Distance of food advertisements	School 4	School 1	-71.49	17.89	**<0.001**	-106.70	-36.28
		School 2	-96.79	15.47	**<0.001**	-127.24	-66.35
		School 3	12.87	17.19	0.455	-20.97	46.72

Table 13 illustrates the logistic regression between overweight and obesity and the four schools. A significant statistical association (p=0.043) was found between the schools and overweight and obesity in school children, even after adjusting for sex, mother's age, mother's education, and household income. This model suggests that the odds of having overweight and obesity are 61.3% lower if children study in school 2 compared to school 1 (OR=0.387, 95%CI; 0.183, 0.891). No associations were found between child gender, household income, and mother's level of education and age.

Table 13 Association between overweight and obesity and schools

		95% CI for Odds Ratio		
Covariate	**Odds Ratio**	**Lower bound**	**Upper bound**	**P value**
Schools				**0.043**
School 1	(Ref)	(Ref)	(Ref)	(Ref)
School 2	0.387	0.183	0.819	**0.013**
School 3	1.119	0.683	1.836	0.655
School 4	0.826	0.386	1.769	0.623
Male	(Ref)	(Ref)	(Ref)	(Ref)
Female	0.676	0.440	1.040	0.075
Tertiles mother's education				0.708
Tertile 1	(Ref)	(Ref)	(Ref)	(Ref)
Tertile 2	0.890	0.525	1.510	0.666
Tertile 3	0.797	0.465	1.364	0.407
Mother's age	0.986	0.956	1.017	0.365
Tertiles household income				0.823
Tertile 1	(Ref)	(Ref)	(Ref)	(Ref)
Tertile 2	0.955	0.503	1.427	0.532
Tertile 3	0.825	0.503	1.813	0.889

Discussion

A positive association between the prevalence of overweight and obesity with schools was found. However, when examined between schools, it appears that study in school 2 decrease the likelihood of having overweight or obesity compared to school 1. No studies that assess the obesity epidemic and food environment in rural communities in Guatemala were found when this document was prepared. The Guatemalan 2015 World Health Survey for Schoolchildren reported a national prevalence of overweight of 29.39%, and 8.40% for obesity (20). The prevalence of overweight and obesity found in the four schools was 32.4%. The results of this study are in line with what was reported in the 2015 Survey. However, less than one percent of the survey sample were children younger than 11 years (20). Moreover, these results are similar to one study conducted in an urban area in Quetzaltenango city, located west of the country. This study showed that 32.1% of school children in a high socioeconomic status (SES) had overweight and obesity (68).

A study that analyzed the results of the Guatemala 2014–2015 National Maternal and Child Health Survey (ENSMI) found that overweight and obesity are more prevalent in high-income and non-indigenous children younger than five years old as compared with lower income and indigenous children under five years old (19). However, in the current study, the association between overweight/obesity and schools was not affected when adjusting for the household income. The results of this study were opposite of what has been previously reported (19, 68). The majority of the schoolchildren with overweight and obesity were found in the lower tertile of the SES. According to Mazariegos et.al., it has been documented that Guatemala —like many Latin American countries— is in the first stage of obesity epidemic (19). Stage one of the obesity epidemic is characterized by a higher prevalence of obesity among women of reproductive age, and among people with higher socioeconomical status as compared to those with lower socioeconomic status (69). Unfortunately, it is likely transitioning to stage two because more than 20% of women of reproductive age suffer from overweight and obesity (19). It could be possible that another indicator that Guatemala is in stage two or transitioning to other phases is that the gap in socioeconomic levels starts to close or even reverse, and that could be a reason why a higher overweight and obesity prevalence was found in the lower SES tertile (19, 69). The use of stronger socioeconomic indicators to evaluate the association of SES with overweight and obesity is still needed (26).

One important thing to mention is that even though the waist-to-height ratio (W/Hr) was measured, it was not used as one of the principal outcomes in this research. This ratio gives information about the likelihood of developing cardiovascular diseases. It does not use specific cutoff points for age and sex and could be used in children (70). Results showed that more children had a higher prevalence of central obesity than children with overweight and obesity

using BMI. It would be interesting to evaluate any association of central obesity with the food environment in future research.

The food environment inside schools has been widely discussed in many studies as one of the causes of overweight and obesity in school children (21). The existence of weak policies or the lack of them to regulate what is sold and available inside schools is often studied. Most of the research efforts had focused on this (24). A strength of the current study is that it focused on the food environment around the schools as a possible contributing factor to the obesity epidemic.

The food environment has been understudied —especially in Latin American Countries— (24). Literature has provided evidence that the consequences of an obesogenic food environment are worse in neighborhoods where unhealthy food is more available to children (26). The rapid transformation of the food system in Latin American countries related to commercial trades (e.g., the Dominican Republic-Central America Free Trade Agreement (CAFTA-DR)) has been shown to be associated with some negative diet trends. For example, an increase in the intake has been observed coinciding with a decrease in the prices of fast-food and ultra-processed food (6). This transformation has changed the way people access food and the way consumers interact with food. At the same time, a technological change has occurred, diminishing physical activity levels. All these combined factors have led to an increase in obesity prevalence (6).

A high percentage of food outlets found around the schools sold unhealthy food —especially within a 100 meters buffer area—. Most of them were corner stores (44.9%). The majority sold processed and ultra-processed foods, although some sold fruits and vegetables. These types of stores are common and play an influential role in the distribution of ultra-processed foods (71). They are smaller than convenience stores and usually family owned (71).

When the percentage of corner stores between schools was compared, results showed that school 2 had a higher number of corner stores than the rest of the schools. However, the main difference is that most of the corner stores are within 300 meters around schools. On the other side, most corner stores in school 1 are within 100 meters around the buffer area. Borradaile et al., 2009 mentioned that closer proximity of corner stores may contribute to a higher snacking behavior especially of unhealthy foods in children (72). However, in the current study no individual evaluation of eating habits or purchased behavior was conducted. More research is needed to evaluate if this finding is somehow related to the lower prevalence of overweight and obesity in school 2 compared to school 1. Similar results have been reported in other Latin American countries and some industrialized countries (26). A study conducted in two Mexican cities found a higher quantity of food outlets around public schools but did not detect any statistical difference associated with children's BMI (26). Other studies in the United States have found associations between obesity in adolescents and schools where corner stores are located closer to schools (30, 31, 73). They also have found that in low-income areas, obesity is more related to fast-food restaurants and convenience stores (30, 31, 73). Some other studies have studied the association of residential food environments and childhood obesity in urban areas. Mixed results have been found depending on the gender and urbanicity of the residence (32, 33).

Two studies conducted in New York city showed a positive association between very near distances to fast-food restaurants and corner stores around childrens' homes and childhood obesity (29, 30). In the current study a smaller number of food outlets in all categories within 100 meters and 200 meters was found around school 2, and children from this school had lower risk of having overweight and obesity. In general, this school has fewer food outlets than the others except for school 4. However, the 500 meters buffer area of school 4 was not fully

examined due to security risks for the research team. Besides, the buffer areas of schools 3 and 4 were overlapping at some point because they were less than 500 meters far from each other. The food advertisements and food outlets of the overlapping area were counted only one time as part of the food environment around school 3. Overall, in all schools, a higher percentage of unhealthy food outlets was found. These results are in line with a study conducted in two Mexican cities where authors found a higher number and easily available processed and unhealthy food around public schools (26).

Walton et.al. have previously discussed that a considerable presence of food marketing around schools is a contributing aspect to childhood obesity (74). In the current study more than 75% of the food that was advertised did not meet the WHO criteria to advertised food targeted to children. This finding is consistent with a study conducted in Guatemala that showed that 37% of the food advertisements within 200 meters around public schools were of sugar-sweetened beverages and 30% were of soft drinks (64). A study conducted in Mexico used the PAHO recommendations for food and beverage marketing and found that 83.5% of the food ads did not fulfill the guidelines (53). These results are similar to the current study. Another study this time conducted in El Salvador found similar results. The most predominant ads found in rural communities were from sweet sugar beverages followed by snacks (75).

Even though mixed results have been found in the literature, it is necessary to continue with the research. This study did not look for an association between the food environment and the nutritional status of schoolchildren. It is still a gap in the exploration of food environments in Guatemala.

This investigation reassures the necessity of research and to create health policies that address the obesity determinants in children, especially in developing countries like Guatemala.

Evidence from Guatemala's obesogenic environment is limited. Some countries like South Korea had implemented what are called "Green Food Zones" that prohibit the sale of fast-food and sodas within 200 meters of the schools (76). Likewise, the city of Detroit in Michigan prohibits building fast-food stores within 500 feet of all schools (77). Among the Latin American countries, Mexico was the first to implement taxes on sugar-sweetened beverages (SSB) (78). However, not all attempts were successful. In 2016, Colombia did not succeed in passing the law to tax SSB, possibly to lobbing created by the soda industry (78). In 2016, Chile approved the law that included mandated front-of-package warning labels, restriction of child-directed marketing, and the prohibition of sales in schools of all foods and beverages containing added sugars, sodium, and saturated fats that exceeded the guidelines (79). In 2020, the Mexican Congress approved the inclusion of the front-of-pack warning labels in the General Health Law. The warning labels should appear on products that are high in calories, sugar, salt, saturated fats, and trans fats (80).

Strengths and Limitations

The present research has some strengths and limitations that need to be addressed. One strength is the use of direct measurements like anthropometric measures and the used of coordinates to measure the food environment. Although these measurements are more time-consuming, they give a more accurate description of the food environment and the children's BMI. The buffer size can be compared to those used in other studies. However, there is no consensus on which is the best buffer size to measure the food environment.

The cross-sectional design of the study is a limitation because it only reflects associations. The measures of the food environment and weight status were taken only at one point in time. There is no information on the possible change during time. Since it is the first

study that describes the food environment and weight status of school children in rural communities in Guatemala is a good starting point. Due to the low number of schools in the study, the external validity cannot be assured. More research on this topic is needed to comprehend the contributing factors to childhood overweight and obesity at a national level. In addition, information related to eating habits and physical activity in children was not assessed in this study. Furthermore, the general characteristics of the food environment were described, but there was no information of the individual-level of exposure to the food outlets and the food advertisements.

Conclusions

This study showed the associations between less healthy food intake and overweight and obesity in children. Monitoring the food environment not only inside the schools but also around them is important for determining the potential for harm to Guatemalan children.

Chapter 3 - Conclusions

Childhood obesity is an epidemic that is growing in developing countries (5). Guatemala is known for its long history of undernutrition. Most efforts have been designed to decrease this problem. However, recent studies have documented the existence of the double burden of malnutrition, especially in indigenous people at the household and individual level (18, 19). Despite this information, few efforts have been made to document the obesity epidemic in the country. It has been shown that schools are important places to promote or prevent obesity (21). Also, the food environment around schools has the potential to contribute to the reduction of overweight and obesity from a population-based perspective (21). It is necessary to understand the potential contributing factors to enhance public health policies to prevent rates of overweight and obesity from continuing to increase.

The associations between less healthy food access and advertisements around schools and rate of overweight and obesity in rural communities in Guatemala has been understudies. This study aimed to evaluate if the prevalence of overweight and obesity was associated with schools. The analysis was conducted on the assumption that the environment that surrounds schools contribute to promoting a higher caloric intake —which potentially could lead to greater BMI—.

A higher number of corner stores were found around all schools compared to other types of food outlets like mobile street food vendors, ice cream shops, or mobile street food stands. Besides, these corner stores were more prevalent within 100 meters around almost all schools. A greater number of unhealthy food outlets were located around all schools as compared to healthier food outlets. A similar pattern was observed for the food advertisements. These were classified according to the WHO nutrient profile. The results showed that the majority of food advertisements should not be advertised. Most of them were small posters or banners and were

found in the corner stores. The prevalence of food advertisements was also higher within 100 meters around schools.

First a characterization of the food environment was conducted, and then the prevalence of overweight and obesity in children was determined. Then it was determined whether there were differences between schools for overweight and obesity prevalence and what factors could be related with that prevalence rate. Finally, a logistic regression was conducted to assess if the prevalence of overweight and obesity was associated with schools. However, no association between food environment and overweight and obesity was conducted in this study. Furthermore, this study cannot assess causality because of its cross-sectional nature.

Other countries like South Korea and the USA have started to implement policies restricting the sale of fast-food around target locations as schools (27). Mexico was among the first countries to put in effect taxes on sugar-sweetened beverages (78). Chile implemented the front-of-pack warning food labels, and recently Mexico has implemented it too (79, 80). On the other hand, in Guatemala, only one law has been implemented regarding healthy eating. The School Feeding Law was enacted in 2017 (19). Since 2018, the Law Initiative for Healthy Food Promotion has been promoted. It includes nutritional education in the schools' curricula, the implementation of front-of-pack warning labels, and regulating the food promotion targeted to children (19).

What does this study add?

This study contributes with evidence about the prevalence of overweight and obesity among schoolchildren in Guatemala. The evidence generated shows the necessity of evaluating the association between the food environment and childhood obesity in rural and urban areas

Future research questions

Several questions were not contemplated in this study, like the association between the food environment and schoolchildren. Knowing the relationship of the dietary behaviors of children could help to broader the picture of the role of the food environment on overweight and obesity. The physical activity information could also contribute to giving a fuller picture of the detrimental factors of childhood obesity. Questions like, what is the association with the dietary patterns, physical activity, consumer environment, and childhood obesity in rural and urban communities? Also, what is the relationship with adult obesity? Longitudinal studies are needed to assess these associations and determine causality.

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Appendix A - **World Health Organization Nutrient Profile**

Table 1 Adaptation of the World Health Organization Nutrient Profile (67)

			Marketing not permitted if product exceeds, per 100 g						
	Food category	**Examples of food included in the category**	**Total fat (g)**	**Sat fat (g)**	**Total sugars (g)**	**Added sugars (g)**	**Non-sugar sweeteners (g)**	**Salt (g)**	**Energy (kcal)**
1.	Chocolate and sugar confectionery, energy bars, and sweet toppings and desserts	Chocolate and other products containing cocoa; white chocolate; jelly, sweets, and boiled sweets. Chewing gum and bubble gum; caramels; liquorice sweets; spreadable chocolate and other sweet; sandwich toppings; nut spreads, including peanut butter; cereal, granola, and muesli bars; marzipan				Not permitted			
2.	Cakes, sweet biscuits and pastries; other sweet bakery wares, and dry mixes for making such	Pastries; croissants; cookies/ biscuits; sponge cakes; wafers; fruit pies; sweet buns; chocolate-covered biscuits; cake mixes and batters				Not permitted			
3.	Savory snacks	Popcorn and maize corn; seeds; nuts and mixed nuts; savory biscuits and pretzels; other snacks made from rice, maize, dough, or potato				0		0.1	
4.	Beverages								
	Juices	100% fruit and vegetable juices; juices reconstituted from concentrate, and smoothies				Not permitted			
	Milk drinks	Milks and sweetened milks; almond, soya, rice and oat milks	2.5			0	0		
	Energy drinks					Not permitted			

	Other beverages	Cola, lemonade, orangeade; other soft drinks, mineral and/or flavored waters (including aerated) with added sugars or sweetener				0	0	
5.	Edible ices	Ice cream, frozen yoghurt, iced lollies and sorbets				Not permitted		
6.	Breakfast cereals	Oatmeal; cornflakes; chocolate breakfast cereals; mueslis	10		15		1.6	
7.	Yoghurts, sour milk, cream and other similar foods	Yoghurt; kephir; buttermilk; flavored sour, fermented milk and drinking yoghurt; fromage frais; cheese-based and other yoghurt substitutes; yoghurt products containing additional ingredients (such as fruit; muesli); cream	2.5	2.0	10		0.2	
8.	Cheese	Medium-hard and hard cheeses; soft cheeses; fresh cheese (such as ricotta, mozzarella); grated or powdered cheese; cottage cheese; processed cheese spreads	20				1.3	
9.	Ready-made and convenience foods and composite dishes	Pizzas; lasagna and other pasta dishes with sauces; quiches; ready meals; ready-made sandwiches; filled pastas; soups and stews (packaged or tinned); mixes and dough	10	4	10		1	225
10.	Butter and other fats and oils	Butter; vegetable oils, margarines and spreads		20			1.3	
11.	Bread, bread products and crisp breads	Ordinary bread (containing cereal, leavens and salt); gluten-free bread; unleavened bread; crisp breads; rusks and toasted breads	10		10		1.2	
12.	Fresh or dried pasta, rice and grains		10	10			1.2	

13.	Fresh and frozen meat, poultry, fish and similar	Eggs			Permitted	
14.	Processed meat, poultry, fish and similar	Sausage, ham, bacon; chicken nuggets; smoked and pickled fish; tinned fish in brine or oils; fish fingers and breaded/battered fish	20			1.7
15.	Fresh and frozen fruit, vegetables and legumes	Fruit and vegetables; legumes; starchy vegetables, roots and tubers			Permitted	
16.	Processed fruit, vegetables and legumes	Tinned fruit, vegetables and legumes; dried fruit, dried vegetables and legumes; marmalade; jams; pickled vegetables and fruit; stewed fruits; fruit peel; frozen French fries; frozen fruit with added sugar	5	10	0	1
17.	Sauces, dips and dressings	Salad dressings; tomato ketchup; mayonnaise; ready-to-use dips; soya sauce; mustard and mustard flour	10		0	1

Appendix B - **Characterization of the sample population**

Table 1 Nutritional status by socioeconomic status in the sample population, El Progreso, Guatemala, 2018

	Socioeconomic Status		
	Tertile 1	**Tertile 2**	**Tertile 3**
Nutritional status	n (%)	n (%)	n (%)
Overweight and obesity	**81 (62.8)**	**29 (22.5)**	**19 (14.7)**
Severe thinness	1 (50.0)	1 (50.0)	0 (00.0)
Thinness	5 (38.5)	4 (30.8)	4 (30.8)
Normal weight	157 (61.8)	62 (24.4)	35 (13.8)
Overweight	46 (62.2)	15 (20.3)	13 (17.6)
Obesity	35 (63.6)	14 (25.5)	6 (10.9)
Central Obesity	91 (63.2)	31 (21.5)	22 (15.3)
Stunting	36 (62.1)	15 (25.9)	7 (15.5)

Table 2 Description of the nutritional status by gender in the sample population, El Progreso, Guatemala, 2018

	Gender	
	Male	**Female**
Nutritional status	n (%)	n (%)
Overweight and obesity	**75 (58.1)**	**54 (41.9)**
Severe thinness	0 (00.0)	2 (100.0)
Thinness	11 (84.6)	2 (15.4)
Normal weight	117 (46.1)	137 (53.9)
Overweight	41 (55.4)	33 (44.6)
Obesity	34 (61.8)	21 (38.2)
Central Obesity	70 (48.6)	74 (51.4)
Stunting	26 (44.8)	32 (55.2)

Appendix C - **Characterization of food outlets**

Table 1 Characterization of food outlets found around four schools in three villages, El Progreso, Guatemala, 2018

Type of retail food source	n (%)
Mobile street vendor	11 (5.9)
Corner store	83 (44.9)
Convenience store	0 (00.0)
Fruit and vegetable store	7 (3.8)
Poultry or meat market	2 (1.1)
Bakery/ Tortilla shop	26 (14.1)
Ice cream shop	18 (9.7)
Diner (homemade food)	5 (2.7)
Markets	0 (00.0)
Fast food chain	1 (0.5)
Temporary street food stand	7 (3.8)
Other	25 (13.5)
Total	185 (100.0)

Table 2 Description Corner stores that sell fruits and vegetables in three villages, El Progreso, Guatemala 2018

Corner stores	n (%)
Sell fruits and vegetables	19 (22.9)
Do not sell fruit and vegetables	64 (77.1)
Total	83 (100.0)

Table 3 Characterization of food outlets by schools and type of retail food source in three villages, El Progreso, Guatemala, 2018

	School 1	School 2	School 3	School 4
Type of retail food source	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Mobile street vendor	2 (3.2)	1 (2.6)	8 (12.5)	0 (00.0)
Corner store	30 (47.6)	25 (65.8)	19 (29.7)	9 (45)
Convenience store	0 (00.0)	0 (00.0)	0 (00.0)	0 (00.0)
Fruit and vegetable store	3 (4.8)	1 (2.6)	2 (3.1)	1 (5.0)
Poultry or meat market	1 (1.6)	0 (00.0)	1 (1.6)	0 (00.0)
Bakery/ Tortilla shop	8 (12.7)	2 (5.3)	11 (17.2)	5 (25.0)
Ice cream shop	9 (14.3)	0 (00.0)	8 (12.5)	1 (5.0)
Diner (homemade food)	3 (4.8)	1 (2.6)	1 (1.6)	0 (00.0)
Markets	0 (00.0)	0 (00.0)	0 (00.0)	0 (00.0)
Fast food chain	0 (00.0)	0 (00.0)	1 (1.6)	0 (00.0)
Temporary street food stand	1 (1.6)	0 (00.0)	6 (9.4)	0 (00.0)
Other	6 (9.5)	8 (21.1)	7 (10.9)	4 (20.0)
Total	63 (100.0)	38 (100.0)	64 (100.0)	20 (100.0)

Table 4 Characterization of food outlets by schools, type of retail food source, and 100 meters of distance, in three villages, El Progreso, Guatemala, 2018

	100 meters			
	School 1	**School 2**	**School 3**	**School 4**
Type of retail food source	n	n	n	n
Mobile street vendor	2	1	7	0
Corner store	13	2	5	1
Convenience store	0	0	0	0
Fruit and vegetable store	2	0	1	0
Poultry or meat market	1	0	1	0
Bakery/ Tortilla shop	6	0	3	1
Ice cream shop	3	0	1	1
Diner (homemade food)	0	0	0	0
Markets	0	0	0	0
Fast food chain	0	0	1	0
Temporary street food stand	0	0	4	0
Other	1	1	3	0
Total	28	4	26	3

Table 5 Characterization of food outlets by schools, type of retail food source, and 200 meters of distance, in three villages, El Progreso, Guatemala, 2018

	200 meters			
	School 1	**School 2**	**School 3**	**School 4**
Type of retail food source	n	n	n	n
Mobile street vendor	0	0	1	0
Corner store	8	4	3	5
Convenience store	0	0	0	0
Fruit and vegetable store	1	1	0	0
Poultry or meat market	0	0	0	0
Bakery/ Tortilla shop	2	2	2	4
Ice cream shop	4	0	1	0
Diner (homemade food)	0	1	0	0
Markets	0	0	0	0
Fast food chain	0	0	0	0
Temporary street food stand	0	0	2	0
Other	3	2	0	3
Total	18	10	9	12

Table 6 Characterization of food outlets by schools, type of retail food source, and 300 meters of distance, in three villages, El Progreso, Guatemala, 2018

	300 meters			
	School 1	**School 2**	**School 3**	**School 4**
Type of retail food source	n	n	n	n
Mobile street vendor	0	0	0	0
Corner store	5	11	7	3
Convenience store	0	0	0	0
Fruit and vegetable store	0	0	1	1
Poultry or meat market	0	0	0	0
Bakery/ Tortilla shop	0	0	5	0
Ice cream shop	1	0	2	0
Diner (homemade food)	2	0	1	0
Markets	0	0	0	0
Fast food chain	0	0	0	0
Temporary street food stand	1	0	0	0
Other	1	5	2	1
Total	10	16	18	5

Table 7 Characterization of food outlets by schools, type of retail food source, and 400 meters of distance, in three villages, El Progreso, Guatemala, 2018

	400 meters			
	School 1	**School 2**	**School 3**	**School 4**
Type of retail food source	n	n	n	n
Mobile street vendor	0	0	0	0
Corner store	4	2	1	0
Convenience store	0	0	0	0
Fruit and vegetable store	0	0	0	0
Poultry or meat market	0	0	0	0
Bakery/ Tortilla shop	0	0	1	0
Ice cream shop	1	0	4	0
Diner (homemade food)	0	0	0	0
Markets	0	0	0	0
Fast food chain	0	0	0	0
Temporary street food stand	0	0	0	0
Other	0	0	2	0
Total	5	2	8	0

Table 8 Characterization of food outlets by schools, type of retail food source, and 500 meters of distance, in three villages, El Progreso, Guatemala, 2018

	500 meters			
	School 1	**School 2**	**School 3**	**School 4**
Type of retail food source	n	n	n	n
Mobile street vendor	0	0	0	0
Corner store	0	6	3	0
Convenience store	0	0	0	0
Fruit and vegetable store	0	0	0	0
Poultry or meat market	0	0	0	0
Bakery/ Tortilla shop	0	0	0	0
Ice cream shop	0	0	0	0
Diner (homemade food)	1	0	0	0
Markets	0	0	0	0
Fast food chain	0	0	0	0
Temporary street food stand	0	0	0	0
Other	1	0	0	0
Total	2	6	3	0

Appendix D - **Characterization of food advertisements**

Table 1 Characterization of food advertisements

	n (%)
WHO criteria	
Meets WHO criteria	33 (11.0)
Does not meet WHO criteria	238 (79.6)
Cannot be classified	26 (8.7)
Not apply	2 (0.7)
Size	
Small	269 (90.0)
Medium	25 (8.4)
Big	5 (1.6)
Context	
Inside the school	0 (00.0)
Cafeteria/ dinner	4 (1.3)
Corner store	279 (93.3)
Street	9 (3.0)
House	2 (0.7)
Bus stop	0 (00.0)
Food stand	0 (00.0)
Food store	0 (0.3)
Other	4 (1.3)
Marketing type	
Poster/banner	242 (80.9)
Sign	21 (7.0)
Isolated	12 (4.0)
Painting	13 (4.4)
Proper of establishment	1 (0.3)
Boxes or bottles (street or window)	7 (2.3)
Other	3 (1.0)

Table 2 Characterization of food advertisements by schools and advertisements size in three villages, El Progreso, Guatemala, 2018

	School 1	School 2	School 3	School 4
Size	n (%)	n (%)	n (%)	n (%)
Small	46 (80.7)	85 (81.7)	66 (100.0)	72 (100.0)
Medium	9 (15.8)	16 (15.4)	0 (00.0)	0 (00.0)
Big	2 (3.5)	3 (2.9)	0 (00.0)	0 (00.0)
Total	57 (100.0)	104 (100.0)	66 (100.0)	72 (100.0)

Table 3 Characterization of food advertisements by schools and context in three villages, El Progreso, Guatemala, 2018

	School 1	School 2	School 3	School 4
Context	n (%)	n (%)	n (%)	n (%)
Inside the school	0 (00.0)	0 (00.0)	0 (00.0)	0 (00.0)
Cafeteria/ dinner	2 (3.5)	0 (00.0)	0 (00.0)	2 (2.8)
Corner store	48 (84.2)	104 (100.0)	61 (92.4)	66 (91.7)
Street	5 (8.8)	0 (00.0)	2 (3.0)	2 (2.8)
House	1 (1.8)	0 (00.0)	1 (1.5)	0 (00.0)
Bus stop	0 (00.0)	0 (00.0)	0 (00.0)	0 (00.0)
Food stand	0 (00.0)	0 (00.0)	0 (00.0)	0 (00.0)
Food store	0 (00.0)	0 (00.0)	0 (00.0)	1 (1.4)
Other	1 (1.8)	0 (00.0)	2 (3.0)	1 (1.4)
Total	57 (100.0)	104 (100.00)	66 (100.0)	72 (100.0)

Table 4 Characterization of food advertisements by schools and marketing type in three villages, El Progreso, Guatemala, 2018

	School 1	School 2	School 3	School 4
Marketing type	n (%)	n (%)	n (%)	n (%)
Poster/banner	38 (66.7)	85 (81.7)	57 (86.4)	62 (86.1)
Sign	10 (17.5)	4 (3.8)	3 (4.6)	4 (5.6)
Isolated	3 (5.3)	1 (1.0)	5 (7.6)	3 (4.2)
Painting	5 (8.8)	8 (7.7)	0 (00.0)	0 (00.0)
Proper of establishment	0 (00.0)	0 (00.0)	0 (00.0)	1 (1.4)
Boxes or bottles (street or window)	1 (1.8)	6 (5.8)	0 (00.0)	0 (00.0)
Other	0 (00.0)	0 (00.0)	1 (1.5)	2 (2.8)
Total	57 (100.0)	104 (100.0)	66 (100.0)	72 (100.0)

Table 5 Characterization of food advertisements by schools, WHO criteria and size in three villages, El Progreso, Guatemala, 2018

		School 1	School 2	School 3	School 4
Meet WHO criteria	**Small**	9	10	6	7
	Medium	0	1	0	0
	Big	0	0	0	0
Do not meet WHO criteria	**Small**	35	63	57	57
	Medium	8	13	0	0
	Big	2	3	0	0
Cannot be classified	**Small**	2	10	3	8
	Medium	1	2	0	0
	Big	0	0	0	0
Not apply	**Small**	0	2	0	0
	Medium	0	0	0	0
	Big	0	0	0	0
Total		57	104	66	72

Table 6 Characterization of food advertisements by schools, WHO criteria, and context in three villages, El Progreso, Guatemala, 2018

		School 1	School 2	School 3	School 4
Meets WHO criteria	Inside the school	0	0	0	0
	Coffee shop/ dinner	0	0	0	1
	Corner store	8	11	4	5
	Street	1	0	0	0
	House	0	0	1	0
	Bus stop	0	0	0	0
	Food stand	0	0	0	0
	Food store	0	0	0	0
	Other	0	0	1	1
Does not meet WHO criteria	Inside the school	0	0	0	0
	Coffee shop/ dinner	2	0	0	1
	Corner store	37	79	54	53
	Street	4	0	2	2
	House	1	0	0	0
	Bus stop	0	0	0	0
	Food stand	0	0	0	0
	Food store	0	0	0	1
	Other	1	0	1	0
Cannot be classified	Inside the school	0	0	0	0
	Coffee shop/ dinner	0	0	0	0
	Corner store	3	12	3	8
	Street	0	0	0	0
	House	0	0	0	0
	Bus stop	0	0	0	0
	Food stand	0	0	0	0
	Food store	0	0	0	0
	Other	0	0	0	0
Not apply	Inside the school	0	0	0	0
	Coffee shop/ dinner	0	0	0	0
	Corner store	0	2	0	0
	Street	0	0	0	0
	House	0	0	0	0
	Bus stop	0	0	0	0
	Food stand	0	0	0	0
	Food store	0	0	0	0
	Other	0	0	0	0
Total		57	104	66	72

Table 7 Characterization of food advertisements by schools, WHO criteria, and marketing type in three villages, El Progreso, Guatemala, 2018

		School 1	School 2	School 3	School 4
Meets WHO criteria	Poster/banner	7	8	5	5
	Sign	0	0	0	1
	Isolated	2	0	1	1
	Painting	0	1	0	0
	Proper of establishment	0	0	0	0
	Boxes or bottles (street or window)	0	2	0	0
	Other	0	0	0	0
Does not meet WHO criteria	Poster/banner	28	64	49	50
	Sign	10	4	3	3
	Isolated	1	1	4	2
	Painting	5	6	0	0
	Proper of establishment	0	0	0	1
	Boxes or bottles (street or window)	1	4	0	0
	Other	0	0	1	1
Cannot be classified	Poster/banner	3	11	3	7
	Sign	0	0	0	0
	Isolated	0	0	0	0
	Painting	0	1	0	0
	Proper of establishment	0	0	0	0
	Boxes or bottles (street or window)	0	0	0	0
	Other	0	0	0	1
Not apply	Poster/banner	0	2	0	0
	Sign	0	0	0	0
	Isolated	0	0	0	0
	Painting	0	0	0	0
	Proper of establishment	0	0	0	0
	Boxes or bottles (street or window)	0	0	0	0
	Other	0	0	0	0
	Total	57	104	66	72