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The African food environments

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The African food environments

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Editorial: The African food environments

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Africa, food environments, nutrition transition, non-communicable diseases, public health

Editorial on the Research Topic
The African food environments

In many respects, the continent of Africa is undergoing multiple transitions of which the nutrition transition is the most prominent—from a public health perspective. Popkin et al. (1) define nutrition transition as shifts in diets at the population level coinciding with globalization and changes in a country's overall development, food environments, and food systems. One consequence of the nutrition transition is the increase in nutrition-related non-communicable diseases (NCDs) such as obesity, type 2 diabetes, cardiovascular diseases, and certain cancers. Although NCDs are a global public health problem, their rate of increase in low and middle income countries (LMICs) is staggering (2). The surge has been linked to modifiable environmental factors, including physical and social environments—in which people live, work, and eat. Referred to as the food environment—the physical and metaphorical interface that mediates people's food acquisition and consumption within the wider food system (3), available evidence show that it is a key determinant of population health. Unhealthy food environments avail unhealthy foods, and drive unhealthy diets—facilitating the excessive consumption of ultra-processed energy-dense nutrient-poor foods, rather than healthier alternatives such as unrefined cereals, seeds, nuts, fruits, and vegetables.

While the papers included in this Research Topic do not cover the current COVID-19 pandemic, the Russia-Ukraine war, and other global crises such as climate change, the impact of these crises on the food environments, food availability, food prices, food affordability, and food security is real (4, 5). The pandemic and related global economic recession are severe setbacks to already insufficient progress toward meeting the global nutrition targets set for 2025 for stunting, wasting, maternal anemia and breastfeeding (6), and now threaten to exacerbate maternal and child undernutrition across low LMICs (7). Africa is particularly hard hit, having been disproportionally affected by the combined effects of other conflicts, and climate change.

However, our current understanding of the dynamics of the rapidly transitioning African food environments is limited. While hunger and food insecurity still persist, other forms of malnutrition such as obesity and related NCDs have emerged. Toward addressing malnutrition in all its forms, improving food environments in Africa is an urgent priority. Data-driven approaches, fit-for-local policies and actions and responding to all forms of

malnutrition are needed. Fit-for-local purpose data can give insights into which policies may be more effective in combating the multiple forms of malnutrition in Africa. This Research Topic on African Food Environments aimed to solicit practice-impacting and policy-influencing evidence from researchers and practitioners working on the African food environments. It comprises a collection of nine papers from six African countries—eight empiric studies, and a review.

Two studies from South Africa characterized the operations of the street food enterprises (Mahopo et al.) and examined the nexus between food security indicators and anthropometric health. The authors identified opportunities for improving the food environments of a rural South African setting through the implementation of government policies that target street vendors. The authors recommended that, government in partnership with non-state actors deliver such interventions as training and microfinance to improve the business skills of street food vendors while promoting food safety and nutritious foods. Harper et al. estimated the prevalence of double burden of malnutrition in select South African households, and showed that about 70.2% of all stunted children lived with an overweight or obese adult.

In Addis Ababa, Ethiopia, Trübswasser et al. assessed factors influencing adolescents' dietary behaviors in the school and home environments. The authors reported pervasive advertising and availability of unhealthy ultra-processed foods and beverages within the 0.5 km radius around the schools. In their interpretations of the association of unhealthy food environments and outcomes like dietary diversity and nutritional status, the authors acknowledged that their study was not appropriately powered and that the cross-sectional design did not allow for control of temporal factors. Nevertheless, the study provided unique characterization of the food environment of adolescents in Addis Ababa, leading to the conclusion that unhealthy food environments as observed in the study could be an impediment to the success of interventions that promote healthy dietary behaviors.

Tione et al. examined the role of farm input subsidies in wasting prevention among Malawian children under-5 years. Data from the study suggest that input subsidies can speed up wasting reduction among children under-5 years through pathways such as increased maize production, sustained food availability. In Uganda, Nankumbi et al. assessed vitamin A-rich food consumption and its predictors among women of reproductive age from an orange-fleshed sweet potato-growing households of Uganda. This work showed that knowledge about vitamin A did not predict vitamin A rich food consumption.

Three studies from Ghana explored different dimensions of the school food environment. Amevinya et al. examined the extent and nature of food and beverage advertising around primary and junior high schools in Ghana's most populous and urbanized region, Greater Accra. As in the Ethiopian study, Amevinya et al. report a pervasive advertising of sugar-sweetened and alcoholic beverages in the studied schools. They recommend policy action such as restriction of marketing of unhealthy foods, and zoning regulation to limit the exposure to children of unhealthy food advertisements. A related study by Adjei et al. reveals widespread availability of ultra-processed foods in modern retail outlets in the same setting. Toward a healthier food retail environment, public health, and food regulators, in partnership with other stakeholders need to institute measures that improve availability of healthy foods within supermarkets and mini-marts. Nanema et al. explored Accra-based food retailers' perceptions and appreciation of "healthiness of food" as a concept. They also documented measures that food retailers adopt to encourage healthy food choices. Accra-based retailers have a fair understanding of what constitutes healthy food–exhibiting limited knowledge of the connection between very salty, very sugary, and very fatty foods and health outcomes, the researchers reported. Retailers in Accra would benefit from interventions that improve their food, health, and nutrition literacy.

Presenting regional data (focusing on School Meal Programs in Africa) from the 2019 Global Survey of School Meal Programs, Wineman et al. commended the "home-grown school feeding philosophy" in Africa. These favor national ownership and domestic food procurement, with positive externalities spanning social, and economic dimensions. A salient, but rather worrying finding from the survey was the limited attention given to overweight/obesity in school meal programs in Africa (Wineman et al.). Only about 10% of the School Meal Programs identified overweight/obesity prevention as an objective. As Africa becomes increasingly urbanized, with transitioning dietary practices that favor processed foods, high in salt, high in sugar, high in unhealthy fat foods with limited consumption of fruits and vegetables but (8), policy and program inattention to the multiple burdens of malnutrition in the continent is concerning. Facing a syndemic of undernutrition, overweight/obesity and other diet-related NCDs, it is crucial that population health policies are responsive to all of these realities. Complementary food environment policies and practices that respond to malnutrition in all its forms—a mix of both low and high agency policy interventions—interventions that seek to "inform and empower"; those that "guide and influence" and those that "incentivize (consumption of healthier foods)," and dis-incentivize/discourage intake of unhealthy foods are urgently needed (9).

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

ALaa: conceptualization and writing of first draft. KB, FZ, GA, and ALar: reviewing and editing of first and final drafts. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Factors Influencing Adolescents' Dietary Behaviors in the School and Home Environment in Addis Ababa, Ethiopia

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Background: Malnutrition affects many adolescents in Ethiopia. Over one-third of adolescent girls and two-thirds of boys are thin. Overweight and obesity in Ethiopia is mostly a concern in urban populations of higher wealth quintiles. Urbanization and globalization of diets is shifting food environments. The objective of this study was to assess whether food environments in and around schools in urban Ethiopia influence dietary diversity, quality, BMI status or perceptions of adolescents.

Methods: Twelve high schools were selected in Addis Ababa (private/government). From each school, 20 pupils aged 15–19 years were randomly selected ($n = 217$) and interviewed about assets in their households, their diets (categorized into 10 food groups of the Minimum Dietary Diversity, the Global Dietary Recommendations scores and four categories of the NOVA classification based on level of processing) and their use of pocket money. In addition, food environment audits were conducted within the school compound and a 0.5 km radius around each school and types of food outlets.

Results: On average there were 436 food outlets and 246 food or drink advertisements around each school. The majority of the advertisements (89.9%) were of ultra-processed foods, mostly sugar-sweetened beverages (SSBs). Most were positioned on food outlets (89.1%). SSBs or sweets were visibly on display in 26.3% of the outlets and fresh fruits and vegetables in 17.9% of outlets. Dietary diversity of adolescents was poor with an average of 3.6 food groups out of 10 consumed in the last 24 h. Ultra-processed foods and beverages were consumed by 23.5% of adolescents. The majority of adolescents spent their pocket money on SSBs, sweets or fried foods. Our analysis found that higher assets in adolescents' households were associated with higher dietary diversity and consumption of healthy food groups. We found no association between the food environment and dietary indicators or the BMI-z-score.

Conclusion: While the school food environments investigated were not conducive with promoting healthy dietary behaviors, we cannot conclude that these environmental factors directly influence adolescents' diets. The pervasive advertising and availability of unhealthy foods and beverages requires policy action for healthy school food environments.

Keywords: food environment, urban, food advertising, food outlet, adolescents

INTRODUCTION

Dietary behaviors within populations are highly dependent on which food and beverages are available, affordable, safe or convenient in their surroundings (food environment) (1). Food environments can be defined as the spaces where individuals interact with the food system and encompass availability, promotion, quality, convenience and physical and economic access (2). Availability and cost influence adolescents' dietary behaviors, as well as their appeal and aspirational association (3). Food environments are changing globally due to expanding urbanization, technology, trade and labor markets. These changes are leading to increased availability of energy-dense, nutrient-poor, ultra-processed foods and beverages associated with the 'nutrition transition' (4). This in turn can negatively affect dietary quality, with high consumption of ultra-processed foods and beverages, such as sugar-sweetened beverages (SSBs). SSBs are associated with poor nutrition and health outcomes, including overweight and obesity and diet-related non-communicable diseases (5).

The nutrition transition has taken place in high-income countries over the last few decades and is well underway in low- and middle-income countries (LMICs) (5, 6), including in Africa (7).

Changing food environments can influence the dietary habits of adolescents (8), who spend a lot of their time at school and are at a critical time of habit formation and increasing autonomy (9–11). The promotion of ultra-processed foods and beverages often targets children and adolescents to generate brand awareness, preference and loyalty, securing a future consumer base (12). Hence, food environments around schools can play a critical role in adolescents' diets (9, 13, 14). As studies from mostly high-income countries but also LMICs have shown, the availability of unhealthy food or beverages inside or around schools, in the absence of parental supervision, negatively affects dietary choices (9, 15–18). In LMICs, parental education and occupation were also found to be associated with better nutritional status and dietary behaviors (19, 20).

Adolescents' diets in LMICs seem to be inadequate: predominantly cereal-based and limited in terms of animal-source foods, fruit and vegetables (21). Particularly in urban areas, increased consumption of processed energy-dense and nutrient-poor foods and drinks has been reported (8). In Ethiopia, up to a third of adolescents consume SSBs on a daily basis (22). Whether these dietary behaviors are related to the food environment surrounding schools in Ethiopia remains unknown. Pupils in many countries, including Ethiopia, have limited pocket money to spend and their caregivers act as "gatekeepers" of their choices (10). However, how Ethiopian adolescents from different socio-economic backgrounds are exposed to food outlets on the way to and from school and how this can affect their dietary and purchasing behaviors and nutritional status requires exploration. Therefore, this study assessed whether food environments in and around schools in urban Ethiopia influence dietary diversity, quality, body mass index (BMI) status or adolescents' perceptions of their school and home food environment.

METHODS

Study Design and Context

A cross-sectional study was conducted, including school food environment audits as well as interviews with students of private and government schools. The selection of private and government schools was used as a proxy for socio-economic status, based on the rationale that private schools charge tuition fees (23). The schools were selected in collaboration with Addis Ababa Bureau of Education and the Addis Ababa sub-city administration using a list of all middle and high schools in the city. Our aim was to identify a pair of one private and one government school that had less than a 0.5 km distance between them to ensure that participants from both schools shared the same food environment. Twelve schools fulfilled this criterion and were located in six different sub-cities of Addis Ababa, Ethiopia (Arada, Bole, Kality, Kirkos, Kolfe-Keranio and Laphto).

Participant Recruitment

Given the scarcity of data on adolescents in schools, and the multiple outcomes of interest, the sample size was calculated to detect a medium effect size (Cohen's *d*; 0.5 SD) difference between two means, assuming $\alpha = 0.05$ and power $= 0.95$. Lists of all enrolled students and their ages were obtained for all the sampled schools. From these lists, containing a total of 1,500 students/school on average, 20 adolescents (aged 15–19 years) were randomly selected. In every school, a teacher assisted with identifying adolescents and informing them and their parents about the study. This resulted in a total target sample of 240 adolescents who were invited for interview.

Data Collection Procedure

Enumerators with experience in data collection and with an excellent command of the local language, Amharic, were recruited and trained for 3 days on interviewing skills, dietary intake assessments and anthropometric measurements.

The training was followed by a pre-test of the adolescents' questionnaire and the food environment audit tools, which permitted adaptations when necessary. Using interview-administered questionnaires, information on socio-demographic characteristics and food consumption was assessed for the recruited adolescent participants in all schools. Moreover, height and weight were measured to assess the BMI status. As a next step, the external and internal food environment in and around all 12 schools was assessed using protocols from the International Network for Food and Obesity/Non-Communicable Diseases Research, Monitoring and Action Support (INFORMAS) network to measure food environments that contain elements on food promotion (advertising) and types of food outlets (24). Data were collected between March and June 2019.

Socio-Economic Variables and Purchasing Behavior

Since adolescents were not able to provide information on family income, they were asked about 13 different assets that their family owned, based on the family affluence scale (25) and the asset list included in the Ethiopian Demographic Health Survey (26) (yes = 1, no = 0). From the responses, we calculated the sum of all scores by assigning one point to each asset (min–max score = 0–13). Additionally, we asked if adolescents had their own bedroom, received pocket money and how they commuted to school. If they received pocket money, we asked for the amount they received per week and if they spent it on SSBs, sweets, fruit or fried foods.

Adolescents' Perceptions of Their School and Home Food Environment

We assessed adolescents' perceptions in terms of the availability of fruit and vegetables or snacks at their homes, as well as their perception of availability and advertising of (un)healthy foods in the school food environment. We used tested statements previously used in studies with adolescents (20) or in studies assessing perceptions of the food environment (27, 28). The statements were read to the participants and they reported their agreement with each statement using a five-point Likert scale (1 = *strongly disagree* to 5 = *strongly agree*).

Dietary Intake Assessment

Interviewers used an open-ended qualitative 24-h recall, starting with an unstructured listing of all foods and beverages consumed, followed by memory cues to assess consumption over the previous 24 h.

Anthropometric Measures

Height and weight were measured with standardized measurements in triplicate. Height was measured with stadiometers (SECA 213) in a standing position without shoes and was recorded to the nearest 0.1 cm (29). Electronic weighing scales (SECA 872) with a weighing capacity of 10–140 kg were used to assess the weight of all participants to the nearest 0.1 kg.

TABLE 1 | Socio-demographic and anthropometric characteristics of study participants (total and separated by school type).

	Total (n = 217)	Private schools (n = 107)	Government schools (n = 110)	*P* value
	Mean ± SD or *n (%)*			
Age (years)	17.2 ± 1.0	17.1 ± 1.1	17.2 ± 0.9	0.25
Gender				
Female	128 (59)	59 (55.1)	69 (62.7)	0.27
Socio-economic indicators				
Number of assets[2]	10.1 ± 1.6	10.8 ± 1.4	10.8 ± 1.4	<0.001
Own bedroom	88 (40.6)	63 (58.9)	25 (22.7)	<0.001
Receives pocket money	161 (74.2)	93 (43.3)	68 (31.6)	<0.001
Weekly pocket money amount (Ethiopian Birr)[1]	94.8 ± 87.2	110.9 ± 101.0	72.9 ± 57.4	<0.001
Nutritional status				
BMI-for-age *z*-score (mean)	−0.7 ± 1.2	−0.6 ± 1.3	−0.8 ± 1.1	0.15
Underweight[3]	28 (12.9)	16 (14.9)	12 (10.9)	0.21
Overweight[3]	16 (7.4)	11(10.3)	5 (4.6)	0.21
Obesity[3]	4 (1.8)	2 (1.9)	2 (1.8)	0.21
Normal weight	168 (77.8)	78 (72.9)	90 (82.6)	0.21

[1] *Ethiopian currency.*
[2] *Min–max score = 0–13.*
[3] *Underweight, z-score < −2; overweight, z-score > +1 and < +2; obese, z-score > +2.*

Food Environment Assessment

For each school, the external food environment around the school within a radius of 0.5 km was assessed for visibility and advertising of foods and beverages using the INFORMAS protocol for "Promotion – Outdoor Advertising," which has been used in other LMICs (24). Food advertisements were categorized as advertisements promoting food or beverage brands on stationary objects, such as posters, banners, bus-stop advertisements, flags, furniture, umbrellas, tables, fridges or free-standing signs in public spaces. For every advertisement, the category, location (GPS code), size (small, medium or large) and type of food or beverage advertised were recorded. Food outlets were assessed in terms of outlet categories, location (GIS code), presence of advertising and display of fruit, vegetables or SSBs. Enumerators did not enter any stores but walked up and down every single street in the defined radius.

The data collection tool for the food environment assessment was pre-tested in October 2018, in central Addis Ababa (Arat Kilo), in an area close to two of the schools. During the pre-test 12 categories of food outlets were identified, as any shop, café or restaurant selling food or beverages, and categorized as "informal" if the shop's structure (if any) was movable and not permanent (see **Supplementary Material 1** for the 12 categories). The tool was tested on each food outlet type and the findings

TABLE 2 | Dietary and purchasing behavior of study participants: consumption and purchase by food group and level of processing (total and separated by school type).

	All schools (n = 217)	Private (n = 107)	Government (n = 110)	P value
	Mean ± SD or n (%)			
Dietary diversity				
Mean dietary diversity score	3.6 ± 0.9	3.7 ± 1.0	3.4 ± 0.8	<0.001
GDR				
GDR Total	11.72 ±1.26	11.64 ± 1.36	11.80 ± 1.16	0.34
GDR-Healthy	3.35 ± 1.03	3.34 ± 1.14	3.28 ± 0.90	0.29
GDR-Limit	0.64 ± 0.75	0.79 ± 0.79	0.48 ± 0.67	<0.001
Consumption of different food groups				
Grain	216 (99.5)	107 (100)	109 (99.1)	1.00
Pulses	168 (77.4)	82 (76.6)	86 (78.2)	0.87
Nuts	14 (6.5)	10 (9.3)	4 (3.6)	0.10
Dairy	11 (5.1)	6 (5/6)	5 (4.5)	0.77
Meat	33 (15.2)	26 (24.3)	7 (6.4)	<0.001
Egg	6 (2.8)	5 (4.7)	1 (0.9)	0.12
Dark-green leafy vegetables	44 (20.3)	27 (25.2)	17 (15.5)	0.09
Vitamin A-rich fruit or vegetables	56 (25.8)	27 (25.2)	29 (26.4)	0.88
Other vegetables	213 (98.2)	105 (98.1)	108 (98.2)	1.00
Other fruit	11 (5.1)	5 (4.7)	6 (5.5)	1.00
Ultra-processed foods or beverages	51 (23.5)	29 (27.1)	22 (20)	0.26
Use of pocket money for[1]				
SSBs	31 (19.3)	25 (26.9)	6 (8.8)	0.01
Sweets	40 (24.8)	25 (26.9)	15 (22.1)	0.84
Fruit	9(5.6)	6 (6.5)	3 (4.4)	1.00
Fried food	89 (55.3)	57 (61.3)	32 (47.0)	0.20

[1]*n = 161: n = 93 for private schools; n, 68 for government schools; GDR, Global Dietary Recommendations; SSBs, sugar-sweetened beverages.*

were used to amend the tool. The food environment of the first two schools was assessed by two independent teams of enumerators to align the data collection procedure and assess inter-rater reliability. Within the school compound, we assessed any presence of food or beverage advertising and whether SSBs were sold at the school cafeteria.

Data Quality Control

All tools were translated into Amharic, a local language. The quality of the translation was checked by back-translating the questionnaires into English. All data from the individual interviews and the food environment were entered on tablets (Lenovo TAB 7 essentials) and questionnaires were programmed with Skip Logic using the Open Data Kit, which is an electronic data collection program. Data were uploaded daily on a secure, centrally managed server, allowing daily quality checks from the first author. Daily debriefs with enumerators were conducted by the first and third authors to discuss and resolve any potential challenges.

Data Analysis

All consumed food items and beverages from the previous 24 h were categorized into 10 food groups following the Minimum Dietary Diversity for Women (MDD-W) approach, which is useful to reflect the micronutrient adequacy of diets and is recommended for use in LMICs (30). In addition, foods and beverages were assigned to one of four categories of the NOVA classification based on their level of processing (31). However, our study only focused on whether the foods and beverages consumed fell into the fourth NOVA category of ultra-processed foods. Dietary data were also categorized into Global Dietary Recommendations (GDR) scores, which in addition to the MDD-W add value as indicators of dietary quality. Diet patterns were assessed in terms of their adherence to global dietary recommendations for fruit and vegetables, dietary fiber, free sugars, saturated fat, total fat, legumes, nuts and seeds, whole grains and processed meats. The GDR score is composed of two subcomponents: GDR-Healthy, which is an indicator of the recommendations on nine groups of "healthy" foods; and GDR-Limit, which is an indicator of the recommendations on eight dietary components to limit, such as snacks, ultra-processed foods/beverages and deep-fried foods (32).

Dietary data are presented in terms of mean dietary diversity scores based on the number of food groups (min–max score = 0–10), the mean GDR-Healthy, GDR-Limit and GDR total (calculated by subtracting GDR-Limit from GDR-Healthy and adding 9 to transform the indicator to a range of 0–18), the percentage of adolescents consuming different food groups and ultra-processed foods (based on the NOVA classification) and the percentage of adolescents.

The BMI-for-age z-scores were calculated using WHO AnthroPlus v 1.0.4 to assess the nutritional status of the participants.

IBM SPSS Statistics v25.0 was used for data analysis. Continuous variables are presented as mean ± SD and counts as frequency (percentage). To estimate the relationship of food environment and socio-economic indicators with dietary and nutritional outcomes, we performed a multiple linear regression analysis with dietary diversity scores, diet quality (GDR-Healthy, GDR-Limit) scores or BMI z-scores as the dependent variable and number of outlets around the school, SSB advertising or sale within the school compound, number of assets in the household and pocket money of the student as independent variables. Education level of the parents was included in the model as a potential confounding factor. We dichotomized the food environment variables (number of outlets) into low density (defined as equal or below the median) or high density (values above the median) so that the estimated coefficient was not influenced by outliers.

Perceptions of the school and home food environment were also dichotomized by collapsing "strongly agree and agree" together and "strongly disagree and disagree" together. We then performed a binary logistic regression of the perception variables

with the same food environment and socio-economic variables as independent variables. Statistical significance was set at $\alpha = 0.05$ and all tests were two-sided.

RESULTS

Description of Sample

From a total of 240 eligible adolescents, 217 completed the study; the average age of participants was 17.2 (SD 1.0) years and slightly more than half (59%) were female (**Table 1**). More adolescents from private schools received pocket money and the amounts were also higher for private school students. Over three-quarters of adolescents (79%) walked <10 min from a car or bus to the school gate. Only private school children reported traveling to school in their parent's car (data not shown).

BMI, Dietary Diversity and Quality of Adolescents

Over three-quarters of adolescents (77%) had a normal weight, whereas 13% were classified as underweight and 9% as overweight or obese (**Table 1**); the mean BMI *z*-score was −0.7 (SD 1.2). The mean dietary diversity (DD) score of adolescents was 3.6 (SD 0.9) out of 10 food groups (**Table 2**). Adolescents from private schools had significantly higher mean DD than their peers from government schools ($P < 0.05$). With regard to the GDR, on average, adolescents consumed 3.4 out of the 9 health-promoting food groups (GDR-Healthy) and <1 food or drink of the 8 groups that should be limited or avoided (GDR-Limit). Private school adolescents had higher GDR-Limit scores. In the 24-h period before the interview, most adolescents consumed grains (99%), vegetables (mostly onions: 98%) and pulses (77%), but eggs (3%), dairy foods (5%) or nuts (6%) were rarely consumed. Dark-green leafy vegetables and other vitamin A-rich fruit or vegetables were consumed by less than one-third of adolescents. In contrast, ultra-processed foods and beverages, basically sweets and SSBs, were consumed by almost a quarter (23.5%) of adolescents. Meat consumption was higher in private school adolescents (24.3 vs. 6.4% in government schools).

Three-quarters of adolescents (74%) received pocket money, which they spent on fried food (55%), sweets (25%) or SSBs (19%). While this was the case for all adolescents receiving pocket money, private school attendance was associated with purchasing more SSBs.

Adolescents' Perceptions of Their Home and School Food Environment

Adolescents from both schools agreed that food outlets around the school sell snack foods, although they also perceived healthy food to be available (**Table 3**). While most of them perceived the advertising to be of unhealthy foods or beverages, most also disagreed that there was a lot of advertising in the neighborhood. Having fruit and vegetables available in their homes, in addition to unhealthy snacks, was more likely to be reported by government school adolescents.

Description of the Internal and External Food Environment

Within the school compound, we found that all but two private schools sold SSBs at their cafeteria and three government schools had advertising for SSBs on the school compound. In the 0.5 km radius around a private or a public school, we found an average of 436 (SD 366) food outlets, but with large differences between sub-cities, ranging from 113 to 924 food outlets. The schools in the Kality and Arada sub-cities had the highest numbers of food outlets surrounding them (**Table 4**), which is due to the dense inner-city location of Arada and the large market area in Kality. Consequently, the absolute exposure to outlets selling fruit and vegetables was highest in Kality. Display of SSBs was highest in food outlets in Arada. Kiosks were the most common food outlets, representing 21.9% of all outlets in all clusters, and they had the largest proportion of advertisement and displays of SSBs (46.9% and 60.0%, respectively). The absolute number of advertisements was also highest in Arada ($n = 720$) and Kality ($n = 405$). However, in all sub-cities most of these advertisements promoted SSBs (89.9%). Most advertisements were positioned on food outlets (89.1%) and presented as posters, boards or banners. The second most common form of advertising was as part of the food outlet's equipment, such as umbrellas, tablecloths or fridges (20.0%). The least common forms of advertisements were large billboards (0.9%).

Factors Influencing Adolescents' Diets and BMI Status

Dietary diversity was higher in adolescents with assets in the household when considering both food environment and socio-economic variables; this was also the case for the GDR-Healthy score (**Table 5**). This association remained when including parents' education into the model. No other associations were found with consumption of unhealthy food groups (GDR-Limit) or BMI-for-age and socio-economic indicators. Factors in the food environment were neither associated with dietary scores nor BMI-for age *z*-scores.

Adolescents' perceptions of the home environment were also associated with assets and pocket money (data not shown). Adolescents from households with more assets or pocket money were more likely to perceive that, at their homes, they always had fruit and vegetables as well as snacks, which could be an explanation for the positive association of assets with dietary outcomes.

DISCUSSION

The aim of our study was to examine food environments in and around schools in urban Ethiopia and to explore how they might influence dietary diversity, quality, BMI status or adolescents' perceptions of their school and home food environment. We observed that high dietary diversity as well as higher consumption of healthy foods was associated with adolescents from households with more assets. For both groups of students, our study found a high density of food outlets within the 0.5 km radius around the schools, as well as widespread promotion and

TABLE 3 | Adolescents' perception of the school and home food environment.

Statement	All schools ($n = 217$)	Private ($n = 107$)	Government ($n = 110$)	*P* value
		n (%)		
In my house we always have fruit and vegetables				
(Strongly) disagree	105(48.4)	35 (32.7)	68 (64.8)	<0.001
(Strongly) agree	105 (48.4)	63 (58.9)	33 (31.4)	
Neither agree nor disagree	7 (3.2)	9 (8.4)	9 (8.2)	
In my house we always have fast food, sodas and snacks				
(Strongly) disagree	174(80.2)	76 (71.0)	98(89.1)	<0.001
(Strongly) agree	30 (13.8)	23 (21.5)	7 (6.4)	
Neither agree nor disagree	13 (6.0)	8 (7.5)	5 (4.5)	
There are lots of shops selling snack food in the school neighborhood				
(Strongly) disagree	29 (13.4)	16 (15.0)	13 (11.8)	0.79
(Strongly) agree	184 (84.8)	89 (83.2)	95 (86.4)	
Neither agree nor disagree	4 (1.8)	2 (1.9)	2 (1.8)	
Healthy foods are available in the school neighborhood				
(Strongly) disagree	27 (12.4)	12 (11.2)	15 (13.6)	0.47
(Strongly) agree	176 (81.1)	90 (84.1)	86 (78.2)	
Neither agree nor disagree	14 (6.5)	5 (4.7)	9 (8.2)	
There is a lot of food advertising in the school neighborhood				
(Strongly) disagree	127 (58.5)	63 (58.9)	64 (58.2)	0.99
(Strongly) agree	84 (38.7)	41 (38.3)	43 (39.1)	
Neither agree nor disagree	6 (2.8)	3 (2.8)	3 (2.7)	
The advertising is mostly promoting unhealthy food and drink				
(Strongly) disagree	77 (35.5)	36 (33.6)	41 (37.3)	0.81
(Strongly) agree	127 (58.5)	65 (60.7)	63 (56.4)	
Neither agree nor disagree	13 (6.0)	6 (5.6)	7 (6.4)	

display of ultra-processed foods and beverages in and around the schools. While such an environment is not conducive to promoting healthy dietary behaviors, we cannot conclude that these environmental factors directly explain adolescents' diet or weight status.

The differences between private and government-school adolescents in terms of their dietary diversity and purchasing of SSBs could be explained by the socio-economic status of their families, which we assessed using the number of assets or the amount of pocket money the adolescents receive. Parents who give pocket money without spending stipulations could create financial autonomy, but the lack of supervision could also potentially worsen the unhealthy dietary behaviors of adolescents (33). Studies have shown the different roles that parents play in food consumption. Mothers preparing food at home have been described as a positive influence, whereas high-income parents who are too busy to prepare food may become negative role models (33–35). In our sample, adolescents from households with more assets also perceived that both healthy and unhealthy foods were available in their households. Globally, consuming SSBs is socially stratified, with high-income groups consuming them in LMICs and shifting to lower income groups as a country's income level increases (5). Our data support this, as purchases of SSBs in Ethiopia were greater among participants with more household assets.

We observed that adolescents who spent their pocket money on food/beverages were more likely to spend it on fried foods, sweets or SSBs rather than on fruit. Purchasing little or no fruit on the way to or from school, even though it is widely available, could also be due to food safety concerns related to fruit sold in unhygienic conditions or lack of clean water to wash it (36). Furthermore, adolescents' purchasing choices provided an insight into their preference for fried food, sweets or SSBs over fruit. As opposed to fresh fruit, adolescents could consider packaged ultra-processed foods or beverages to be a safer and socially more acceptable and desirable option (33, 36).

Ultra-processed food and beverages, such as sweets and SSBs, were found to be widely advertised and displayed visibly in the food outlets surrounding schools. A recent review found that in high-income countries, unhealthy retail food establishments are increasing and tend to cluster around schools (16). Furthermore, in LMICs, food companies are developing extensive distribution networks, providing point-of-sale advertising materials or free distributions (5), and using spaces with the highest consumer traffic to tempt consumers into buying ultra-processed foods or

TABLE 4 | Food outlets (type, characteristics) and advertising in and around (0.5 km radius) schools (private and government) in the respective sub-city of Addis Ababa, Ethiopia, *n* (%).

	Mean, all sub-cities	Arada		Bole		Kality		Kirkos		Kolfe-Keranio		Laphto	
School[1]		PS	GS	PS	GS	PS	GS	PS	GS	PS	GS	PS	GS
SSBs sold at school		y	y	n	y	y	y	y	y	y	y	n	y
SSBs advertised at school		n	y	n	n	n	n	n	n	n	y	n	y
Type of outlet													
Outlets, total	436	832		134		924		155		460		113	
Kiosks	93	121 (14.5)		26 (19.4)		193 (20.9)		46 (29.7)		136 (29.6)		38 (33.6)	
Supermarkets	5	9 (1.1)		3 (2.2)		4 (0.5)		0		4 (0.9)		9 (7.9)	
Sweet seller, informal	35	100 (12.0)		7 (5.2)		39 (4.2)		0		63 (13.7)		0	
Fruit and vegetable stall	39	34 (4.1)		7 (5.2)		156 (17.2)		8 (5.2)		23 (5.0)		4 (3.5)	
Local café	101	313 (37.6)		38 (28.4)		116 (12.5)		51 (32.9)		70 (15.2)		18 (15.9)	
Other	163	255 (30.6)		53 (39.6)		416 (45.0)		50 (32.3)		164 (35.7)		44 (38.9)	
Outlets with food or beverage visibility/advertising													
FV visibly displayed in outlet	78	28 (3.4)		21 (15.7)		295 (31.9)		19 (12.3)		85 (18.5)		21 (18.6)	
SSBs visibly displayed in outlet	115	353 (42.4)		82 (61.2)		145 (15.7)		41 (26.5)		48 (10.4)		20 (17.7)	
Food and beverage advertising on outlet	103	234 (28.1)		41 (30.6)		195 (21.1)		48 (30.9)		74 (16.1)		25 (22.1)	
Food and beverage advertising													
Advertising, total	246	720		87		405		99		126		44	
Advertising of ultra-processed food or beverages	222	628 (87.2)		77 (88.5)		388 (95.8)		92 (92.9)		113 (89.7)		34 (77.3)	
Position of advertising on food outlet	220	648 (90.0)		80 (92.0)		359 (88.6)		90 (90.9)		105 (83.3)		40 (90.9)	
Advertising type (poster, board or banner)	176	401 (55.7)		74 (85.0)		359 (88.6)		91 (91.9)		89 (70.7)		33 (88.6)	

[1]*PS, private school; GS, government school; y, yes; n, no; FV, fruits or vegetables; SSBs, sugar-sweetened beverages.*

TABLE 5 | Potential influencing factors on dietary diversity, quality or nutritional status by applying multiple linear regression.

	Dietary diversity			GDR-Healthy			GDR-Limit			BMI-for-age		
Predictors	**Beta**	**S.E.**	***P***	**Beta**	**S.E.**	***P***	**Beta**	**S.E.**	***P***	**Beta**	**S.E.**	***P***
Food environment												
High number of food outlets (> 460)	−0.18	0.16	0.25	−0.11	0.17	0.52	0.04	0.12	0.73	0.14	0.19	0.48
SSBs sold at school	0.09	0.21	0.67	0.21	0.23	0.36	0.25	0.16	0.14	0.43	0.26	0.09
SSBs advertised at school	0.07	0.17	0.67	−0.98	0.18	0.59	0.04	0.13	0.76	0.16	0.21	0.45
Socio-economic												
Asset score	0.11	0.05	0.04	0.12	0.06	0.03	0.02	0.04	0.65	0.09	0.06	0.15
Receiving pocket money	−0.83	0.18	0.64	0.23	0.19	0.23	0.13	0.14	0.37	0.22	0.22	0.31
Education of parents	−0.04	0.08	0.63	0.01	0.09	0.94	0.12	0.06	0.06	0.01	0.10	0.96

S.E., standard error; GDR, Global Dietary Recommendations; BMI, body mass index; SSBs, sugar-sweetened beverages.

beverages (37). Unlike other studies from LMICs, we did not find that unhealthy food environments around schools were directly linked with poorer dietary quality (9) or higher BMI (38, 39). This could largely be due to the fact that students take their own lunch to school, with their parents acting as "gatekeepers" of their choices (10). Therefore, parental and social norms could have a stronger influence on adolescents' diets than the physical food environment. However, adolescents are at a critical stage in life, learning to make their own dietary choices, and with decreasing influence of parents and increasing financial autonomy their dietary behaviors could be more strongly influenced by the food environment (10).

Schools provide a well-defined and preferred setting for prevention strategies to improve the diets of children and adolescents (14). The external and internal school environment assessed by our study was not conducive to healthy food choices. Current Ethiopian school policies are limited to school feeding and food safety, and lack actions on the availability or advertising of food in and around schools (40), which are needed to extend policy action to focus on addressing all forms of malnutrition.

Strengths and Limitations

To our knowledge, this is the first study to map food environments in and around schools in urban Ethiopia and explore how this is associated with the dietary behaviors and weight status of adolescents. Due to its cross-sectional nature, the study only provides a snapshot of the prevailing food environment and diet diversity at the time of the survey and therefore does not allow causal inferences to be made. Assessing only the school environment might have been a limitation

because the home environment can also play an important role. Considering the limited amount of pocket money that students reported receiving and also the "gatekeeping" role of parents, adolescents' interaction with the food environment in and around the school was limited. Given this limited interaction with the food environment, adolescents' perceptions of the food environment could be a better proxy for their potential behavior. Furthermore, reducing our food environment measures to the number of food outlets might have simplified the complexity of the study. Measuring specific elements of the food environment that we identified as relevant for adolescents' purchasing behavior, such as availability, price and vicinity of fried food, could have been a better indicator. However, such a detailed assessment of the food environment was not feasible with the resources available. Despite this limitation, our detailed description of the food environment in and around the schools, the auditing of advertising by food group and by processing level, along with the diet characterization and perceptions of the adolescents, make this study uniquely important in light of the limited data on school food environments and adolescents' diet in Ethiopia, Africa and beyond.

Conclusions and Implications

Our study found a high density of food outlets within the 0.5 km radius around the schools, as well as widespread promotion and display of ultra-processed foods and beverages in and around the schools. Such an environment is not conducive to promoting healthy dietary behaviors. While our study could not conclude that these environmental factors directly explain adolescents' diet or weight status, the influence of socio-economic and family backgrounds appeared more relevant.

These findings suggest that parents need to be directly involved in school interventions so that the home food environment can also be addressed. To ensure that adolescents make healthy dietary choices with their own pocket money, education on dietary quality through multiple channels is necessary. In addition, the currently widespread unhealthy choices in the school food environment need to be regulated. Advertising of unhealthy food and beverages in and around schools should be restricted and food and beverages offered in school cafeterias should follow food-based dietary guidelines (41), which are currently being drafted and validated in Ethiopia (42).

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the study protocol was approved by the College of Natural and Computational Science Institutional Review Board of the Addis Ababa University (No. IRB/035/2018). Informed written consent was obtained from all study participants prior to data collection. For participants under 18 years, additional parental/guardian-informed written consent/ascent was obtained. All interviews were conducted on school premises and after school hours with no school staff present. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

UT conceptualized the research question, conducted the analyses, and authored the paper. KB coordinated the data collection. SE assisted in data collection and analysis. ET, EF, MH, MP, and KB assisted with conceptualizing the study, interpreting the results, and revising the manuscript. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.861463/full#supplementary-material

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School Meal Programs in Africa: Regional Results From the 2019 Global Survey of School Meal Programs

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Introduction: School meal programs operate throughout Africa, serving as a social safety net and aiming to improve children's nutrition, influence their dietary choices, and strengthen the agrifood economy through local procurement. Despite their rapid expansion in the past decade, there has been no systematic effort to comprehensively document school feeding activities across the continent.

Methods: Detailed information on school feeding activities in each country was captured in the Global Survey of School Meal Programs©, which launched in 2019. An invitation to participate was extended to each government, which appointed a national-level respondent to gather information on every large-scale school meal program in the country.

Results: Forty-one countries in Africa (38 in sub-Saharan Africa) responded to the survey in 2019 with information on 68 large-scale programs that together reached 60.1 million children. Across these countries, the aggregate school feeding budget was USD 1.3 billion. Diversity in school meal programs is evident across regions, country income levels, and levels of national commitment. Coverage rates tended to be highest in southern Africa, in countries with school feeding as a line item in the national budget, and in countries with the greatest domestic share of the school feeding budget. Diversity in the school menu tended to be greatest in programs that sourced food through domestic purchase rather than relying on foreign in-kind donations. To address micronutrient malnutrition, about two-thirds of the programs served fortified foods, and one-quarter included micronutrient supplements. Even as rates of overweight/obesity are rising among African school children, just 10% of school meal programs identified its prevention as an objective.

Conclusion: The extent to which school meal programs in Africa are supported with domestic funding reflects a dramatic shift in favor of national ownership and domestic food procurement. At the same time, programs have grappled with inadequate

and unpredictable budgets and challenges related to supply chains and logistics—impediments that need to be addressed if these programs are to achieve their objectives. Overall, the survey results underscore the important position of school meal programs within African food systems and their potential (if well-designed) to sustainably improve food security, child health, and nutrition.

Keywords: Africa, agriculture, education, health, nutrition, school feeding, school meal programs, social protection

INTRODUCTION

School meal programs—through which students are provided with meals, snacks, or take-home rations—comprise one of the most widespread safety nets in the world, reaching an estimated 388 million children (1) and operating in a greater number of countries than any other safety net program (2). For many children, particularly those in low-income settings, the food served in schools represents their only regular meal of the day, making school meal programs relevant to achieving the second Sustainable Development Goal (SDG) of ending hunger. The past decade has seen a rapid expansion of school meal programs in Africa, with the number of children who benefit growing by 71% between 2013 and 2019 (3, 4), and African governments have increasingly exhibited support for school feeding through their budget allocations and policy frameworks (4, 5).

School meal programs are intended to address multiple cross-sectoral objectives. They aim to enhance access to education by reducing barriers to school enrollment, raising attendance and retention, increasing students' ability to concentrate during the school day, and improving learning outcomes (3). They also aim to reduce the gender gap in education by addressing barriers to schooling that are particularly salient for girls (6, 7). By targeting children from low-income households, school meal programs additionally serve as a social safety net (4, 8, 9). They address objectives related to health and nutrition by reducing hunger and improving children's micronutrient status with diverse menus and food fortification, and, particularly in high income settings, school meal programs are often designed to model healthy eating habits and influence children's food choices (10).

Along these lines, evidence has accumulated regarding the positive impacts of school meal programs, with effects often mediated by variations in program design. Many studies have documented a positive impact on school enrollment, attendance, and retention, particularly where baseline levels of school participation are low (9, 11–13). In-school feeding has been found to have a greater impact on enrollment for girls than for boys (14), though in at least some cases, the persistence of this pattern is contingent on the supplementary provision of take-home rations for girls (6, 12). There is also considerable evidence of the impact of school feeding on children's cognitive performance and educational achievement (11, 14). In terms of health and nutrition, there is evidence of positive outcomes for children's height and weight (13) and micronutrient status, such as hemoglobin concentration/anemia and vitamin A status (15, 16). A recent analysis of school meal programs took account of impacts across multiple sectors and arrived at a benefit-cost ratio of between 7 and 35 (17), attesting to the numerous benefits generated by such programs.

In recent years, home-grown school feeding (HGSF) has increasingly gained traction. HGSF programs incorporate the procurement of locally grown food into the design of school meal programs with the intent to promote local economic development and agricultural transformation. By meeting the schools' demand for food with that supplied by smallholder farmers, these programs aim to foster a new market for farm output and create jobs all along the food value chain (4, 9, 18, 19). Local procurement is further employed to address health and nutrition objectives by ensuring that school menus contain a variety of nutritious foods (10, 16, 20–22). However, as HGSF programs are a more recent innovation, there is limited evidence regarding their impacts on agricultural and local economic development (3).

Reflecting their mani-fold objectives, school meal programs encompass a diverse set of designs and implementation arrangements. Programs can vary in the modality through which food is provided, the contents of the menu, the way children are targeted to receive food, the embedding of conditions into the criteria for participation, and the pairing of school meals with other health and nutrition programs, among many other factors. The three main modalities through which food is provided to school children include in-school meals, in-school snacks (such as fortified biscuits, fruits, or milk), and take-home rations given to the students' families, often conditional upon their children maintaining a certain rate of school attendance (3).

In addition to variation in the food items served, school meal programs can vary in their inclusion of fortified foods, biofortified foods, or micronutrient supplements to enhance the nutritional content of the menu. School meals and snacks may also vary in their site of preparation (on school grounds or off-site) and their level of processing, and the programs can vary in their level of centralization, with decisions alternatively made at the central, regional, local, or school levels. Finally, programs may choose to incorporate a wide variety of complementary services, such as deworming treatment, handwashing with soap, or nutrition education, which augment the value of the food provided (7).

Even as school meal programs have grown in scale, scope, and function, the data landscape on school feeding tends to be fragmented, with inconsistent quantity and quality of information across countries and even across different programs within the same country (23). While it is relatively easy to find information on programs implemented by the World Food Program or other international partners, information on

nationally owned programs (i.e., those managed by governments, either alone or with support from development partners) can be quite scarce—though the latter are substantial in scale and geographic reach. Furthermore, information is not collected and published regularly, making it difficult to compare school feeding operations across different settings or discern trends over time.

The disarray in the school feeding data landscape prompted Bundy et al. (24), pp. 94–95 to call for "a database on school feeding programs that describes the coverage and functioning of programs globally… [in order] to estimate, for example, the global population served by school feeding programs, the gaps in coverage, the costs of different programs, the regularity of program functioning, or the popularity of different modalities." In response to this call, the Global Survey of School Meal Programs © was launched in 2019, capturing information on the scope and nature of school feeding activities in each country in a consistent, comprehensive, and recurring manner.

This paper presents results for the 41 African countries that responded to the Global Survey of School Meal Programs in 2019. Results are used to estimate the scale, coverage, and budgets of school meal programs in Africa; characterize the programs and their beneficiaries; analyze the food baskets provided and food sources accessed; assess various health and nutrition aspects of the programs; and comment on the enabling environment around school feeding.

MATERIALS AND METHODS

Data

The 2019 Global Survey of School Meal Programs collected information on the existence of school meal programs in each country. The survey was reviewed by the University of Washington Institutional Review Board and was deemed to be exempt from consent procedures, as this data collection exercise did not constitute human subject research. The survey was based on the United Nations listing of 193 countries plus Palestine, which has observer status at the U.N., and the survey's reference period was the most recently completed school year, which was 2017/2018 for most countries in Africa.

The survey captured detailed information on the number and characteristics of beneficiaries; the avenues through which school meal programs procured and distributed food; the extent and nature of government involvement with school feeding; job creation in school meal programs and engagement with farmers and the private sector; and related health and sanitation topics. While some information was collected at the country level, most information was collected at the level of each large-scale school feeding program. In the context of this survey, this is defined as a program that is managed and/or administered by the national government, by regional or local governments, or by a non-governmental entity in coordination with the national government, or one that reaches a substantial proportion of students in the country or covers a substantial geography.

Data collection took place throughout 2019, when the survey team reached out to national governments to secure their cooperation. Each government designated a "focal point," an individual who was knowledgeable about school feeding activities in the country and/or could gather needed information to complete the survey. To ensure a consistent understanding of terminology, the survey was accompanied by a detailed glossary of terms used in the questionnaire. The data set and further details on the data collection process can be accessed through the Global Child Nutrition Foundation (23).

Of the 54 countries in Africa, 41 countries (38 in sub-Saharan Africa (SSA)) responded to the survey in 2019 (**Figure 1**). These countries were Benin, Botswana, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, Egypt, Ethiopia, Gabon, The Gambia, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mozambique, Namibia, Niger, Nigeria, Republic of Congo, Rwanda, São Tomé and Príncipe, Senegal, Sierra Leone, South Africa, South Sudan, Sudan, Togo, Tunisia, Uganda, Zambia, Zimbabwe, and eSwatini. This equals 76% of the countries in Africa (79% in SSA), which together held approximately 82% of the continent's population as of 2017 (86% in SSA). Two countries (Comoros and Gabon) reported that they had no large-scale school feeding activities, while the others together provided information on 68 programs.

As of 2017, half of the countries in Africa were categorized as low income; one-third were considered lower middle-income; eight countries were upper middle-income; and just one country was high income (25). The African response rate to the 2019 Global Survey of School Meal Programs tended to decline with rising wealth levels, such that 85% of low-income countries, 72% of lower middle-income countries, and 63% of upper middle-income countries responded to the survey. The sole high-income country did not respond. Summary statistics in this paper reflect only the sample of respondent countries, and hence most accurately capture conditions in low-income and lower middle-income settings within Africa.

Variables and Methods

The survey results are used to construct key indicators related to school feeding, several of which merit explanation. First, the school feeding coverage rate for a given country or region is defined in this analysis as the share of primary and secondary school-age children (usually ages 6 through 18) that received food through school meal programs. The denominator in this indicator is therefore inclusive of both enrolled students and out-of-school children/youths. Second, budgets for school meal programs have been converted to United States dollars (USD) using an exchange rate that correlates to the timing of the school year in each country. However, these monetary values have not been standardized to account for differences in the length of school year or number of school feeding days, which can vary across countries and programs. Third, some indicators, such as the share of food from local sources, reference "local" settings. "Local" refers to an administrative level more localized than the region/state/province level, hence at the district, county, municipality/town, or community level. Fourth, the survey did not ask focal points to categorize programs as being "home-grown" or not, given the ambiguity in this delineation. However, some programs are named this way, and many respondents used the term in their narrative accounts of school feeding in

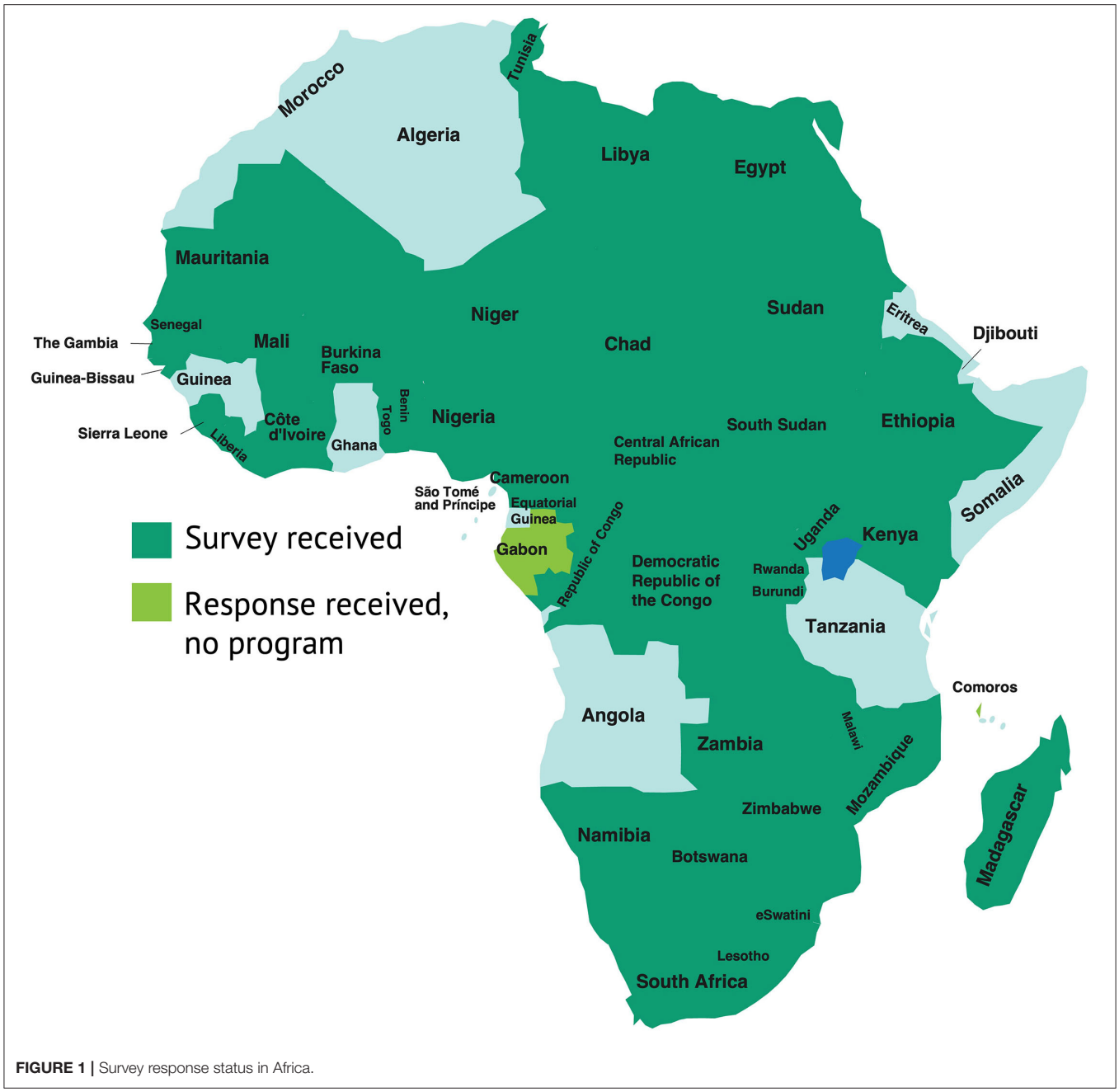

FIGURE 1 | Survey response status in Africa.

their countries. The discussion below therefore maintains this language. Fifth, the survey collected information on food sources and avenues of procurement. In the analysis below, school meal programs are alternately classified as either relying on domestic purchase (drawing at least 70% of food through purchase and purchasing only from domestic sources), relying on foreign in-kind donations (drawing at least 70% of food through in-kind donations, at least some of which came from faraway countries), or relying on neither.

These variables related to school feeding are analyzed in a descriptive manner using Stata (version 16.1), alternately reporting average values across countries, aggregate values across Africa or Africa's subregions, or average values (or percentages) across school meal programs. Correlations between two variables are sometimes also calculated using a simple linear regression.

RESULTS

Coverage of School Meal Programs and Characteristics of Beneficiaries

Across the 39 African countries with school feeding, 59% had just one school meal program, 18% had two programs, 13% had three programs, and 10% had four programs in operation.

TABLE 1 | School feeding coverage rates (percent of school-age children receiving food).

		Coverage rate (%)	
		Cross-country average	Total (aggregated across countries)
A. Primary and secondary school age			
	All countries	23	21
Income group	Low-income	17	15
	Lower middle-income	26	24
	Upper middle-income	46	67
Region	Central	11	3
	Eastern	11	12
	Northern	21	40
	Southern	50	42
	Western	19	22
B. Primary school age			
	All countries	33	30
Income group	Low-income	24	20
	Lower middle-income	38	37
	Upper middle-income	61	73
Region	Central	19	4
	Eastern	14	17
	Northern	36	71
	Southern	63	45
	Western	33	35
C. Secondary school age			
	All countries	7	6
Income group	Low-income	4	3
	Lower middle-income	8	2
	Upper middle-income	16	57
Region	Central	0	0
	Eastern	5	4
	Northern	4	4
	Southern	20	24
	Western	4	2

In these countries, an estimated 60,053,496 children of all ages received food through school meal programs. The three countries with the greatest absolute numbers were Egypt (11.52 million), Nigeria (9.83 million), and South Africa (8.95 million); the rate at which Nigeria's national school meal program was scaled up is particularly noteworthy, as it was newly launched in 2016.

Across the 41 African countries that submitted a survey response, the average school feeding coverage rate was 23%. Similarly, when aggregating across countries (i.e., when summing populations rather than calculating a cross-country average), 21% of school-age children received food through their schools (**Table 1**). Coverage increased with wealth, rising from 15% in low-income countries to 24% in lower middle-income countries and 67% in upper middle-income countries.

Coverage rates also varied across regions within Africa, ranging from 3% in central Africa to 42% in southern Africa. Eight countries had school feeding operations that reached at least half of their primary and secondary school age children, including Namibia (50%), Burkina Faso (52%), São Tomé and Príncipe (53%), Lesotho (56%), Botswana (62%), Zimbabwe (67%), South Africa (72%), and eSwatini (85%).

The survey results revealed a striking correlation between coverage rates and having school feeding as a national budget line item. Across the 13 countries with no line item, 15% of primary and secondary school-age children received food through their schools, while across the 28 countries with a line item, this value was 25%. Countries in central or eastern Africa were least likely to report school feeding as a line item.

All African countries with school feeding programs provided food to those in primary school, with seven countries reporting that they reached at least 80% of their enrolled primary school students, including Botswana, Burkina Faso, Egypt, Lesotho, São Tomé and Príncipe, Sierra Leone, and eSwatini. Over half (56%) of the countries also provided food to pre-school students; 44% reached students in secondary school; and two countries (Burkina Faso and Madagascar) reached some students in vocational/trade schools. It follows that coverage rates for primary school-age children tended to be higher than for other ages: Across all countries, 30% of primary school-age children received some food through their schools, while this value is just 6% for those of secondary school-age.

Across the 68 school meals programs, 63% provided gender-disaggregated student numbers, usually reporting a roughly equal gender breakdown of beneficiaries. Many of the school meal programs were targeted geographically, serving all schools within a given area that was selected based on the prevalence of poverty/food insecurity and rates of school enrollment/attendance. At the same time, three quarters of programs with take-home rations targeted these with consideration of individual characteristics, such as the students' gender or poverty status.

Characteristics and Components of the School Meal Programs

School meal programs in Africa exhibited a range of objectives. All were designed to meet educational goals, 88% aimed to meet nutritional and/or health goals, and 81% served as a social safety net, ensuring food access for poor or vulnerable children. It was less common (at 46%) for programs to report agricultural objectives, and just 10% of the programs in Africa explicitly aimed to prevent obesity.

In-school meals were the most common modality through which food was provided, with 94% of programs serving meals in schools, 12% serving snacks, and 26% providing take-home rations. It was common for programs to pair meals/snacks with take-home rations; in fact, there were no programs that *only* provided take-home rations. In-school meals were served (or at least intended to be served) 5 or 6 times per week in 92% of the programs and 2 times per week in another 8%. Take-home rations were provided less frequently, often at monthly intervals or at other frequencies, such as quarterly, biannually, or during the lean (hunger) season. Lunch was part of school

meal programs in 90% of the countries, while breakfast was served in 31% of the countries. Only programs in Niger and Tunisia served an evening meal, generally in the context of public boarding schools.

Across the 41 African countries that responded to the survey, the total school feeding budget summed to USD $1,318,904,945 for the most recently completed school year. In aggregate, the continent spent $22 per year per beneficiary child. As expected, this value increased with rising wealth (from $16 in low-income countries to $56 in upper middle-income countries) and varied across regions (ranging from $7 in northern Africa to $34 in southern Africa). Across countries, the average share contributed by government was 45%, the average share from international sources was 51%, and the private sector or other sources provided the rest. While 14 countries contributed less than one quarter of their school feeding budget, 10 countries contributed over three quarters of the budget (**Figure 2**). Furthermore, when aggregating across countries, 80% of the total (summed) budget for school feeding on the continent came from African governments.

The survey results reveal a positive correlation between the national school feeding coverage rate and the government share of the school feeding budget (Coefficient in a simple linear regression = 0.375, $P < 0.001$)—a correlation that remains statistically significant even when controlling for total budget size and/or budget per beneficiary child. Though countries with the greatest domestic funding share tended to be clustered in southern Africa, some outliers demonstrate that this goes beyond regional variation. Burkina Faso, for example, had a domestic funding share of 82% and a coverage rate of 52%. Domestic

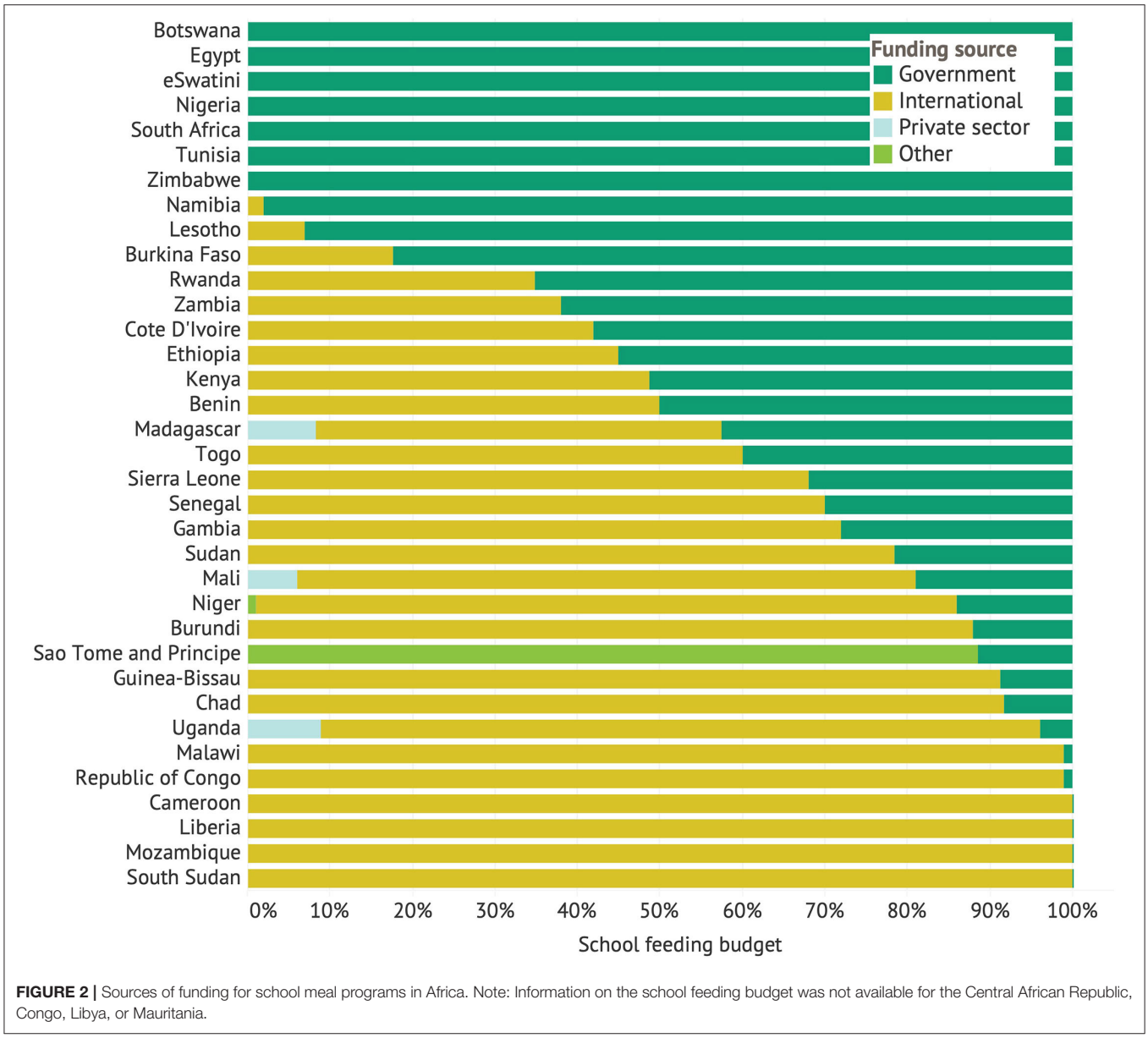

FIGURE 2 | Sources of funding for school meal programs in Africa. Note: Information on the school feeding budget was not available for the Central African Republic, Congo, Libya, or Mauritania.

TABLE 2 | Food items served in school meal programs.

Category	% of programs
Grains/cereals	99
Oil	90
Legumes, nuts	87
Salt	78
Green leafy vegetables	37
Other vegetables	31
Fish	28
Roots/tubers	27
Sugar	24
Meat	21
Fruits	19
Dairy products	18
Eggs	15
Poultry	9

funding of school meal programs is a strong driver of the coverage and sustainability of school feeding.

Food Basket and Food Sources

The food basket contents in African school feeding programs are presented in **Table 2**. Grains/cereals were provided in almost all programs (at 98.5%), as were oil (90%), legumes (87%), and salt (78%). Green leafy vegetables, other vegetables, fish, and tubers were provided in 25–50% of cases, while it was uncommon for poultry, eggs, and dairy products to be included. Dairy products were more commonly included on the menu in upper middle-income countries (at 50% of programs), compared to lower middle-income countries or low-income countries (at 18 and 15% of programs, respectively). In their responses to open-ended questions, the focal points (national survey respondents) often celebrated the inclusion of new food items, as in Burundi, which had recently introduced farm-sourced dairy products to schools, or South Africa, which had recently added sardines to the school meal menu.

Of 14 broad food categories (eggs, dairy, fruit, etc.), the food baskets of school meal programs contained an average of just 5.7 categories. There was some regional variation, with the average number of food categories highest in southern Africa (at 6.8) and lowest in eastern and northern Africa (at 4.5 each). The food basket contents also tended to vary by the modality through which children received food. On average, in-school meals contained foods from 7.4 categories, in-school snacks contained 1.5 categories (often grains in the form of biscuits or porridge), and take-home rations contained 2.1 categories (often grains and oil). Countries in Africa that reported having a national policy related to nutrition in school feeding programs tended to have more diverse school meal menus (with an average of 7.3 food categories) than those with no such policy (average = 5.5 categories).

The most common avenue through which school meal programs in Africa procured food was through domestic purchase, with 83% of programs accessing at least some food through this avenue. This was followed by receipt of in-kind donations from within the country (in 50% of programs) and in-kind donations from other countries (in 47% of programs). Foreign purchases were the least common procurement choice (in 29% of programs).

In-kind donations from foreign countries tended to come from faraway countries, i.e., not in the same economic community or "neighborhood." The World Food Program provided the food in 66% of the programs that received foreign in-kind donations, while in-kind donations from domestic sources tended to come from within the local community, often taking the form of parents supplying ingredients, such as condiments, to their children's schools. In 11% of programs that received in-kind donations from within the country, this came from private businesses. For example, the National School Nutrition Program (NSNP) in South Africa provided school lunches but was supplemented by private sector (in-kind) support to also provide some breakfasts.

The domestic purchase of supplies was celebrated in many countries, such as Namibia and Nigeria. Processors in Egypt produced the baked goods for school snacks, while processors in Malawi produced the corn-soy blend served in schools. Among the programs that purchased any food, 77% procured at least some from within the local community. Examples included the National School Feeding Program of Mali, the Home-Grown School Feeding Program in Ethiopia, the National School Feeding Program in Burundi, and the Mary's Meals Program in Malawi. A number of programs reported on recent, ongoing, or anticipated transitions toward a HGSF approach to food procurement. Thus, while the school meal program in Guinea-Bissau incorporated the purchase of local agricultural products in 2014, the shift in Liberia has been more recent, and the Namibian School Feeding Program is just now introducing a HGSF model.

Food basket contents tended to be correlated with the primary avenue through which food was procured. While 20 of the programs in Africa relied primarily on domestic purchase, 12 programs relied on foreign in-kind donations (see variable definitions in section 2). **Figure 3** shows the typical food basket contents across these two categories. While most programs in both categories included grains and oil, it was far more common for the menu in programs that relied on domestic purchase to include fish (50%), meat (43%), fruit (43%), green leafy vegetables (36%), poultry (31%), and eggs (15%), among other items. (Programs that received some in-kind donations, but did not rely on them, tended to have menus in between the two extremes depicted.) It is evident that a reliance on foreign food donations is correlated with less diverse menus. Interestingly, there is no correlation between a program's budget per child and the number of food categories served (Coefficient in a simple linear regression $= -0.004$, $P = 0.267$). In other words, the source of food seems to be more important than the budget for menu diversity.

Health and Nutrition

Beyond the inclusion of different food categories, school meal programs have a number of tools available to enhance their nutrition status. Sixty-eight percent of the programs in Africa

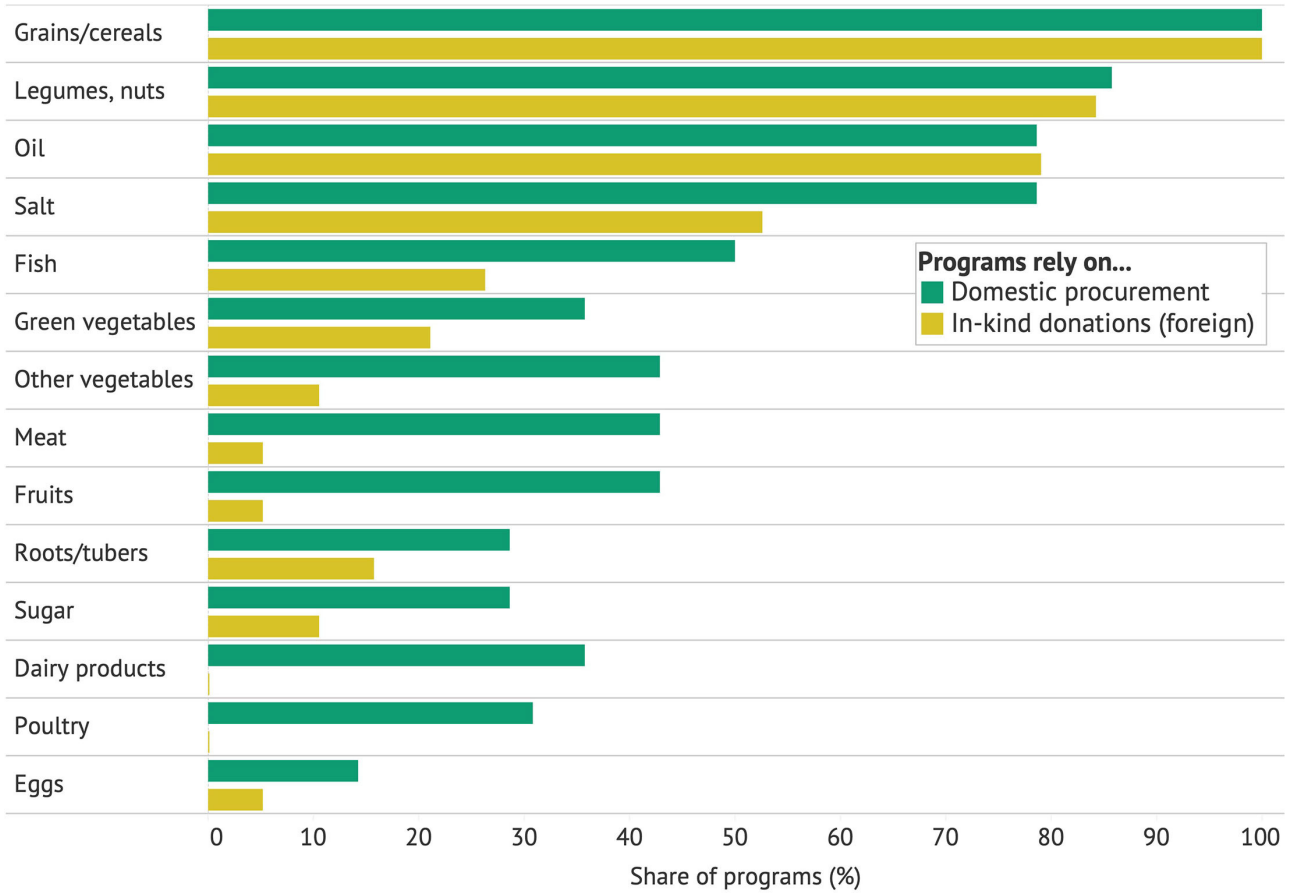

FIGURE 3 | Food basket contents and avenue of food procurement in school meal programs.

served fortified foods, such as oil, salt, grains/cereals, corn-soy blend, or biscuits fortified with vitamin A, iodine, and iron (among other micronutrients). At 30%, it was less common for programs to include micronutrient supplements either added to the food or provided directly to the children. A few programs also served biofortified foods, such as the vitamin A-rich orange flesh sweet potatoes used in The Gambia, Malawi, Mozambique, and Nigeria.

Noting that school feeding is but one component of school health, and that the effects of school meals are mediated by other aspects of health, the survey also gathered information on complementary programs and services offered in schools. It was common for school meal programs to be paired with other health or hygiene services/programs (**Table 3**). All school meal programs in Africa incorporated handwashing into the school feeding activities. The provision of potable drinking water was the next most common accompaniment to school meals (in 86% of programs), followed by deworming treatment (in 78% of programs). Note that worm infections can result in iron deficiency, such that deworming enhances the effectiveness of school meal programs by facilitating the absorption of iron. Other services, such as eye testing or menstrual hygiene programs, were offered less often.

It is similarly common to find complementary education programs offered as part of the school feeding package. Thus, 89% of programs offered nutrition education, and 84% were paired with school gardens. Among those that included school gardens, the garden products were consumed by students in 98% of the cases and were also sold in 48% of the cases. In Tunisia, a common arrangement was for one third of garden production to be used in the school meals program, while the remainder was sold.

Enabling Environment for School Feeding

A robust enabling environment in terms of political commitment, a strong policy and regulatory framework, and supportive infrastructure is necessary for school meal programs to thrive. More specifically, a national school feeding policy can help solidify a country's commitment and clarify its objectives and strategies for school feeding, and nutrition standards can likewise sharpen attention to nutrition objectives (16). About three-quarters (74%) of the African countries with school feeding had a national school feeding policy, law, or standard. It was also somewhat common (at 62%) for countries to have a policy related to school feeding regarding nutrition, and 44% had a policy regarding food safety. Just over half (51%) had

TABLE 3 | Complementary services and education programs.

Services	% of programs	Education programs	% of programs
Handwashing	100	Hygiene	92
Drinking water	86	Nutrition	89
Deworming	78	School gardens	84
Water purification	34	Health	81
Menstrual hygiene	32	HIV prevention	55
Weight measurement	17	Physical education	53
Height measurement	15	Food and agriculture	52
Dental testing	12	Reproductive health	40
Eye testing	6		
Hearing testing	6		

a policy regarding agriculture linked to school feeding. Note that 47% reported some direct involvement of farmers in school meal operations, often with the intent to bolster the rural economy through local food purchases.

A monitoring and evaluation (M&E) system is critical for oversight and quality assurance in school meal programs, and a country-wide system for monitoring school feeding programs was reported in 87% of the countries in Africa. Namibia maintains a system of data capture through the Namibian School Feeding Information System (NaSIS), though consistency in data entry remains a challenge.

Infrastructure also plays a key role in school meal programs. One half of the African countries reported that all or most schools had clean water, while 15% reported that few or no schools had clean water. At the same time, all or most schools had cafeterias or other dedicated eating spaces in just 9% of the countries, while 59% reported that very few or no schools had cafeterias. One half of the countries reported that very few or no schools had electricity; this has implications for the ability of schools to refrigerate or preserve food items.

Most school meals or snacks in Africa were prepared on school grounds. Among the 88% of programs that used charcoal/wood stoves in school kitchens, students were expected to provide fuel in 45% of the cases. Challenges related to deforestation, exacerbated by the use of firewood in school meal preparation, and to finding energy for cooking were highlighted in Burundi, Malawi, and Niger. In addition, 7% of programs brought in food from off-site private kitchens. Just 1.5% of programs only served foods that were purchased in processed form and required no preparation.

Challenges

Though the survey focal points (respondents) could enumerate many successes and positive developments related to school feeding in Africa, the associated challenges were also abundant. Inadequate and unpredictable budgets were reported in many countries, including Côte d'Ivoire, Liberia, and Niger. In fact, funding was considered "adequate" in just 38% of the programs. For example, when the World Food Program ended its support for Zambia's Home-Grown School Feeding program, the remaining government budget was deemed inadequate. Countries that lacked a budget line for their school feeding programs (including Cameroon, Guinea-Bissau, and Mozambique) particularly noted this as a problem.

Difficulties related to supply chains and logistics were also acknowledged. Food losses in storage or in transit to schools were acknowledged in Kenya, with food sometimes being condemned by public health officials due to spoilage. School access was limited during the rainy season in Benin and Sudan, particularly in regions of poor road quality. Respondents for Cameroon, Mali, and Niger also reported that parts of the country were difficult to access due to conflict and socio-political upheaval, or that population displacements caused by security crises disrupted school feeding programs.

Insufficient or inadequate human resources were also noted in Botswana, Guinea-Bissau, Liberia, Madagascar, and Sierra Leone. Among other challenges, frequent turnover of school feeding personnel resulted in inefficiencies and the allocation of scarce resources toward redundant training. Several countries acknowledged weaknesses in their monitoring and evaluation systems or found that that completing the survey was difficult due to a lack of data stemming from poor record-keeping.

Finally, despite the widespread enthusiasm for HGSF, challenges around local procurement were common. Such procurement was particularly challenging in Kenya's arid regions, which is where the Home-Grown School Meals Program operated. Similarly, the School Feeding Program in Mauritania specifically operated in food insecure and vulnerable areas with limited agricultural production. In Liberia and Malawi, limited production even at the national level presented an obstacle for school meal programs.

DISCUSSION

Results from the 2019 Global Survey of School Meal Programs confirm school feeding's place in African food systems, with meal programs present in 95% of the countries and reaching 30% of all children of primary school age. Such programs have grown in popularity in the past decade and are increasingly employed to serve as a safety net, improve children's nutrition, meet education goals, and bolster rural economies. The survey results reveal great diversity in school meal programs across Africa, with variation evident across regions, income levels, and levels of national commitment. Several themes from the survey results deserve mention.

The extent to which school meal programs in Africa are supported with domestic funding seems to reflect a dramatic shift in favor of national ownership (3, 5). This has profound implications for the sustainability of these programs, the coverage achieved, and even the diversity of food provided. The survey results indicated that there was a positive correlation between the government share of the budget and the national school feeding coverage rate. Moreover, countries with a budget line for school feeding were more secure in their funding and were found to reach a greater share of children. Altogether, this underscores

the importance of government commitment to school feeding, with policy implications for efforts to increase school feeding in Africa.

At the same time, for programs operating in less supportive environments, a key theme was the tremendous stress of unreliable funding, which was regarded as inadequate in 62% of programs. This inhibited the programs from reaching their targets and scaling up further. The positive correlation between a country's wealth level and its school feeding coverage rate starkly demonstrates how school feeding tends to be scarcest precisely where needs are greatest (11, 23). Efforts are needed to stabilize and expand budgets for school feeding in the African countries where food insecurity and child malnutrition are likely to be highest.

One particularly encouraging takeaway from the survey was the enthusiastic embrace of HGSF approaches to food procurement, even if this still seems to characterize a minority of Africa's school meal programs. The HGSF concept was first introduced in Africa in 2003, when the New Partnership for Africa's Development (NEPAD) orchestrated HGSF pledges from 11 countries (18). The survey results indicated that a reliance on domestic purchase rather than in-kind foreign food donations was correlated with more diverse school meal menus. In narrative accounts, the focal points (survey respondents) expressed strong support for HGSF, with a projection that HGSF models would be scaled up in coming years. Nevertheless, the survey also exposed some ambiguity regarding the definitional criteria of HGSF, with programs referred to as HGSF when they sourced food from local markets near individual schools, and also when they implemented a fully centralized approach to procurement and distribution. Clearer definitions and a typology of HGSF programs would shed light on this situation and inform research on the optimal HGSF program design—a topic with limited evidence to date (3).

Another salient finding from the survey was the limited attention given to overweight/obesity in school meal programs in Africa, with just 10% identifying overweight/obesity prevention as an objective. As Africa becomes increasingly urbanized, it has undergone a nutrition transition in favor of purchased and processed foods, with limited consumption of fruits and vegetables but high levels of sugar intake (26). Not surprisingly, overweight and obesity have grown increasingly prevalent among African school children, especially those attending urban and/or private schools (27, 28). The establishment of healthy eating habits among children and adolescents is imperative for reducing their risk of non-communicable diseases in later years (29), and school meal programs could play a role in this realm (10). Nevertheless, green leafy vegetables, other vegetables, and fruits were served in just 37, 31, and 19% of programs, respectively. There is clearly scope for allocating greater attention to the prevention or mitigation of overweight/obesity in the design of Africa's school meal programs.

A final lesson from the survey is that African countries can learn a great deal from one another in terms of strategies for scaling up school meal programs, drawing political support and financial commitment, diversifying menus, and building local capacities for program oversight and implementation. Peer-to-peer learning among individuals in different countries who share similar school feeding responsibilities, challenges, and motivations can be particularly powerful (30). The development of a standardized database on school feeding, resulting from the Global Survey of School Meal Programs, along with the shared vocabulary offered in the survey glossary, should also facilitate learning across countries. Data from the second round of the survey, conducted in 2021 and capturing the responses of school meal programs to the COVID-19 pandemic, is forthcoming.

Several limitations of the survey should be acknowledged: First, the data are self-reported and may be influenced by various factors. Governments may aim to issue a positive report of indicators that are considered to reflect positively on the country, such as the school feeding coverage rate. At the same time, governments seeking additional funding for school meal programs (whether from domestic or external sources) may be inclined to issue a less positive report to emphasize the need for support. Second, the data from the 2019 survey reflect a snapshot of a school meals landscape that is dynamic and evolving. As noted, the data from 2019 were collected before the COVID-19 pandemic and therefore do not capture the effects of this global crisis.

DATA AVAILABILITY STATEMENT

The dataset analyzed in this study is based on the 2019 Global Survey of School Meal Programs©. The dataset is available to the public and can be accessed via the Global Child Nutrition Foundation (info@gcnf.org).

AUTHOR CONTRIBUTIONS

AM, AW, and HK conceptualized and initiated the study. Data collection was undertaken by AM-D, LB, ME, EG, and PE. AW conducted the data analysis. AW, YW, ME, EG, and PE wrote the first draft of the paper, which was reviewed by AM, LB, HK, and AM-D. All authors contributed to the article and approved the submitted version.

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Operational Characteristics of Women Street Food Vendors in Rural South Africa

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Objective: To characterize the operations of the street food enterprise in the Vhembe district, focusing on business profile, sold foods, inputs, pricing, record-keeping practices and total running cost.

Methods: A descriptive cross-sectional face-to-face study of 511 vendors was done using a structured researcher-administered questionnaire comprising demographic and operational characteristics. Convenience sampling was used to choose the vending sites. Chi-square tests were conducted between four categorical variables (gender, age, marital status and citizenship) and operational characteristics. *P*-values were considered significant at $p < 0.05$. However, a Bonferroni adjustment decreased the significant value to $p < 0.013$.

Results: The findings highlight the dominance of single middle-aged (35–44) women (63.1%) with some high school education. About 14% migrated from Zimbabwe. Most vendors were owners (86.1%), with 70.0% in business for at least 1–10 years. Food sold included mielie pap (stiff porridge) served with beef or chicken, sometimes with vegetables. Plate prices were R40.00 (2.6 USD) for a full plate and R30.00 (2 USD) for half a plate. The typical street food consumers were government officials, middlemen, and schoolchildren. Social media such as Whatsapp were used to communicate between the street food vendors and customers. The results highlight poor managerial skills as only 15.5% kept records, most of which were sales records (59.5%). On average, street vendors made a monthly profit of R3200.00 (213 USD) while spending R1800.00 (120 USD) on daily running expenses. There were statistically significant variations in some operational characteristics of vendor variables and gender, age, marital status, and citizenship.

Conclusions: There is a need for capital and management for small businesses and food training for rural street food vendors. Therefore, government officials, policymakers, and NGOs could target street vendors to offer training and microfinance to improve their business skills while promoting food safety and consumption of nutritious foods.

Keywords: operational characteristics, street food enterprises, street vendors, South Africa, women's employment

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INTRODUCTION

Foods sold on the street have become a common source of food consumption in many urban towns and cities. Street foods are foods prepared on the street and ready to eat at home or consumed on the street without further preparation (1). Street foods mainly consist of staple food served in various forms and combined with side dishes such as stews, gravies and snacks such as meat, fish, and cereal-based ready-to-eat foods (2, 3). Statistics South Africa and StatsSA (2020) reported that an estimated 18% of citizens to work in the informal sector as the main source of employment (4). Studies highlight an estimated one million street vendors in South Africa, of which over 70% sold food (5).

Street foods are less costly and an accessible means of obtaining a nutritionally balanced meal away from home for many low-income people (3, 6, 7). The street food sector in South Africa has been regarded as an essential channel for food access for a food-insecure population where it reflects a core aspect of low and middle-income countries, including South Africa's poor and vulnerable population (7). Even though its economic contribution goes overlooked on many occasions (8), street food enterprise is the single most significant employers in the informal sector due to its economic contribution (4, 9).

Informal enterprises' success depends on finance, the entrepreneur's characteristics, the business's location, and government support (10). Moreover, the government has established the Ministry of Small Business Development to develop Small and Medium Enterprises (SMEs). However, much support has been focused on the formal business economy and private franchises, leaving the informal sector, such as street food vending (11, 12). A previous study has reported that informal vending is not recognized because the economic activities that operate outside accepted norms of society are not regulated or registered with the government and are non-taxable (12). However, informal businesses in Gauteng are prioritized over other province (5).

The South African government recognizes the informal economy as a viable and essential form of employment and enabler of fiscal mobility for the poor (13). Studies in South Africa (6, 10, 14) and other countries (15, 16) indicated that women entrepreneurs engage in this sector for their entire working years because of a lack of opportunities in the formal sectors. Informal workers are overwhelmingly poor, dominated by young females (16), and have no support for their informal businesses to succeed (17). Moreover, the lack of formality due to poor governmental support contributes to the failure of the informal sector (18–20). This trend has also been documented in most African countries where street food vending is the leading source of income for the poor and vulnerable population, including women (16, 21, 22).

Studies conducted in the Limpopo Province (10, 14, 22) indicated that small-scale food vending contributes significantly to the livelihoods of the poor. Despite recognizing that street food vending forms most of the informal employment sector, the lack of formality means little is known of its operation. The lack of formality could be because no consultation of the street food vendors on any policies developed and implemented for managing their operation (23–25). Street food vending as an enterprise is often overlooked during policy formulation and disregarded in business strategy too easily (13). Nevertheless, these studies also indicate that regulations and by-laws governing street vending operations in South Africa are in place, although with a lack of enforcement by officials (25–29). Given the importance of street food in society, a better understanding of street food vendors in different settings is necessary to characterize its operation.

Limpopo province has the highest number of street food vendors, mainly concentrated in the Vhembe district. Hence the Vhembe district was selected for this study. Most street food vendors are found in public places such as taxi ranks and the road (22, 30, 31). The Vhembe district draws special attention in the province because of a high increase in cooked street foods (2, 14, 28, 31). This paper was the third phase of the main study, whose objective was to develop a model for street food vendors selling ready-to-eat foods in the Vhembe District. In phase one, Poter's competitiveness model investigates street food vendors' perception of vending competitiveness. Street food vendors perceived three main factors that determine the street food vending enterprise's competitiveness: chance, production, and government role factor conditions as determinants of enterprise competitiveness (Mahopo et al. forthcoming). In phase two, we reported that lack of opportunities and financial freedom as the main motivations for entry into the enterprise. We noted a need to establish local representative organizations with health authorities and enforce regulations by various stakeholders to assist street food vendors and their enterprises (32). Hence the current paper highlights the characterization of the street food vendors, focusing on business profile, employment, working hours, foods sold, inputs, pricing, record-keeping practices, total running cost and profit.

MATERIALS AND METHODS

Study Design and Recruitment

The study was a cross-sectional survey that used well-structured close/open-ended questions and a convenience sampling technique to select 527 participating street food vendors during a transect walk-through. All available and willing street vendors selling cooked food were considered for the study. Due to the unavailability of the street food vendors' records, street food vendors were recruited in all towns. The consensus, therefore, deemed the sampling strategy to be used. However, only 511 street food vendors were considered for this study due to incomplete and missing information during data analysis. Data were collected on weekdays during busy times. Before the interviews, the study purpose, aims, and procedures were explained to the street food vendor. The street food vendors obtained informed, written consent, and confidentiality and anonymity were observed.

Study Area

The study was conducted in the Vhembe district in the three towns: Makhado, Thohoyandou, and Musina. Vhembe district has an estimated population of 1.2 million (4). Most of the residents are women, and Thulamela has the highest population

(females 55%) compared to Musina (52%) and Makhado (33). It covers an area of 21,402 square kilometers of mostly rural land. Due to the high level of unemployment (41.1%) (34), residents of the district have developed several survival strategies, including the street food enterprise at major trading points within the local municipalities. Thohoyandou and Makhado are big cities, relatively developed and economically vibrant cities (4). Musina remains relatively under-developed with a high incidence of shortage and constant migration of some of its active labor force to the North Vhembe district at the border of Zimbabwe.

Inclusion and Exclusion

The researchers approached street food vendors selling cooked food. The sample frame included all street food vendors selling cooked foods in the Vhembe district. We excluded street food vendors younger than 18 years and those who provided incomplete information.

Study Duration

The study period was 3 months, from July to September 2019.

Sample Size Determination and Sampling

The municipalities had no records indicating the locations of street food vendors. Hence a non-probability sampling strategy was used as the research population is unknown (35). In the Vhembe district, there are four main towns, of which three of the most populated town were selected (Thohoyandou, Musina and Makhado). The estimated population size of these three towns was that Thohoyandou had 69,000 Musina 43,000, and Makhado population size 23,000. Convenience sampling was used to select study participants from all towns and three towns. The researcher established and maintained a complete list of the primary unit component from the Vhembe district's municipalities. All vendors encountered were approached subject to eligibility criteria.

TABLE 1 | Demographic information of street food vendors.

Variables	Musina frequency (%)	Makhado frequency (%)	Thohoyandou frequency (%)	Total frequency (%)
Sample size	168 (32.9%)	36 (7.0%)	307 (60.1%)	511 (100%)
Gender				
Male	9 (1.8%)	1 (0.2%)	40 (7.8%)	50 (9.8%)
Females	159 (31.1%)	35 (6.8%)	267 (52.3%)	461 (90.2%)
Marital status				
Single	83 (16.2%)	5 (1.0%)	135 (26.4%)	223 (43.6%)
Married	50 (9.8%)	9 (1.8%)	84 (16.4%)	143 (28.0%)
Living with partner	29 (5.7%)	20 (3.9%)	68 (13.3%)	117 (22.9%)
Divorced	1 (0.2%)	0 (0.0%)	10 (2.0%)	11 (2.2%)
Widowed	5 (1.0%)	2 (0.4%)	10 (2.0%)	17 (3.3%)
Age categories				
18–24 years	10 (2.0%)	1 (0.2%)	10 (2.0%)	21 (4.1%)
25–34 years	33 (6.5%)	2 (0.4%)	46 (9.0%)	81 (15.9%)
35–44 years	75 (14.7%)	23 (4.5%)	125 (24.5%)	223 (43.6%)
45–44 years	33 (6.5%)	9 (1.8%)	90 (17.6%)	132 (25.8%)
55–64 years	11 (2.2%)	1 (0.2%)	35 (6.8%)	47 (9.2%)
65–74 years	3 (0.6%)	0 (0.0%)	1 (0.2%)	4 (0.8%)
75 and above	3 (0.6%)	0 (0.0%)	0 (0.0%)	3 (0.6%)
Educational status				
No formal schooling	10 (2.0%)	1 (0.2%)	8 (1.6%)	19 (3.6%)
Primary education	26 (5.1%)	1 (0.2%)	30 (5.9%)	57 (11.2%)
Some high school	101 (19.8%)	19 (3.7%)	138 (27.0%)	258 (50.5%)
Matric	29 (5.7%)	14 (2.7%)	104 (20.4%)	147 (28.8%)
Diploma	2 (0.4%)	1 (0.2%)	23 (4.5%)	26 (5.1%)
Degree	0 (0.0%)	0 (0.0%)	4 (0.6%)	4 (0.6%)
Ownership				
Full owner	129 (25.2%)	25 (4.9%)	286 (56.0%)	440 (86.1%)
Co-owner	34 (6.7%)	8 (1.6%)	18 (3.5%)	60 (11.7%)
Employees	5 (1.0%)	3 (0.6%)	3 (0.6%)	11 (2.2%)
Citizenship				
South Africa	110 (21.5%)	22 (4.3%)	304 (59.5%)	436 (85.3%)
Zimbabwe	58 (11.4%)	14 (2.7%)	3 (0.6%)	75(14.7%)

Data Collection Tools

An adapted questionnaire was used to collect data on street food vendors' demographic and operational characteristics (see study tools below). The study instrument was piloted among 20 selected street food vendors operating in Sibasa, approximately 6 kilometers outside Thohoyandou.

Demographic Variables

Four demographic variables, gender, age, marital status, and citizenship, were used to characterize the operations of the food vendors.

Operational Characteristics

The operational variables assessed were (1) business profile, (2) foods sold and sources of inputs, (3) food per plate pricing, (4) target market, (5) enterprise record-keeping practices, and lastly, (6) total cost and profit.

Data Analysis

All analyses were carried out using the Statistical Package for Social Sciences (SPSS version 26). The median and IQR were calculated because the data were skewed for most variables. The test of four *a priori* hypotheses were assessed to characterize the operations of the street food vendors in terms of their background characteristics. Chi-square tests were conducted between four categorical variables (gender, age, marital status, and citizenship) and operational characteristics. *P*-values were considered significant at $p < 0.05$. However, a Bonferroni adjustment decreased the significant value to $p < 0.013$.

RESULTS

Demographic Information

Table 1 reports the street food vendors' demographic information based on the town's location. Among the 511 street food vendors participating in the study, 90.2% were women, and 43.6% were single aged 35–44 years (43.6%). At the same time, those aged 45 years were 3.8 and 32.7% of males and females, respectively. A few young adults (4.1%) participated in the study. Thohoyandou (60.1%) had the most street food vendors, followed by Musina (32.9%) and Makhado (7.0%). Most of the street vendors were never married (43.6%), with just over a quarter of the participants married (28.0%), and a few were widowed (3.3%). Most of the single (26.0%) and married (16.0%) participants were from Thohoyandou. Regarding educational status, more than half (50.5%) of the participants had some high school education, while 28.8% obtained a matric certificate, and only a very few (3.7%) never attended formal education. Most street vendors were owners (86.1%) of their businesses and only 2.2% were employees. Less than 15% (14.0%) of the migrants were of Zimbabwean citizenship, with the majority (85.7%) of the street vendors from South Africa.

Business Profile of the Street Food Vendors

As shown in **Table 2**, 70.1% of the participants were in the business for 1–10 years, indicating that most street food enterprises are relatively well-established. Only 10.0% were still new in the street food business. The median weekly money made from the business was R1300.00 (86 USD). The monthly income from the street food vendor's household income was R4000.00 (266 USD). For an average street food vendor in need of financial assistance, most participants (65.0%) indicated getting money from their savings to start up, while very few indicated money lenders (1.0%), banks (0.8%), and others (1.4%) sources. These results highlight the lack of financial support from commercial banks and street food vendors. The results also show that street vendors save money physically in their pocket (97.1%) and a box (12.7%) to keep money safe while working. At the same time, very few used tills (1.6%). Only 5.1% of the vendors reported saving money in the banks (5.1%).

TABLE 2 | Business profile of the street food vendors.

Variable description	Frequency (%)	Median (IQR)
Age in the business		
Less than a year	51(10.0%)	
1–10 years	360 (70.1%)	
11–20 years	79 (15.5%)	
21–30 years	18 (3.5%)	
More than 30 years	3 (0.9%)	
Average income from stall/week (*R*)		1,300 (1,900)
Average household income (*R*)		4,000 (4,900)
Financial assistance		
Bank loan	4 (0.8%)	
Moneylenders (loan sharks)	5 (1.0%)	
Savings	332 (65.0%)	
Other (not specified)	7 (1.4%)	
Storage of money		
In a till	8 (1.60%)	
In a box	65 (12.7%)	
Pocket	408 (97.1%)	
Bank	26 (5.10%)	
Other (unspecified)	1 (0.20%)	

Employment and Operational Hours of the Street Food Vendors

Table 3 reports the street food vendors' employment and hours worked. The enterprise had at least one permanent person working. Although there was no difference between the number of days worked, the median hours worked by the unskilled was 11 h compared to 9 h of the skilled street food vendors on weekdays and Saturdays, respectively. There was no difference in days worked between the skilled and unskilled, as shown by a median of 300 days yearly. The median amount paid for unskilled labor was R1470.00 (98 USD), while skilled laborers were paid a median of R1400.00'(93 USD) per month.

Food Sold and Sources of Inputs Profiling

Table 4 reports the foods and sources of input. Street food vendors predominantly cooked meat (98.8%) and Millie pap

TABLE 3 | Employment status and operational hours of street food vendors.

Variables	*Skilled (*N* = 33) Median (IQR)	Unskilled (*N* = 144) Median (IQR)
Permanent employment status	1 (0)	1(0)
Total days worked	6 (1)	6 (1)
Weekday hours	9 (3)	11 (3)
Saturday	9 (3)	11 (2)
Sunday	0 (8)	0 (12)
Holidays	9 (3)	9 (5)
Days worked per year	300 (0)	300 (50)
^Salary bill (R)	1,400.00 (0)	1,470.00 (975.00)

**Skilled, received some unofficial training; unskilled, never had any training. ^currency: 1USD = R15.00.*

(stiff porridge) (97.1%), a South African staple food. Three quarters (75.3%) of the vendor's cooked vegetables and 34% were served as gravy and chakalaka (8.2%). The various meats cooked by the street vendor were chicken (88.8%), beef (68.3%), beef offal/*magulu* (14.3%), and beef sausage (5.5%), with very few street vendors selling fish (1.4%) or pork (2.2%). The median cost of meat was R400.00 (27 USD). The street food vendors cooked and sold two main starchy foods, mielie pap (97.1%) and rice (14.1%), at R70.00 (5 USD) daily. Although vegetables formed part of the plate, only 60.1% sold green vegetables as part of the menu, with others serving gravy (34.8%) and chakalaka (8.2%) as supplements. The median cost of vegetables used for cooking was R 40.00 (3 USD). Food was mainly cooked on-site (93.3%), with owners (74.5%) as the prominent people cooking food and very few assisted by the employees (23.9%) or spouses (1.6%). Most street food vendors (86.3%) took left-overs home to eat with family members, while 0.2% reported selling leftovers.

Street Food Plate Pricing

Table 5 reports street food plate pricing. The median price for a full plate of chicken was R40.00 (2.7 USD), with a minimum of R20.00 (1.3 USD) and a maximum of R140.00 (9.3 USD). The median price of a full plate of beef was R40.00 (2.7 USD), with a minimum of R25.00 (1.7 USD) and a maximum of R75.00 (5 USD). Moreover, a median price of a half-plate was R30.00 (2 USD).

Target Market

Table 6 reports the target markets of the street food vendors. Most participants reported rural consumers (81.2%) as their primary customers, while 52.3 and 58.7% reported middlemen and government officials. Moreover, 40.9% reported school children as their target market. Most participants (72.0%) highlighted using personal visits/face-to-face, whereas 62.4% used phone calls/WhatsApp to retain customers. Some street vendors indicated that word of mouth (2.7%) and posters (0.6%) communicate with their customers about their services and food sold.

TABLE 4 | Inputs and inputs supplier profiling.

Variable description	Frequency (%)	Median (IQR)
Foods mostly cooked (ready-to-eat foods)		
Meat (R)		400.00 (240.00)
Chicken	454 (88.8%)	
Beef/ox	349 (68.3%)	
Wors	28 (5.5%)	
Pork	11 (2.2%)	
Beef Offal	73 (14.3%)	
Fish	7 (1.4%)	
Starch		70.00 (60.00)
Pap (R)	496 (97.1%)	
Rice	7 (14.0%)	
Vegetables (*R*)		40.00 (50.00)
Beans	9 (1.8%)	
Green leafy vegetables	307 (60.1%)	
Carrots	1 (0.2%)	
Gravy	178 (34.8%)	
Chakalaka	42 (8.2%)	
Cooking place		
At the site	477 (93.3%)	
Home	38 (7.4%)	
Person responsible for cooking		
Spouses	8 (1.6%)	
Employee	122 (23.9%)	
Self	381 (74.5%)	
Preservation of leftovers		
Take home to eat	441 (86.3%)	
Sell next day	1 (0.2%)	
Sell at a lesser price	25 (4.9%)	
Throw it away	22 (4.3%)	

TABLE 5 | Street food plate pricing.

Variable items	Median (IQR)	Min	Max
Plate prices			
Beef/pork full plate	R40.00 (R10.00)	R25.00	R76.00
Beef/pork half plate	R30.00 (R5.00)	R15.00	R55.00
Chicken full plate	R40.00 (R10.00)	R20.00	R140.00
Chicken half plate	R30.00 (R10.00)	R15.00	R70.00

*[a]Full plate consists of 4 or more servings of meat. [b]Half a plate consists of 2–3 servings of meat; *Currency: 1USD = R15.00.*

Record Keeping

Table 7 highlights that all street food vendors keep similar records. However, some participants (15.5%) could only keep business records. Most records were sales (59.5%), and 46.8% could keep production records. More than a quarter of the participants (36.7%) kept marketing records. Most of the street

TABLE 6 | Street food vending target market.

Variables	Frequency*(%)
Target market	
Rural customers	415 (82.2%)
School children	209 (41.5%)
Government employees	300 (59.5%)
Middlemen	267 (53.0%)
Other	9 (1.8%)
Mode of communication	
Personal visits	368 (72.0%)
Phone call/WhatsApp	319 (62.4%)
Recruit professionally	22 (4.3%)
Word of mouth	14 (2.7%)
Posters	3 (0.6%)
Nothing	7 (1.5%)

**Number of responses.*

TABLE 7 | Street food vendor's record-keeping practices.

Variables	Frequency*(%)
Keep records	
Yes	79 (15.5%)
No	432 (85.6%)
Production	37 (46.8%)
Marketing	29 (36.7%)
Sales	47 (59.5%)
Yes	357 (69.9%)
No	154 (30.1%)
Home	97 (27.4%)
Stall	75 (21.2%)
Storeroom	108 (30.5%)
Rented room	70 (19.8%)
Other	4 (1.1%)
Yes	54 (11.2%)
No	427 (88.8%)

**Number of responses.*

vendors indicated that due to lack of infrastructure, they sometimes keep stock (69.9%) in their storeroom (30.3%), homes (27.2%) and stalls (21.0%). Some street vendors reported using rented rooms (19.6%) in the vicinity to keep their stock safe. The practice of stock inventory was not typical because only 11.2% of street vendors could do so.

Total Running Cost and Profit

Table 8 shows that the daily median total running cost was R1800.00 (120 USD). Monthly street food vendors could make a median monthly profit of R3200.00 (213 USD). Only 32% had employees with a monthly expenditure of R1400.00 (93 USD). Street food vendors spent R430.00 (29 USD) and R340.00 (23 USD) on gas and transportation. Other business expenditures were electricity (R100.00) (7 USD), water (R100.00) (7 USD), cell phone (R100.00) (7 USD) and bank charges (R50.00) (3 USD).

TABLE 8 | Total running cost and profit.

Variable description	Frequency (%)	Median (R)	IQR (R)
Total running cost/day	494 (97.0%)	1,800.00	2,200.00
Total profit	473 (93.0%)	3,200.00	3,900.00
Monthly expenditure			
Electricity	191 (37.4%)	200.00	150.00
Gas	402 (79.0%)	430.00	241.00
Employees	162 (32.0%)	1,400.00	1,000.00
Transportation	339 (66.3%)	340.00	250.00
Water	380 (74.4%)	100.00	100.00
Cell phones	329 (64.4%)	100.00	70.00
Bank charges	21 (4.1%)	50.00	86.00

Rand (R), Currency; IQR, Interquartile range.

Association Between Operational Characteristics With the Four Demographic Characteristics of the Street Food Vendors

Table 9 reports the association between the operational variables with the four demographic characteristics of the street food vendors. The test of four a priori hypothesis was assessed using four independent categories. Chi-square associations were determined with a Bonferroni adjusted alpha level of 0.013. The street vendors in the four categories differed in gender, age, marital status, and citizenship level. There was no significant difference in gender, age, or marital status regarding the days worked. However, there was a statistical difference in the number of days worked and nationality. South Africans (76.6%) worked 6–7 days a week compared to 94.7% of Zimbabweans ($p < 0.001$).

Total hours worked on a Sunday were not statistically different based on gender or marital status. However, there was a statistical difference in the hours worked on a Sunday based on age, with 50.0% of 65–74-year-olds working more than 8 h on a Sunday compared to lower percentages in the younger age groups ($p < 0.001$). Similarly, there was a statistical difference in hours worked on a Sunday based on citizenship, with 6.4% of South Africans working more than 8 h on a Sunday compared to 45.3% of Zimbabweans ($p < 0.001$). Moreover, a significant difference was observed between marital status and the preservation of leftovers, with the separated (100%), married (92.3%), and single (88.3%). Street food vendors take food for home consumption while 4.2 and 36% of married and single throw food.

Ownership had no statistical difference with age, gender, or marital status. However, a significant difference was observed between citizenship and full-ownership ($p < 0.001$), with 91.5% of South Africans as full-owners compared to 54.7% of Zimbabweans who own the businesses. Similarly, a statistical difference in age and number of employees had statistical significance ($p = 0.012$), as more than 50% of the vendors aged 65 years and above have at least 1–3 employees.

TABLE 9 | Operational variables for which there was a significant difference in the characteristics of the respondents using Bonferroni adjusted level.

Variables	Gender	Age	Marital status	Citizenship
Operational working day				
Total hours worked on a weekday				<0.001
Total days worked				<0.001
Total days on a sunday		<0.001		<0.001
Total days worked sunday				<0.001
Types of food sold				
Meat	a	a	a	a
Pap	a	a	a	a
Vegetables	a	a	a	a
Sell same food always				<0.001
The site where food is sold				
Preservation of leftovers			<0.001	
Ownership				<0.001
Number of employees		0.012		
Inputs cost				
The average cost of meat			0.004	
The average cost of millie pap		<0.001	0.002	0.003
Total running cost			0.004	
Total profit	0.008			0.008
Expenditure				
Amount spent on employees		0.004		<0.001
Transportation		0.003	<0.001	<0.001
Cell phones		<0.001		0.001
Water			<0.001	<0.001
Plate pricing				
Chicken full	<0.001			
Chicken half	<0.001			<0.001

a-refers to the same food type that are sold throughout the year.

There was no significant difference between gender, age, or citizenship status and the cost of meat. However, a significant difference was observed between marital status and the cost of meat, with single (6.7%) vendors who could purchase meat for more than R1,000 compared to married (3.5%), living with partners (1.7%) and the separated (9.1%). Most participants could afford to buy meat at a price ranging from R100–R500. A significant difference was also observed between the cost of mielie pap and age ($p < 0.001$). Compared to all marital statuses, vendors living with their partners (70.1%) could afford mielie pap ranging from R51 to R100 ($p = 0.002$).

Citizenship and selling price of mielie pap (stiff porridge) differed with most Zimbabweans (73.7%) selling at R51–R100 of mielie pap than 54.6% of South African. There was also a significant difference between total running costs with marital status ($p < 0.004$), where single (10.8%) as compared to married (5.6%) and living with partners (8.5%) could spend more than R5,000 on the total cost for the business. Furthermore, significant differences were observed regarding profit made in gender ($p = 0.008$) and citizenship ($p = 0.008$). Males (42%) in the study profited more than females (23.2%) and could make a monthly profit of more than R5,000. Moreover, only South Africans (26.4%) could make enough profit compared to Zimbabweans (17.3%).

Expenditure had differences as shown by the p-value of electricity ($p = 0.004$), the amount spent on employees ($p < 0.001$), transportation ($p < 0.001$), cell phone use ($p < 0.001$), and water ($p < 0.001$). Most of the time, South African street food vendors (11.9%) were the most to price the plate at more than R50 compared to the non-South Africans. The difference was only observed with half chicken plate pricing on meal pricing ($p < 0.001$).

DISCUSSION

This survey aimed to characterize the operations of the street food vendors in the Vhembe district. Previous street food vending studies have not characterized street enterprise availability and distribution across the Vhembe district towns. The predominance of women aged 34–44 in the present study is not surprising, although men were available. Lower than the monthly earnings of the informal sector employees reported nationally in 2016 (36). The reason for women dominating the street food vending in the study could be that the business is focused only on cooked meals where women are commonly involved in preparing and serving food. In South Africa, studies have reported women's dominance in street food enterprise (19, 31, 37) who depend on the business for social relief (4, 20, 38). A lack of employable skills, insufficient work experience, and inadequate financial resources are among the factors contributing to women's dominance in the sectors (28). Similar trends were observed in other African countries (15, 18, 20).

Food vending activities enhance income for some households to meet their additional financial needs (39). In the current study, most street food vendors were never married, which may be attributed to the declining marriage in South Africa amongst youth (40). However, in Uganda, single street food vendors engage in street food vending as their only source of income (41). It is documented that marital status is one reason for establishing the household's livelihood strategies for the consumers and vendors (42). Even though the current study highlights that the proportion of married street vendors was significant, married street food vendors could be engaging in the business as an additional financial resource (41).

Education is essential for the design of appropriate training interventions. In South Africa, studies have shown that most street food vendors are educated, with most having achieved secondary education or post-secondary/tertiary qualification (43). The Vhembe district reported a decrease of 1.8% in people without schooling (33). The current study also shows that most street food vendors are educated, contrary to other studies in part of the African countries (15, 16, 21). A highlight is that if vendors are trained adequately in business establishments, their business skills could improve while promoting food safety and consumption of nutritious foods. Even though it is documented in South Africa that educated vendors venture into the business because of a lack of employment opportunities in the formal

market (44–47). Hence the need to acknowledge that many people engage in street food vending to survive and meet their basic needs due to poverty and unemployment and that it is not by choice, but the country's employment status forces them (48).

The vendors' business profile highlights that most worked long hours with the sole employer. Significant differences were observed between operational working hours and citizenship, where foreign nationals worked fewer hours than South Africans. According to the Basic Employment Conditions Act of 1997, an employee who works more than 5 days a week should work 8 h daily (49). Nevertheless, street food vendors worked more hours and days, contrary to the Basic Employment Conditions Act of 1997. Similar findings were also observed in Cape Town, where street food vendors worked more than the average population (2, 23). Although business hours tend to vary per enterprise, meal types are prepared and served because enterprise locations are influenced primarily by the specific days of the week, and it was not the case in the current study as the same foods were sold (50). Furthermore, males worked for longer hours on weekdays and weekends, especially Sundays, which could be attributed to female street food vendors having other responsibilities after work, such as taking care of families.

Similar to other studies (9, 20, 27, 28, 31, 51), this study showed that street food vending could reduce unemployment as 9.0% of the enterprises had employees. However, challenges such as lack of access to capital, with only 0.8% of the street food vendor who had access to financial assistance, could make it difficult for street food enterprises to strive (52). Street food enterprises' survival was based on vendors' savings and, at times, getting some financial assistance from the "loan sharks," where they are expected to return the money with a certain percentage that could hinder profit. The current study's findings are not different from those of other studies (20, 53) that street food vendors source initial money from their savings to establish and sustain the enterprise. Furthermore, street food vendors borrow money from money lenders (loan sharks) for continued food business operation, although it comes at a cost (54).

Further attributes that need to be considered are expenditure and business record-keeping practices. A study in Ghana highlighted a need for policy interventions to improve the street food sector regarding managerial constraints (55). As reported in other studies (20), the current study highlighted that vendors spend more money on business expenses, including buying inputs, with little monthly profit. These results are consistent with a study in Ghana (55) that was a constraint to the growth of micro and small scale enterprises where increased inputs and business expenses were identified as a constraint to street food enterprise growth.

Street food is consumed mainly by working-class people who use public transport (3, 6, 19, 31). In Mexico, it is reported that those who commute long distances or lack time to prepare food at home consume most food outside their homes (56). This street food vendor location was also observed in other parts of the country (5, 10, 29) and Africa, although their location is sometimes illegal (57–60). Plate costs in the study remained affordable and attractive to the poor groups compared to the expensive meal of R70–R300 (5–20 USD) from a restaurant (https://www.numbeo.com/cost-of-living/in/Polokwane). With the association's help, street food vendors determined the standard price needed in the same vicinity. There is a need to strengthen this partnership amongst the street food vendors with the formal institution and train them in business management. Training will help street food vendors produce and circulate goods and services within the informal food vending, expanding job opportunities in the absence of formal employment.

Food sold in the current study included traditionally cooked starches such as pap and rice served with chicken/beef/pork, and very few vendors served fish. However, green leafy vegetables were uncommon. These foods were not different from food reported in other studies selling cooked street food (3, 23, 61) and highlight that if healthy food items are made available and affordable, people are more likely to consume them (56, 62). The limitation observed was that cooked food was not individually identified, and due to the nature of the study, portion sizes were also not being calculated. Other research (3) in the country highlighted the nutritional contribution of street food, citing its importance in providing energy and micronutrients to supplement the home meal. Street food vendors should be encouraged on the types of foods sold to customers to improve the nutritional quality of foods sold on the street.

Although there was no significant difference between gender and place food is cooked, the use of leftovers in the current study highlighted across all marital status that street food vendors take along their leftovers to use at home. All street food vendors could be encouraged to save on food and use food profitably rather than throwing and reselling, posing health issues. Like our findings, consuming leftovers is common among street food vendors (17). Although 56% of street food vendors indicated using the leftovers for the next day in Zimbabwe, posing health risks to customers (15), many (44%) still use the leftovers for home consumption. This indicates that the street food vending enterprise contributes to the food vendor's mass and family. In addition, studies conducted in South Africa highlighted that traditionally cooked street food microbial safety was surprisingly better than expected (9, 23). It is reported that the less availability of the microbial concerns in the cooked food could be because street vendors should ensure that the environment they are operating from is always kept clean (60). Such practices must be encouraged to all vendors selling cooked foods to avoid loss in the business and contribute to the family diet. Therefore, public health professionals should better engage the street food vendors by selling cooked food and keeping them safe for consumption to contribute to the household's nutritional wellbeing.

CONCLUSIONS

The majority of our sample were women, who were single with some school education. The study also highlighted the presence of migrants working as street food vendors in the Vhembe district. Most vendors owned the business and have been

operating for 1–10 years. Males comprised 10% of our sample, and indicated higher working hours than females. Food sold in the study were commonly consumed foods such as mielie pap, beef, chicken, and seasonal vegetables. The street vendors encountered many constraints, such as a lack of essential services, including water, financial assistance from the formal institution, energy, and transportation.

Moreover, street vendors portray poor managerial skills. However, street vending has shown that street food enterprise contributes to the local economy by offering employment. There is an urgent need for an intensive capital provision for street food vendors' businesses and a management food training that will equip these entrepreneurs, mainly in the grassroots communities of the Vhembe district of South Africa. Therefore, government officials, policymakers, and NGOs could target street vendors to offer training and microfinance to improve their business skills while promoting food safety and consumption of nutritious foods.

STUDY STRENGTH AND LIMITATIONS

This is the first study to evaluate women's street food vendor business operational characteristics on a larger scale in the Vhembe district, Limpopo province. The study's findings can help customize supporting policies for different street food vendors to improve the country's economic status, informal business equity, food safety and nutrition security. Furthermore, our measurement tools were piloted, resulting in their increased reliability. However, this study had some weaknesses. First, the cross-sectional nature of the study design prevented us from making any causal conclusions between variables. Second, some explanatory variables relied on participants' self-reported data, prone to recall and social desirability biases. To minimize this bias, study participants were allowed adequate time to recall previous information as best as possible.

DATA AVAILABILITY STATEMENT

The data sets used or analysed during the current study are available upon reasonable request from the corresponding author.

ETHICS STATEMENT

Ethical approval was obtained from the University of Venda (project No: SHS/19/NUT03) and the University of the Free State (project No UFS-HSD2019/0059). The researcher obtained approval from the Vhembe district municipalities and the street food committee to conduct the study. The researchers surveyed street food enterprises, interviewing street food vendors available and knowledgeable about the business. The business owner/employees were informed of the research objectives and conducted interviews to secure consent. The participants were informed of the purpose of the investigation before participating in the study. Furthermore, participants were given assurance of privacy, confidentiality, and anonymity regarding the information provided. Street vendors signed the consent form after explaining the study's aim and objectives.

AUTHOR CONTRIBUTIONS

TM, CN, and AN contributed to the conception and design of the study. JN, MB, and RA contributed to the manuscript writing. All authors reviewed the manuscript and approved the submitted version.

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Improving wasting among children under-5 years in Malawi: The role of farm input subsidies

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Wasting among children under-5 years remains a public health problem in Malawi, despite the quest to improve food availability through Farm Input Subsidy Program (FISP). As such, the study examined the link between FISP and child wasting. Using Malawi Integrated Household Panel Surveys for 2013, 2016, and 2019, two-stage least squares approach was employed to run a Cobb Douglas production function and a correlated Random Effects (CRE) Model to account for endogeneity challenges and an unbalanced panel dataset. The study hypothesized the role of FISP to dietary diversity at the household level on child wasting [weight-for-height (WHZ)]. Based on the analysis, the study found that household access to FISP coupons was not a stand-alone predictor for low wasting among children under-5 years. However, increased maize production due to FISP coupon access significantly correlated with lower wasting likelihood incidences at the household level. Worth to note, that in 2015/16, households that had accessed FISP coupons and were in the central region had higher wasting probabilities among the children under-5 years in Malawi compared to other counterparts panels. This implies challenges to addressing wasting among children under-5 years– which can be attributed to higher redemption costs of the FISP coupon. Therefore, the current study suggests that input subsidies can improve the reduction of wasting among children under-5 years through specific pathways, among them, increased maize production and considering appropriate targeted approaches to ensure households access the inputs for sustained food availability, which in turn enhances improved the children under-5 years health dividends in Malawi.

KEYWORDS

FISP, wasting, child malnutrition, dietary diversity, correlated random effects

Introduction

Globally, child malnutrition remains a fundamental public health challenge and is associated with undesirable health outcomes such as reduced cognitive and physical development, increased rates of sickness and death from common illnesses, and reduced educational outcomes and lifelong productive capacity (1, 2).

Wasting, stunting, and underweight are expressions of undernutrition and are anthropometric indicators for assessing a child's nutritional status (3). Recent global undernutrition estimates suggest that 149.2 million children under the age of 5 were stunted, 45.4 million wasted, and 38.9 million overweight in 2020 (2). Incidents of child undernutrition are particularly higher in Sub-Saharan Africa (SSA), which has 37 and 25% of the world's stunted and wasted children, respectively (2). The FISP has been widely critiqued, with scholars indicating that political considerations and corruption impede clear targeting of households that could make productive use of fertilizer but cannot afford to pay for it (4–6).

While causes of child malnutrition vary across geographical spaces, key determinants of malnutrition are most commonly; household food insecurity, inadequate dietary intake, diseases, low household income, lack of access to adequate clean water, insufficient health facilities, low educational level, distance to health facilities, poor hygiene, and sanitation (7–9). In addition, the incidences of child malnutrition have been further exacerbated by the global social and economic crisis caused by the COVID-19 pandemic (10, 11). The pandemic, through its negative impacts of reduced household incomes; disruption of production, transportation, and sale of nutritious, fresh, and affordable foods; and interruptions to health, nutrition, and social protection services, pose a risk to the nutritional status of children (12, 13).

In Sub-Saharan Africa (SSA), investments in nutrition policies, programs, and related advocacies to reduce child malnutrition offer important pathways to reduce negative outcomes of malnutrition (14). For example, in the case of Malawi, several programs such as exclusive breastfeeding among infants in the first 1,000 days of life have been implemented, with reported positive outcomes in reducing child nutrition-related problems (15–18). Complementary programs in the agriculture sector to reduce food insecurity and improve food diversity have also been implemented through various forms of agricultural subsidy programs (19–22). Evidence suggests that these programs can play a role in reducing child malnutrition outcomes and, therefore, the need for adequate research that informs policies.

In their various forms and contexts, agricultural input subsidies have been widely implemented in developing countries and are hypothesized to reduce malnutrition through their impacts on dietary diversity (6, 23–25). While the objectives of AIS vary widely in the Sub-Saharan region, the underlying concepts focus on higher agricultural productivity, improved food through lesser food prices, and nutrition security (6, 26).

The Farm Input Subsidy Program (FISP) in Malawi, currently known as the Affordable Input Program (AIP), is implemented to increase cereal and legumes production and provide farmers with the incentives to diversify production (21, 27–29). On a global scale, FISP also responds to the attainment of Sustainable Development Goal (SDG) 2 "End hunger, achieve food security and improved nutrition and promote sustainable agriculture" (30). The AIP program in Malawi has undergone several adjustments to align it to improved welfare outcomes. FISP was re-introduced in 2005/06 after an initial suspension of the program, consisting of fertilizer and seed inputs for maize and soybean crops (27). The core stated objective of the FISP has consistently been to improve resource-poor small-holder farmers' access to improved agricultural inputs to achieve their and national food self-sufficiency and raise these farmers' incomes through increased food and cash crop production (21).

Evidence on the performance of AIPs suggests that the overall production and welfare effects of subsidy programs tend to be smaller than expected (5, 31). Since the inception of the program, studies that have assessed the role of the FISP have focused on the contribution of FISP to coping with negative shocks (32); reduction of the gender adoption gap (33); nutrition outcomes (25); agricultural diversification (19); gendered agricultural productivity (20); and adoption of natural resource management technologies (34).

Despite the wide implementation of Agricultural Input Subsidies (AIS) and recent interest in assessing the linkages of the programs to food and nutrition security outcomes, the evidence continues to be scanty and unclear (26, 35). Like many AISs, the FISP has targeted increased productivity of agricultural households by providing input subsidies to small-scale farmers (21). In addition, the FISP program has been aligned with national development goals such as the Malawi Growth and Development Strategy (MGDS) and the global Sustainable Development Goals (SDGs) (36–38).

The prevalence of wasting among children under-5 years is generally unwanted among populations, as it reflects the short-term unavailability of food among households. While the prevalence of wasting among children in Malawi is lower than the global estimates of 6.7%, at 3.7%, the presence of wasting among children is highly undesirable. Despite the widespread use of subsidies for agricultural inputs as a crucial agricultural policy for reducing food insecurity in SSA countries, such as Malawi, discourses examining the pathways of the subsidy programs to nutrition outcomes are sparse and do not take into consideration the changing policies and implementation arrangements of the programs (35). Further, few studies link the FISP to children's outcomes (25). In this study, we address this research gap by assessing the relationship between access to FISP subsidy and the nutrition outcome of wasting among children under-5 years.

Ideally, improvements in child wasting cannot be achieved without consuming a healthy diet, and healthy food comes from either own production, gift, or purchase (39). The agricultural sector in many developing countries consists of small-holder farmers characterized by small land size (less than 3 ha) and constraints to agricultural inputs, which the Agricultural Inputs Subsidy Program (AISPs) attempt to

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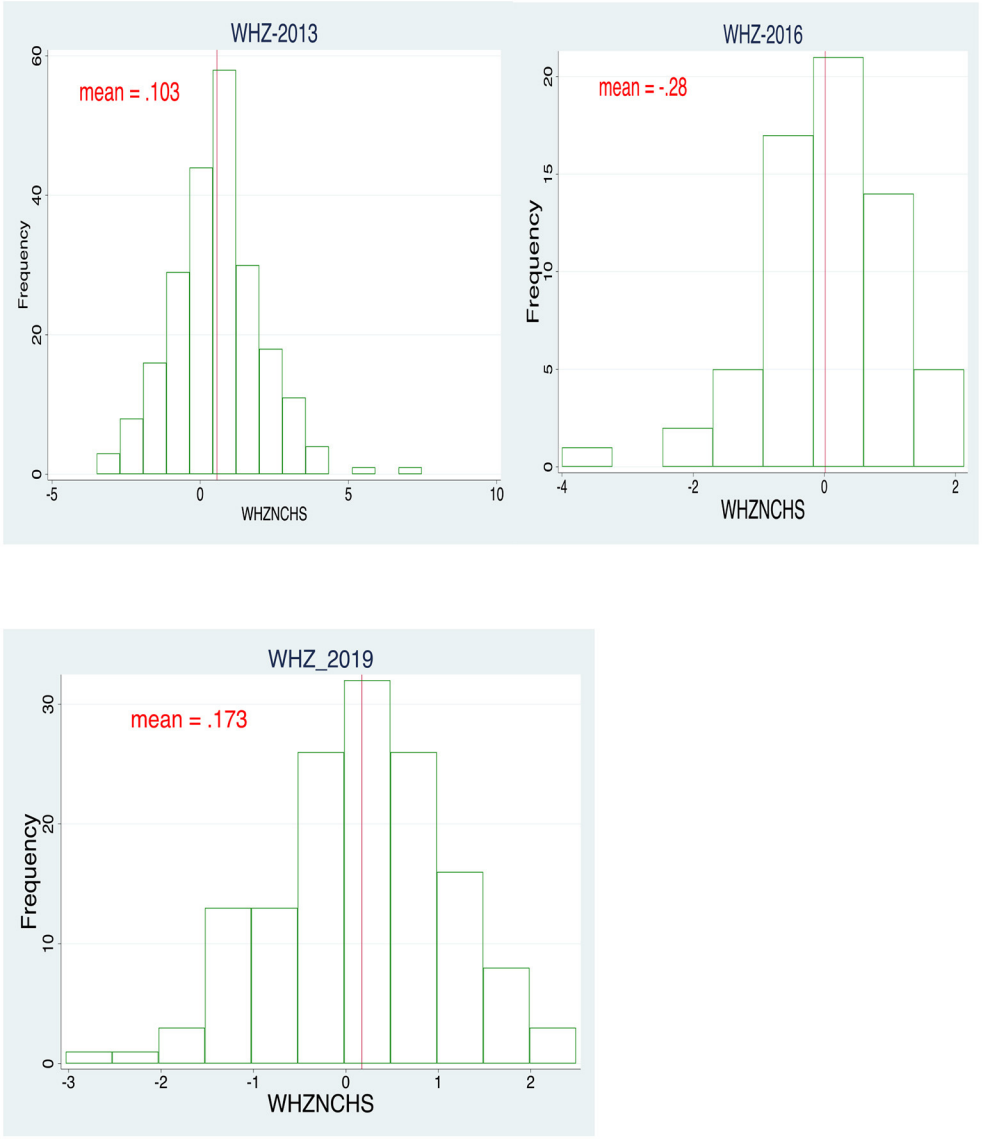

FIGURE 1
Wasting levels of children under-5 years in 2013,2016, and 2019.

address (5, 21). The Farm Input Subsidy Program (FISP) implemented in Malawi is this study's Agricultural input subsidy program of interest. The FISP is implemented as a social protection program that promotes food availability through subsidized inputs to increase own production and consumption of Maize and legumes (6, 19, 20). We adapt the conceptual framework offered by Walls et al. (6) and develop a conceptual framework specific for the FISP program in Malawi. Figure 1 shows wasting levels of under 5 children in the studied years.

We conceptualize FISP as being linked to child malnutrition through increased food production, especially Maize and legumes outputs, and subsequently contributing to nutritious and diversified food to children under-5 years dwelling in FISP beneficiary households. In our framework, malnutrition develops from two main immediate causes, inadequate dietary intake, and poor healthcare. In this study, we limit our analysis to the relationships between inadequate dietary intake and nutrition outcomes. Several authors have provided evidence that suggests that food insecurity, through inadequate dietary intake, is one of the major leading risk factors for child malnutrition (40–44).

FISP theoretically relates to dietary diversity through the inclusion of legumes in the program. While maize production

is associated with access to starchy food sources, the inclusion of legumes is a deliberate and direct way of introducing dietary diversity in FISP beneficiary households and enhances increased food availability at the household level. The increased food access pathway is closely related to this pathway and is achieved through maize and legume production. Lastly, dietary diversity is associated with increased access to nutritious foods through household incomes. Households with disposable income realized from their crops may be better able to purchase more nutritious foods and non-food products that are imperative for dietary diversity, hence enhanced nutrition of children under-5 years.

Our study builds on the previous scholars to further establish causality between FISP and child-related nutrition outcomes. Our contribution to literature is the time dimension element whereby we used three waves of the IHP data, i.e., 2013, 2016, and 2019. It is hypothesized that previous impacts, such as those established by Harou (25), are still consistent. Our study measures the contribution of the FISP program, which has undergone significant changes in its targeting criteria (from 1.5 million farmers to 1 million farmers in 2018/2019) and increased farmers' contribution fees toward redeeming coupons, which consequently have reduced the number of beneficiaries (21). Our study is, therefore, timely in addressing these changes.

Methods

Study design and setting

This study used three-wave panel data from Malawi's Integrated Household Panel Survey (IHPS) for 2012/2013,2015/2016, and 2018/2019 agricultural seasons to assess the role of input subsidy in improving malnutrition in Malawi. The IHPS data is collected by the Malawi National Statistical Office (NSO) with financial support from the World Bank to monitor and evaluate changing conditions of Malawian households. The data is nationally representative and incorporates both rural and urban respondents. The surveys provide comprehensive information on households' production under agricultural modules, household consumption, income, employment, health, education, and other household characteristics under the household module and community characteristics under the community module. The selection of households is based on a stratified two-stage sample design, which firstly selects primary sampling units (PSUs) Enumeration Areas (E.A.s), and then later identifies households. A useful element to note about this dataset is that the selection criteria for beneficiaries differed in the three data collection periods. Firstly, the number of beneficiaries in 2019 was fewer than in 2013 and 2016. Secondly, the beneficiaries in 2019 and 2016 were expected to contribute MK15,000 toward the cost of fertilizer, while the beneficiaries in 2013 contributed MK4,500 (21).

Sampling and sample size

In our analysis, the analytical sample size of 1947 households that either received subsidy coupons in one period or did not receive input coupons. It is worthy to note that these households that received FISP coupon were selected using a targeted approach due to their poverty vulnerability attributes and identified within their community by village headmen and related community leaders (4, 45). Their community defined these households as productive poor but had land and human capital yet lacked financial capital to acquire farm inputs either timely or not.

The pooled sample size for the three periods was 1947 households. However, it is important to note that only the rural households were eligible to participate and acquire inputs under FISP. Further, not all farmers benefited from both periods (either received input coupons in 2013 or 2016, or 2019), thus creating an unbalanced data structure.

Children under-5 years wasting

On the malnutrition outcome, we concentrated on wasting [calculated using anthropometric measurement, Weight for Height (WHZ)]. Our choice for wasting as an anthropometric indicator was twofold. First, when severe, Wasting weakens the child's immunity system and makes the child susceptible to long-term development delays but can be reversible with urgent feeding, treatment, and care (46). Secondly, changes in wasting levels can also be observed in a short time, such as the time frame of the three-panel data periods in this study (2013-2016-2019). Children are considered moderately malnourished if they have a z-score between −3 and −2, and severely malnourished if their z-score is less than −3 (25). We further determined a child to be wasted if weight for height; (WHZ) is less than −2.

Empirical model specification

To examine the impact of FISP in reducing child's wasting, we used two-stage least square to control for unobserved variables that cannot be controlled for but may be correlated with attributes used in selecting farming households. The first stage was to estimate Cobb Douglas production function while in the second stage, we linked the estimates in the first stage to assess whether the household that receive coupon experiences reduced wasting of its children under-5 years. It is worthy to note that our unit of analysis was at the household level.

In order to control for potential levels of endogeneity, in the first stage, we applied a Cobb Douglas production function for Maize and legume in that included production inputs in natural logs (i.e., inorganic fertilizer, organic manure, labor, land, and whether the household received input coupon in either 2012/2013 season or 2015/2016 season or 2018/2019 or one or

more of them). The model was specified as follows:

$$lnM_{it} = \alpha_0 + \gamma lnX_{it} + \theta lnZ_{it} + \mu \quad (1)$$

Where M_{it} in equation 1 was output of Maize and legumes in year t, for household i; X_{it} is a vector of input variables of inorganic fertilizer, organic manure, labor, land and whether the household received input coupon in either 2012/2013 season or 2015/2016 season or both; and household characteristics were given by Z_{it}. μ is the error term, while α_0, γ *and* θ are coefficients.

In stage two, we specified the model as follows:

$$\begin{aligned} lnN_{it} &= \alpha_0 + \alpha_1 FISP_{it} + \alpha_2 lnM_{it} + \alpha_3 (M_{it} * FISP)_{it} \\ &+ \alpha_4 \left(year * FISP\right) + \alpha_5 Z_{it} + \varepsilon_{it} \end{aligned} \quad (2)$$

Dependent variables

The dependent variable specified as N_{it} is the nutrition outcome from anthropometric indicators for children under-5 years in household i in year t. The nutrition outcome of interest, wasting, measures the weight for height (WHZ) ratio of the under-five child in households i. We then specified children under-5 years to be wasted if z-score for variable WHZ is less than −2. A child has adequate nutrition if WHZ is between −2 and 2.

Independent variables

The key independent variable, input subsidy ($FISP_{it}$), was measured in two forms: whether a household is a beneficiary of input subsidies and the quantity of subsidized inorganic fertilizer used by the beneficiary household. Empirical evidence reports a positive correlation between access to subsidized inputs and the production of target crops such as Maize (47–52). Since production is an intermediary indicator of nutrition security, we expect that an increase in crop production should positively correlate with nutrition security. Thus, access to subsidized inputs is expected to positively influence nutrition security through improved agricultural production.

M_{it} controls for production of the target crop. These are maize and legume (Beans, Soya bean and Groundnuts). As discussed in the previous paragraph, we expect an increase in production of these commodities to have a significant positive influence on nutrition security. It is however not automatic that an increase in food production will result in improved nutrition security. However, naive causality cannot be assumed due to endogeneity assumptions which we discuss below. Firstly, food surpluses do not necessarily translate into access to dietary quality and nutritious food (53). Secondly, most vulnerable people in Malawi have inadequate access to calories even in years when there is a surplus of Maize (39). It is, therefore, important to establish the farm-level link of agricultural production with dietary quality and nutrition security to understand the impact of agricultural policies and programs on nutrition security (54).

We interacted maize production and quantities of subsidized inputs (fertilizer and seed). This interaction (equation 2) is represented by $M_{it}^{*}FISP$. If the coefficient of the parameter α_3 is positive and significant, it suggests that an increase in food production due to access to subsidized inputs has a positive and significant correlation with nutrition security. Thus, access to subsidized inputs potentially enhances nutrition security through improved food crop production.

We also interacted in equation 2 above access to subsidized inputs to the year the household received input subsidy. This interaction represented as *Year*FISP* indicates the significance of receiving input subsidy in 2016 and year 2019 taking 2013 as base year. If the coefficient of parameter α_4 is significant and negative, then wasting of children under-five years of age was improved in the households that receive input coupon in 2016 and 2019.

Control variables

Control variables included household characteristics (Z_{it}) such as age of household head, education, and household size, Where ε_{it} is normally distributed error term. Age of the household head assumes that the older one is, the more responsible one becomes hence likely to positively influence nutritional security. Similary, the more educated a household head, the more knowledgeable one is in terms of the child's nutritional requirements and hence enhance nutritional security by reducing Wasting among the under five.

Data analysis and estimation

Our data analysis consisted of both descriptive and regression analysis. We analyzed key descriptive variables of access to FISP coupon, land size, maize output, legume output, household size and education. The descriptive statistics are presented as means and standard deviations. Cobb Douglas and Correlated Random Effects (CRE) regression analysis were conducted to examine the correlation of access to FISP coupons to anthropometric outcome of wasting among children under-5 years. Data was managed and analyzed using STATA 17, and all statistical analyses were performed within the program.

This CRE strategy addresses the problem of unobserved heterogeneity in the model especially with unbalanced panel data. The CRE strategy also partially address the endogeneity problem associated with access to input subsidies because the identification strategy of beneficiaries is not random. This problem is partly addressed in the CRE strategy because it

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TABLE 1 Study sample of the 2013_2016_2019 panels.

Year	Total observations		Beneficiary	Non-beneficiary
	Frequency	%	N	N
2013	622	31.95	225	397
2016	296	15.36	220	76
2019	1,026	52.70	143	883
Number of observations	1,947			

TABLE 2 Descriptive statistics of the explanatory variables.

	2013	2016	2019
Age	36.59	34.07	35.63
Household size	5.81	5.21	5.17
Education (years)	7.06	6.45	7.56
Maize yield (kg)	811.62	375.22	426.39
Legume (kg)	147.42	90.01	1,546.39
Land (acres)	1.79	1.56	1.53

controls for unobserved heterogeneity which is the main cause of the endogeneity (55). It is important to note that, we included the mean of time-invariant variables in these correlated random effects (CRE) specification.

Results

Background characteristics

In Table 1 through Table 4, we present summaries of descriptive statistics of variables used to analyze the impact of the input subsidy program in reducing wasting of children under-5 years in Malawi. Table 1 provides the distribution of the sample across the three sampling periods. We observe a decline in the number of FISP beneficiaries as we move across the three periods, with 2019 registering the lowest number of 143 from 225 in 2013. These results are consistent with the reduction in the number of beneficiaries of the FISP program (21).

In Table 2, we presented the descriptive statistics of the explanatory variables. This mainly showed household characteristics, including demographic and economic variables such as land size (farm size) measured in acres, and maize and legume output measured in kilograms.

It can be observed that the mean land size cultivated by the households decreased across the years, with a corresponding decrease in maize output (from 811.62 kg in 2013 to 426.39.30 kg in 2019). On the other hand, legume production increased from 147.42 to 1546.39 across the panels.

TABLE 3 Descriptive statistics of the explanatory variables by beneficiary category.

Variables	Beneficiary	Non-beneficiary	Pooled
Age (Years)	37.09	35.28	35.69
Household size	5.7	5.3	5.4
Education (years)	6.9	7.3	7.2
Maize yield (kg)	640.58	512.1	541.59
Legume (kg)	215.72	1,072.52	878.04
Land (acres)	1.90	1.53	1.62

TABLE 4 Descriptive statistics of the outcome indicator- wasting.

	Observations	Mean	Std. Dev.	Min	MaxW
WHZNCHS	1,947	3.668906	18.04792	−4	30

Table 3 presents the descriptive statistics of the explanatory variables disaggregated by beneficiaries and non-beneficiaries of FISP. We found that on average, FISP beneficiaries cultivated relatively bigger land sizes (19%) than non-beneficiaries, with a corresponding 20% higher maize output (640.58 kg) than their non-beneficiary counterparts (512.1 kg). However, non-beneficiaries produced more legumes than beneficiaries (399 % more).

Wasting among children under-5 years

Table 4 presents descriptive statistics of wasting among children under-5 years in Malawi. Overall, the mean Z-score is 3.66, suggesting that, on average, children under-5 years in the sampled households were not wasted.

Figure 1 presents three histograms for 2013, 2016, and 2019 panels. We find fluctuations in the WHZ values across the three periods. Firstly, we observe that the WHZ value in 2013 was positively skewed (0.103). However in 2016, the wasting levels declined, with a mean WHZ value of −0.28. An improvement in the wasting levels is recorded for 2019, at 0.173.

Impact of FISP on reducing wasting amongst children under-5 years

Table 5 presents the determinants of wasting among FISP and non-beneficiary households. The regression analysis showed that wasting among children under-5 years in Malawi was affected by household participation in FISP, location of the household, the interaction of participation in FISP and Maize

production, and the period in which the coupon was received. At a 5% level of statistical significance, there was a positive and significant correlation between households receiving a FISP coupon and the probability of having children under-5 years wasted.

The impact of access to a FISP coupon on reducing wasting is only significant when we observe the maize output levels among beneficiary households. We find that households that accessed subsidized fertilizer and produced Maize had a lower probability of having children under-5 years wasted ($p < 0.05$).

The results further show an improvement in wasting levels of children under-5 years dwelling in households that received input coupons in the 2018/2019 season compared to the other seasons. We find that children under-5 years dwelling in households that received input coupons in 2015/2016 had a significantly higher probability of being wasted ($p < 01$). On the other hand, the probability of having children under-5 years wasted in households that received a coupon in 2018/2019 was significantly lower ($p < 0.05$)

In terms of region of residence, we find a positive and significant correlation of the probability of households having children under-5 years that are wasted if the household resides in the central region of the country ($p < 0.10$).

TABLE 5 Results of impact of FISP on wasting among children under-5 years.

	Wasting (logWHZ) b/se
FISP	1.248**
	(0.659)
Maize1	0.061
	(0.080)
legume1	−0.014
	(0.018)
0.FISP#c.M∼1	0.000
	(.)
i.FISP#c.Maize1	−0.207**
	(0.112)
c.FISP_Seed#c.legume1	0.002
	(0.003)
Age	0.007
	(0.016)
Age2	0.000
	(0.000)
reside	−0.105
	(0.100)
edu_head	−0.006
	(0.011)
1.r egion	0.000
	(.)
2. region	0.204*
	(0.114)
3.region	0.188
	(0.118)
hhsize	0.033
	(0.024)
2013.year	0.000
	(.)
2016.year	0.550****
	(0.112)
2019.year	−0.194**
	(0.088)
Sex	0.121
	(0.105)
Year 2	−0.136
	(0.203)
Year 3	−0.178
	(0.166)
Sex_child	0.063
	(0.060)
devage	0.001
	(0.007)
devfarmsize	0.022
	(0.037)

(Continued)

Discussion

This study establishes evidence of how access to FISP affects household nutrition. The number of targeted beneficiaries in the samples used in this study dropped from 600 in 2013, 276 in 2016, and 145 in 2019 due to the government's reduction of the targeted beneficiaries and increased coupon redeeming fee (21). Overall, the mean wasting was 0.103 in 2013, −0.28 in 2016, and 0.173 in 2019. This finding shows that nutrition outcomes due to access to FISP coupons have been inconsistent, with better outcomes observed in 2013 and 2019.

Interestingly, our three-wave panel data finds that access to FISP coupons as a stand-alone predictor is not associated with reduced wasting values in households and does not directly translate into improved nutrition outcomes of wasting. Households that accessed FISP coupons had a higher probability of having children that were wasted. These results are different from what Karamba (56) and Harou (25) found, where the receipt of subsidized inputs led to a reduction in wasting (weight for height) among children under-5 years in beneficiary households. One possible explanation of these differences is the datasets used, i.e., Harou used two waves of 2012/13 and 2015/16 while Karamba used one wave of 2009/10. This suggests that while FISP aims to improve household food and nutrition security, the direct correlation might not always hold in all contexts. Another possible explanation for this phenomenon might be related to the selection criteria for the program, where households that receive FISP coupons are economically

TABLE 5 Continued

	Wasting (logWHZ) b/se
devsex	0.061
	(0.165)
deveducation	−0.002
	(0.019)
devhhsize	−0.039
	(0.036)
Constant	−0.308
	(0.535)
/	
sigma_u	0.363****
	(0.067)
sigma_e	1.093****
	(0.030)
Wald chi	107.688
Prob > chi2	0.000
Rho	0.100
Observations	1,662.000

WHZ was dummy for 1 = Yes and 0 otherwise. Results are significant at ****, **, * 0.1%, 1%, 5% and 10% levels respectively.

challenged, produce less food for consumption, and have less income to purchase food, which leads to children under-5 years being wasted.

Further on, a possible explanation could be related to the program's focus on Maize as a staple crop with less attention to other nutritionally high-value crops. Evidence shows that it is only in recent times that the program included legumes seed, but how far households are making use of this is yet to be verified. This finding could, however, be due to methodological specifications. We, therefore, tried to interact with the FISP (whether the household redeemed fertilizer and seed) variables with maize and legume production.

When we estimated the interacted effect of maize production conditioned on receiving and redeeming subsidized inputs, we observed a negative and significant correlation between wasting levels of children under-5 years ($p < 0.01$). These results, in principle, imply that nutritional benefits from FISP coupons are contingent on increased maize production, contributing to reduced wasting among children under-5 years old. This finding further implies that even if households have access to FISP coupons, the presence of other forms of constraints in accessing and utilizing additional resources required for higher maize production will likely result in undesirable nutrition outcomes. In light of the fact that no statistically significant impact was found for maize production on wasting, which concurs with Walls et al. (6), we suggest that the selection criteria for the FISIP beneficiaries should target economically challenged households with the appropriate supporting conditions to increase maize production.

We find no significant interaction effect for legumes and no evidence to support the pathway in our conceptual framework that legume production leads to dietary diversity and hence improved nutrition outcomes for children under-5 years in FISP households. Matita et al. (57) found a similar lack of evidence on the contribution of cultivating legumes to dietary diversity for households that accessed FISP coupons. However, a recent study finds a positive linkage between access and redemption of legume coupons with greater dietary diversity and evidence that the type of subsidized seed coupon matters for nutrition outcomes (58). Based on these two differing findings from the literature, we postulate that further analysis focusing on types of coupons redeemed and linkage with anthropometry outcomes should be considered in future studies.

We found that households that received a coupon in the 2015/2016 period had a significantly higher probability of having children under-5 years wasted. But households that received a coupon in the 2018/2019 period had a significantly lower likelihood of having children under-5 years wasted. These results can be understood in the context of the changes that have been implemented for the subsidy program (21, 57). Households that accessed coupons in 2015/2016 were the first group to pay higher redemption fees for the coupons, which could have affected the quantities of inputs redeemed by the vulnerable farming households.

We found that residing in the central region was associated with a household having a significantly higher probability of having children under-5 that are wasted. These results partly render to other findings that farmers in the central region have less diversified production systems, with Maize and tobacco continuing to dominate cultivation (58).

Conclusions and recommendations

Our current study examines the link between FISP and its effect on the child malnutrition outcome and wasting of children under-5 years in Malawi. The FISP program continues to be a topic of interest due to the significant funding it receives within the Agricultural budget in the study country and the important role of Maize, the main targeted crop within the subsidy program. We find evidence that households that had received a coupon were overall associated with a higher probability of having children under-5 years with wasting. We further find those poor households that received input coupons (FISP) and produced Maize had better outcomes for wasting among children under-5 years. We also note that being a FISP beneficiary in the central region was associated with a higher probability of having children under-5 that are wasted. Across the sampling periods, we find that households receiving a coupon in 2015/2016 had a higher probability of having children

under-5 years, while a lower probability was observed for the 2018/2019 period.

We understand that the use of Input Subsidy is not a stand-alone predictor that directly links to child malnutrition. Nevertheless, where beneficiary households can increase output of cereals such as Maize, important reductions in malnutrition outcomes such as wasting are attained. Based on the above results, we draw the following recommendations for further improvements in implementing the FISP in Malawi.

Firstly, our study highlights the important role that increased output plays in attaining nutritional outcomes such as wasting. We, therefore, propose that to achieve the desired impacts of input subsidy programs on nutrition outcomes, the targeting of beneficiaries needs to be based on the productivity levels of households. We acknowledge the intention of the government to support the highly resource-constrained households to improve food security and the economic wellbeing of the beneficiary households. Nevertheless, we suggest that for the government to achieve this noble objective, the targeted poor resource-endowed FISP beneficiary households should be supported with appropriate household level enabling conditions such as time-bound staggered social safety nets to ensure that they effectively put the inputs into use at the farm level for increased production of Maize and the other chosen crop enterprises. The revision of the targeting criteria for the FISP program initiated in the 2015/16 period and 2018/2019 period is an excellent step in the right direction toward this, and our results, where households that received FISP in 2019 had reduced wasting levels of children under-5, do indeed suggest that the revised criteria can generate significant positive outcomes from the FISP program.

Secondly, our results bring into question how the FISP program can best account for the spatial differences that exist across the three regions. The evidence from this study and other studies has shown that the nutrition outcomes linked to the FISP, such as dietary diversity and child anthropometry, are not consistent across the three regions in the country (58). While it is true that the targeted crops (Maize and legumes) are important crops at a country level, there is room for more conversations on whether the subsidy program should expand its targeted crops. Understanding the broader linkages that income pathways offer to access to important food crops can help streamline investments in other food systems within the regions that can be linked to the intended nutrition outcomes currently outlined in the FISP program.

Potential study limitations and mitigation

As we argue in the paper, evaluating AIP subsidies needs to be a continuous effort to inform policy direction and implementation strategies. Our analysis only focused on the nutrition outcome of wasting. However, there is a need to assess how changes in the implementation of the FISP affect other nutrition outcomes both among children under-5 years and productive adults. Further, we acknowledge that further studies could identify more nuanced relationships by isolating the type of coupons redeemed by households.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: https://microdata.worldbank.org/index.php/catalog/3819.

Ethics statement

The studies involving human participants were reviewed and approved by Malawi National Statistic Office. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

GT contributed to this study by suggesting the topic, data sourcing, data cleaning, file merging, and running the data analysis. EG was responsible for drafting the introduction sections, developing the conceptual framework, and drafting the discussion of results and final edits of the paper. BM improved the research objective and editorial works of the paper, including proper design of the tables, critiquing of the contents of the study, interpretation of the tabulated results, discussion of the research findings, and fine-tuning the recommendations. KM was responsible for reviewing the arguments and constructing linkages of the study findings with existing literature. SK developed the empirical methodologies used in the study. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Advertising of unhealthy foods and beverages around primary and junior high schools in Ghana's most urbanized and populous region

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Introduction: The advertising of energy-dense, nutrient-poor foods and beverages is a common feature in obesogenic food environments. Such advertising, within and around settings where children live, learn, and play, negatively affects their food acquisition and consumption. We examined the extent and nature of food and beverage advertising around primary and junior high schools in Ghana's most populous and urbanized region, Greater Accra.

Materials and methods: Outdoor advertisements for foods and beverages within a 250 m road network distance of 200 randomly sampled schools were geocoded. For each food and beverage advertisement, information was collected on the setting, type, size, and number of product types featured in the advertisement. Promotional techniques (promotional characters and premium offers) used in advertisements were documented. Advertised foods and beverages were classified using the INFORMAS and NOVA food classification systems.

Results: A total of 5,887 advertisements were identified around the schools surveyed, 42% of which were for foods and beverages. Advertisements were most prevalent at food outlets (78% of all food advertisements), but also along roads and on non-food structures. Overall, 70% of food advertisements featured non-core/unhealthy products, while 12 and 14% had core/healthy

and miscellaneous (including soup cubes, seasonings, and tea) products. About 4% of food advertisements had only a product/brand name or logo displayed. One out of two of the foods and beverages advertised were ultra-processed foods, 30% processed, 3% processed culinary ingredients, and 17% unprocessed or minimally processed foods. Sugar-sweetened beverages were the most advertised food product type (32%). Promotional characters were found on 14% of all food advertisements (most–69% were cartoons or manufacturer's characters), while 8% of all food advertisements had premium offers (including price discounts and gift/collectables).

Conclusions: There is an abundance of unhealthy food advertisements around primary and junior high schools in the Greater Accra Region. Policy actions such as restricting the promotion of unhealthy foods in children's settings are needed to protect pupils from such advertising practices.

KEYWORDS

food environments, food advertising, unhealthy foods, schools, children, Ghana

Introduction

Preventing overweight and obesity among children is a global public health priority. Since the 1980s, childhood overweight and obesity have risen worldwide (1, 2). An increase from 4% in 1975 to over 18% in 2016 was reported among school children aged between 5 and 19 years globally (3). Diverse studies have identified exposure to unhealthy food environments as a major determinant of overweight and obesity, especially among countries undergoing what is termed the nutrition transition (4–6). Ghana is at an advanced stage of the nutrition transition; there is a rapid shift toward consumption of energy, fat, sugary, and salty foods and low levels of physical activity (7, 8).

A known factor driving the preference, acquisition, and consumption of unhealthy foods is food and beverage marketing (9, 10). The World Health Organization (WHO) defines marketing as "any form of commercial communication or message that is designed to, or has the effect of, increasing the recognition, appeal, and/or consumption of particular products and services" (11). Existing marketing platforms, such as television, radio, and outdoor advertisement channels (e.g., billboards, merchandise, and posters), are used to communicate messages and promote products and services to consumers (12). Promotional messages featured on these platforms are often packaged using persuasive marketing techniques deployed toward specific target individuals with common needs or characteristics (13). Such marketing techniques include the use of celebrity or sports endorsements, promotional characters, product claims, gifts/incentives, competitions, and games which are likely to appeal to children (14, 15). For children and adolescents, they are mostly exposed to such marketing techniques staged in media/settings (e.g., on television, schools, digital spaces, magazines, etc.) where they frequently utilize (16). They are particularly vulnerable because of their susceptibility to advertising techniques; they lack the cognitive ability to recognize the persuasive intent of advertising (17).

Currently, the literature on food marketing highlights the extensive advertising of less healthy options such as energy-dense foods and beverages, particularly sugar-sweetened beverages (12). Television food advertising remains the most researched advertising platform, although research on other media and settings is increasingly gaining attention. Reports from studies on outdoor food advertisements conducted in New Zealand (18), Australia (19, 20), and the USA (20) consistently show that most outdoor food advertisements are for unhealthy food or beverages, and they vary according to neighborhood characteristics. While data on outdoor food advertising in low-and middle-income countries is limited, accumulating evidence suggests a significant predominance of unhealthy food marketing in these countries. For instance, Chacon et al. found most the advertised food products around public schools in Guatemala were for sweetened beverages and soft drinks (21). In Mongolia and the Philippines, Kelly et al. reported over 85% prevalence of unhealthy food and drinks in the vicinity of schools (22). Furthermore, a recent study of outdoor food advertising around schools in Africa-Uganda recorded that over 80% of the food advertisements featured unhealthy food products (23). Our assessment of outdoor food advertising in the urban cities of Ghana also identified sugar-sweetened beverages as the most widespread food or beverage sold or advertised (24, 25).

Recognizing this evidence, the 63rd World Health Assembly endorsed a set of recommendations on the marketing of food and beverages to children (11). Member states were encouraged to use these recommendations to develop new

and/or strengthen existing policies on food and non-alcoholic beverage marketing to children. However, in 2020, the WHO Global NCD Progress Monitor report indicated that Morocco is the only country within the African region to have fully implemented the WHO recommendation on the marketing of foods and non-alcoholic beverages to children (26). Currently, countries such as Chile and Spain are safeguarding children from unhealthy food environments through the promulgation of zoning laws prohibiting the promotion of unhealthy foods to children (27). In Ghana, food advertising is regulated by the Food and Drug Authority of the Ministry of Health. However, anecdotal evidence suggests that there is indiscriminate advertising of unhealthy foods and beverages within Ghanaian children's settings, including the immediate school environment. Empirical data is required to substantiate this assertion and guide public health initiatives and/or strategies aiming to improve children's food environment, including through policy development and implementation. This descriptive study aimed to examine the extent and nature of outdoor foods, and beverages advertising around selected schools in the Greater Accra region of Ghana.

Materials and methods

Study design

This descriptive cross-sectional survey is part of the MEALS4NCDs Project (28) which aims to measure and support public sector actions that create healthy food marketing, retail, and provisioning environments for children and adolescents in Ghana. The project adopted standardized frameworks, indicators, and tools to assess food promotion, food provision, and the Ghanaian community's readiness to support policy actions toward healthier food environments. The design of this current study draws substantially from the outdoor advertising protocol developed by the International Network for Food and Obesity/NCDs Research Monitoring and Action Support (INFORMAS) (29).

Study location

Figure 1 displays the geographical location of the 16 administrative districts in the Greater Accra Region. The Greater Accra region was purposively selected out of Ghana's ten geographical regions (at the time the study was being conducted). It is the most populous and urbanized region in Ghana and hosts the capital city, Accra. The region has a cosmopolitan mix of cultures from all the other regions of Ghana. In 2018, the region had a total of 862 public primary schools and 812 public junior high schools, with a total enrolment of 431,782 (30).

A representative sample of six study districts was selected from the Greater Accra Region using a multistage sampling approach. We first grouped the 16 administrative districts within the Greater Accra region using the decentralized system of administration under the local government system of Ghana into three strata: Metropolitan, Municipal, and District. A metropolitan covers urban areas with populations of over 250,000. A municipal has a population of 95,000 or more, while a district covers a wider geographical area, combining rural areas and small towns, with a minimum population of 75,000 people. These administrative divisions are by themselves indications of the population density and urbanization status and give an idea of district-level "poverty incidence" (PI). The Ghana Statistical Service calculates and defines poverty incidence as the proportion of the population living below the national poverty line (6.6%). From each stratum, a random selection of Accra Metropolitan (PI: 2.6%) out of two metropolitans; Ningo Prampram District (PI: 31.2%) and Kpone Katamanso District (PI: 3.5%) from the five district assemblies; and La Nkwantanang Madina Municipal (PI: 2.8%), Ashaiman Municipal (PI: 4.4%), and Ga South Municipal (P1: 15.2%) from nine municipalities was performed.

Schools sampling

Schools were the primary sampling unit (PSU) in this study. A sample of 200 schools representing about 25% of the schools within the region was selected from the six study districts. For each district, schools were stratified by levels (primary only, JHS only, and those having both JHS and primary levels). The required number of schools for each stratum from each district was calculated and sampled using proportionate sampling on the basis of the number of available schools for each level. This information was obtained from the Education Management Information System (EMIS) of the Ghana Education Service. Subsequently, a systematic random sampling technique was used to select the participating schools from each stratum after sorting using roll size data, defined as the number of pupils in the school. Full details on the sampling methodology have been published elsewhere (28).

Data collection

For each selected school, zones earmarked for assessment were road networks within a distance of 250 m from the main entrance of each school. The 250 m distance is in accordance with the INFORMAS protocol (29) and has been used by previous studies investigating outdoor food advertising (19). The 250 m is considered a walkable distance that students

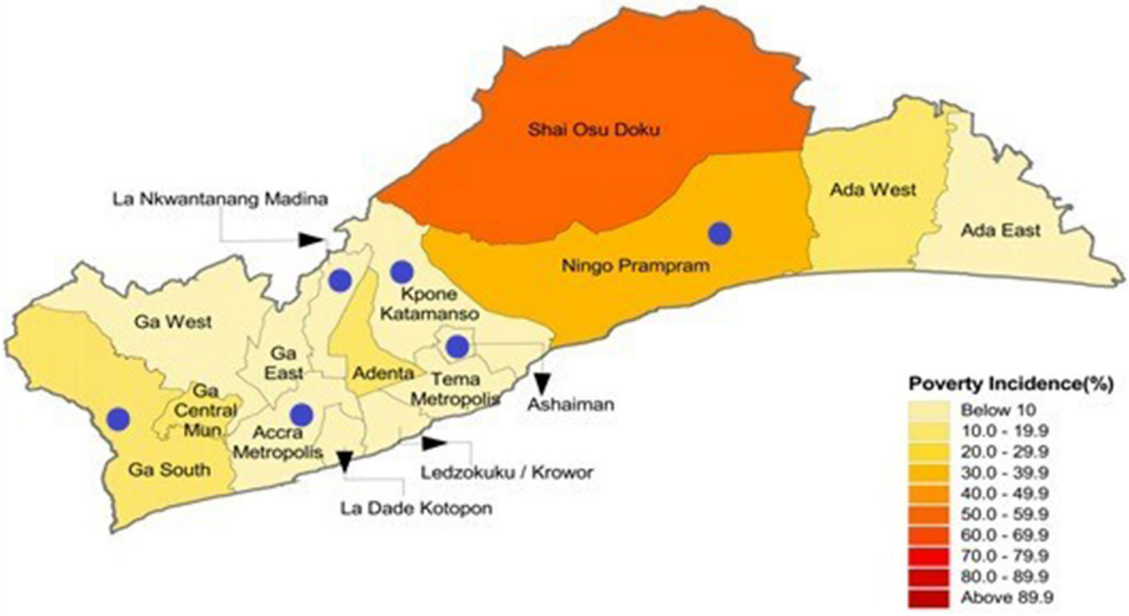

FIGURE 1
Map of the Greater Accra region of Ghana showing the various districts and poverty incidence.

can travel to make purchases during breaktime. Identification of the main entrance of each school was manually done by field supervisors with assistance from the head teachers after providing informed consent. All selected schools consented to participate in the study.

Data collection was carried out between July and August 2020 during weekdays (Monday–Friday, 9:00 a.m. to 5:00 p.m.) while schools were in session. This period ensured survey activities were conducted while full academic session was ongoing, allowing other components of the MEALS4NCDs project that required engagement with school authorities to be carried out. Prior to data collection, field research assistants with a minimum of a bachelor's degree were trained on using the data collection tool and study protocol. Emphasis was placed on the definition of an advertisement and what qualifies as a food (including alcoholic and non-alcoholic beverages) or non-food advertisement. Inter-coder reliability examination among field personnel was performed to check coding reliability after a pretesting exercise as part of the training. A total of 55 advertisements identified at a test site were independently coded by 12 research assistants. Data collected by the first author (GSA) was used as a reference, and percentage agreement was calculated for all field research assistants individually. Inter-code reliability calculated ranged from 85 to 90%. In this study, advertisements were defined in accordance with the INFORMAS Outdoor Advertising Protocol (29).

Six field teams (two-person teams) were each assigned to one of the six districts and tasked with conducting on-site visits and directly auditing all road networks in the dedicated zones at the selected schools for advertisements of food or non-food products. Assessment for each school zone was completed at a visit. Field workers used an observational checklist, designed using the Open Data Kit (ODK) application on an Android-based mobile phone with a built-in camera and geo-positioning functions, to objectively record descriptive information about each food advertisement. This format allowed simultaneous coding of advertisement characteristics (size of advertisement, setting of advertisement, type of advertisement, number of product types in the advertisement, product's name and brand, and the use of promotional characters and premium offers), photograph, and recording of the geo-location coordinates of the advertisements found. Effort was made to record the names of all products depicted in the advertisement in the event the advertisement promoted multiple products.

Food classification

Classification of food products in advertisements was performed after the completion of field data collection. A separate training session was organized for three personnel (including GSA and AL) on how to correctly classify advertised food products. Inter-coder reliability testing was performed before commencing with the actual classification of the food advertisement. Each

coder got a minimum of 80% inter-coder reliability on a test dataset.

Two different food classification systems, the NOVA classification system and the INFORMAS food classification system, were used to classify the foods and beverages advertised. With limited application in the Ghanaian setting, the two classification systems were adopted to ascertain how each evaluates the local food and beverage advertisements. The INFORMAS food classification system classifies food into "core/healthy", "non-core/unhealthy" and "miscellaneous" foods. This classification system is based on defined cut-off points of fat and sugar (per 100 g of food). The cut-off points are different for each food group, taking into account differences in nutrient density. This food-based system encompasses 11 sub-food groups under core/healthy foods, 15 sub-food groups under non-core/unhealthy and 11 subgroups under miscellaneous. Core/healthy foods include fruits, vegetables, and water, while foods such as sweetened beverages, ice cream, and sweet biscuits are categorized as non-core/unhealthy foods. Miscellaneous foods include soup cubes, seasonings, and tea. Those advertisements with only a product/brand name or logo were classified separately. In this study, an advertisement was considered non-core/unhealthy if at least one food item in the advertisement was coded as non-core/unhealthy. This classification system has been used by previous studies, including some in Sub-Saharan Africa on outdoor food advertising (23, 24). The NOVA food classification, which is based on the nature, extent, and purposes of the industrial processes' foods are subjected, classifies foods into four groups: Unprocessed and minimally processed foods; processed culinary ingredients; processed foods; and ultra-processed foods and drinks products (31). Unprocessed and minimally processed foods include fresh and frozen vegetables, fruits, cereals, meats, poultry, and fish. Processed culinary ingredients include plant oils, animal fats, sugar and salt. Examples of processed foods include canned vegetables in brine, fruits in syrup, fish preserved in oil, while ultra-processed foods include ice cream, chocolates, candies, cookies, noodles, and carbonated drinks. Alcoholic drinks are not considered in this classification.

Statistical analysis

Statistical software, IBM SPSS Statistics for Windows version 21, was used for data cleaning and statistical analysis. All recorded outdoor food advertisement data was used in the analysis. Descriptive analyses (frequencies, median, and Interquartile range) were used to summarize the number and characteristics of food advertisements, including those for promotional techniques (promotional characters and premium offers).

Ethics

Permission to conduct this study was obtained in 2019 from the Greater Accra regional office as well as the participating district offices of the Ghana Education Service. Ethics approval was granted by the Ghana Health Service Ethics Review Committee (Approval # GHS-ERC 005-06-19) and the University of Ghana Ethics Committee for Humanities (Approval # ECH 152-18-19).

Results

Assessment was conducted at all 200 sampled schools. Most of the schools were from the Accra metropolitan area (n = 54) with Ashaiman municipality recording the lowest number of sampled schools (n = 13). The "poverty incidence" across the selected districts ranged from 2.6% (lowest) for Accra Metropolitan to 31.2% (highest) for Ningo Prampram District.

Extent of food advertisement in the areas around schools

In total, 5,887 advertisements were identified, of which 2,469 (42%) were food-related. The number of food advertisements per school varied widely (range = 1–125) with a median number of 14 food advertisements. As shown in Figure 2, the proportion of food advertisements recorded in areas (districts) with a low poverty incidence was higher compared to those with a high poverty incidence. Food advertisements were more prevalent in the vicinity around of "JHS only" schools (median = 22) than in the vicinity of "Primary only" schools and Basic (having both primary and JHS units) schools (median= 11)—see Table 1.

Characteristics of foods and beverages advertisements

Overall, the majority (78%) of food advertisements were either within the premises of food shops (mostly convenience/provision shops) or attached to them. About 15% of adverts were by the roadside, and the remaining were posted on non-food buildings (6%) or in other settings (2%)—mobile stalls and bus shelters. Most food advertisements (71%) promoted a single food product, although 19% had two or more different products. About 10% of food advertisements display only the product/brand name or logo. Most food advertisements were in the form of posters or banners (71%). About half (49%) of the food advertisements were small in size, while over one-third (34%) were of medium size and 10% were large (Table 2).

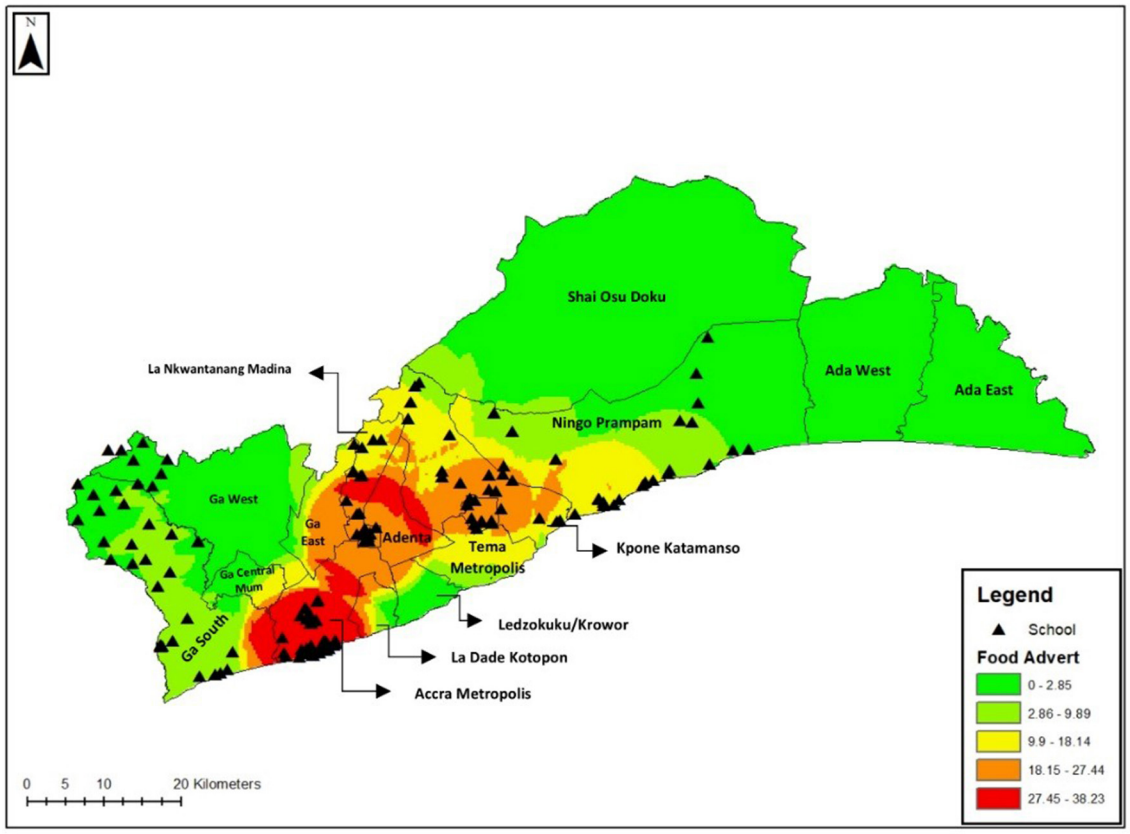

FIGURE 2
Hotspot map of advertisements recorded by district.

TABLE 1 Median number of food and beverage advertisements along a 250 m road network around schools by school type and location characteristics.

	Median food adverts	(25-, 75-percentiles)
School type		
Primary school only (6–11 y)	11	(7, 22)
Junior high school only (12–15 y)	22	(12, 41)
Basic school (6–15 y)	11	(4, 22)
School location		
Accra metropolitan	19	(12, 41)
Ashaiman municipal	13	(8, 35)
Ga South municipal	4	(2, 7)
La Nkwantanang Madina municipal	23	(11, 47)
Kpone Katamanso district	16	(9, 33)
Ningo Prampram district	12	(5, 24)
Location poverty incidence		
High poverty incidence schools	6	(3, 14)
Low poverty incidence schools	20	(10, 39)

Types of advertised foods and beverages

Two-thirds (70%) of the food advertisements featured non-core/unhealthy foods. Core/healthy foods and miscellaneous foods contributed to 12 and 14% of food advertisements, respectively. About 4% of food and beverage advertisements had only a product/brand name or logo. The most frequently advertised food product subcategory was sugar-sweetened beverages (32%), followed by alcoholic beverages (12%) and high-fat and/or sugar-flavored dairy products and their alternatives (11%)—see Table 3. Four out of the top five most frequently advertised product subcategories belonged to the non-core/unhealthy food category. Bottled water (8%) was the most advertised product within the core food category. Advertisements for fruits and fruit products, and vegetables and vegetable products were rarely found (1 and 2%, respectively). About 69% of the foods and beverages advertised were ultra-processed foods; 29% were processed; 5% were processed culinary ingredients; and 19% were unprocessed or minimally processed foods according to the NOVA classification system (see Figure 3). The number of unhealthy food ads was higher

TABLE 2 Characteristics of food advertisements in/around schools in Greater Accra.

	Frequency (*n*)	Percent (%)
Setting of advertisement		
Food shop	1,924	78
Road	364	15
Non-food building	140	6
Mobile stall	38	2
Bus Shelter	3	0
Format of advertisement		
Poster/banner	1,744	71
Merchandise (e.g., branded umbrella, branded fridge)	308	13
Free-standing sign	243	10
Painted building/wall	152	6
Billboard	21	1
Number of product type in advertisement		
Only product/brand name	244	10
Single food product type	1,746	71
Two or more food product types	479	19
Size of advertisement		
>A4 paper	177	7
Small (>A4 but <1.3 × 1.9 m)	1,203	449
Medium (>1.3 × 1.9 m but <2.0 × 2.5 m)	845	34
Large (>2 × 2.5 m)	244	10

around schools in the high poverty incidence area compared to the low poverty incidence urban area, with a median of 12 and 3, respectively (Table 4).

Description of promotional techniques

Approximately 14% (n = 334) of food advertisements featured a promotional character. Cartoons/company owned characters (69%) and "for kids" images (23.4%) were the most predominantly used promotional characters compared to others, such as famous sports people, non-sport celebrities, and amateur sports people. Premium offers were present in 8% (n = 184) of all food advertisements. They include price discounts (28.8%), price promotions (60.9%) and "gifts and collectables" (7.6%). As shown in Figure 4, of the advertisements that featured a promotional technique, non-core foods advertised had the highest number of promotional characters and premium offers used (74 vs. 96%, respectively).

Discussion

Tackling obesity and diet-related NCDs demands a multi-sectoral and multidisciplinary approach, including understanding environmental cues like advertising activities that promote the consumption of unhealthy foods. Findings from this study demonstrate that outdoor food advertisements (42%) are pervasive around schools in the Greater Accra region. Previous studies have reported varying densities of food advertisements at schools, citing neighborhood characteristics such as socioeconomic status and geographical (rural/urban) locations as contributing factors (32–34). Our study reveals s lower density of food advertisements in schools located in areas with high poverty incidence areas compared to those in low poverty incidence areas, which are more urbanized and have high population density neighborhoods. Food marketers gain more value (brand exposure) when food products are advertised in a high-density neighborhood due to the number of people that could be exposed to the advertisements as compared to the same activity in low-population areas.

Several studies have indicated the predominance of marketing of energy-dense, nutrient-poor foods and beverages around schools (18, 23, 24). The presence of unhealthy food advertising in and around schools can influence school children's food choices, considering the repeated exposure to these advertisements (35, 36). Such exposure can also contribute to what is referred to as the "normalization" of junk food (37, 38), as well as act as a cue for unhealthy food purchase and consumption (9).

The vast majority of food advertisements observed in our study promoted unhealthy food products, and most commonly sugar-sweetened beverages. This aligns with earlier research by Green et al. (25), which found that almost half of food and beverage advertisements in deprived urban neighborhoods in Ghana and Kenya were for sugar-sweetened beverages. In Uganda, a study that assessed food and beverage advertising surrounding schools in urban and peri-urban areas using the same methodology as the current study reported that 86% of food advertisements featured unhealthy products, of which sugar-sweetened beverages were again the most advertised product (23). The ubiquitous promotion of sugar-sweetened beverages around schools means school children are exposed to a large number of unhealthy food and beverage advertisements that can influence their intake. The dominance of sugar-sweetened beverage advertising as referenced in the aforementioned studies is consistent with reports of deliberate, relentless, and pronounced marketing activities of such products in this and other LMICs (39). Efforts aimed at improving population food environments and thus NCDs recommend the establishment of local or national policies that will limit the marketing of high-fat, salt, and sugar (HFSS) foods, especially to children (40, 41). It is important that these policies encompass tighter restrictions on sugar-sweetened beverages as they appear to be the most advertised food products.

Health researchers and practitioners have consistently raised concerns about the proliferation of unhealthy food marketing in settings frequented by children, including the school

TABLE 3 Food categories and distribution by proportion of food advertisements in/around schools in Greater Accra.

	N	%
FOOD CATEGORY		
Core foods		
Bottled water	189	8
Meat and meat alternatives—include meat, poultry, fish, legumes and eggs	177	7.2
Rice/rice products without added fat, sugar or salt	143	5.8
Vegetables/vegetable products without added fats, sugars or salt	47	1.9
Low fat milks/yogurts and their alternatives	32	1.3
Fruits/fruit products without added sugar	31	1.3
Baby foods (exclude milk formulae)	28	1.1
Low fat/salt meals—include frozen or packaged meals	24	1.0
Low sugar and high fiber breakfast cereals	17	0.7
Oils high in mono- or polyunsaturated fats	15	0.6
Non-core foods		
Sugar sweetened beverages	799	32.4
Alcohol	302	12.2
High fat and/or sugar flavored dairy products and their alternatives	278	11.3
Meat and meat alternatives processed or preserved in salt	206	8.3
Ice cream, iced confection and desserts	130	5.3
Flavored/fried instant rice and noodle products	127	5.1
Sweet breads, biscuits, cakes, muffins, and high fat savory biscuits, pies and pastries	90	3.6
Fruit juice/drinks (<98% fruit)	64	2.6
Other high fat/salt products	57	2.3
Fast food (not only healthier options advertised), e.g., burgers, fries, soft drinks	56	2.3
Sweet/Savory snack foods	37	1.5
High sugar and/or low fiber breakfast cereals	17	0.7
Chocolate and candy	11	0.4
Miscellaneous food		
Local restaurant mixed dishes	446	18.1
Recipe additions (including soup cubes, oils, dried herbs and seasonings)	214	8.7
Tea and coffee (excluding sweetened powder-based teas or coffees)	31	1.3

Some advertisements depicted more than one food or beverage product.

environment (42). This concern is precipitated by the increasing rates of overweight and obesity among children of school-going age (43). Considering that school nutrition interventions are implemented to positively promote healthy food choice and intake among school-going aged children, the presence of unhealthy food advertising may be a barrier to achieving the desired outcomes. In some countries, like South Korea, areas around schools are prohibited from food advertising practices to prevent school children exposure to unhealthy marketing practices (44). In the literature, it is evident that food-related activities within the environment where people live or spend most of their hours can influence their dietary patterns (45, 46). Basic schools in Ghana are typically situated within the community and are exposed to commercial activities, including the sale and advertisement of food products by food vendors operating in and around the school. Zoning initiatives that restrict unhealthy food promotion and availability and also promote the availability of healthy foods like fruits, and whole grain products could be useful to ensure a healthy school food environment in Ghana.

In our study, more than one in ten food advertisements surrounding schools were for alcoholic beverages. Elsewhere, exposure to outdoor alcohol advertising has been found to be positively associated with intentions to consume alcohol among school children (47). Further, higher exposure to outdoor alcoholic beverage advertising was found to be associated with higher intakes (48). The harmful use of alcohol is recognized by the WHO as a causal factor in more than 200 diseases, including NCDs and injury conditions (49). Like with other unhealthy foods and beverages, exposing children to marketing activities for alcohol could be detrimental to their wellbeing. In recent years, Ghana's Food and Drug Authority has developed guidelines for advertisements on foods and beverages, which include specific requirements for the advertisements of alcoholic beverages (50). The guidelines restrict the airing of alcohol advertising on radio and television between 08:00 a.m. and 08:00 p.m. It also prohibits the placement of alcohol advertising materials within 200 meters of schools. However, observations from this study show that outdoor advertisements, including posters and billboards, are used to promote alcohol within the school neighborhood, some of which were within the 200 meter prohibited zone. It is therefore important that future amendments to the guidelines should encompass restrictions for all outdoor advertising platforms in settings such as the school environment. At the time this study was undertaken, there were no specific national regulations to restrict the marketing of sugar-sweetened beverages to children, even though Ghana is a signatory to World Health Assembly Resolution 63.14, which sought to encourage efforts that would restrict the marketing of unhealthy food and non-alcoholic beverages to children (11). Clearly, results from this study show that efforts by regulatory bodies in Ghana need to be intensified.

Our study also found that posters and banners were the most used outdoor advertising type, accounting for over 70% of all advertisements recorded, although other channels like billboards, merchandise, and free-standing signs were also recorded. The usage of stationary materials like posters and banners as a means of advertising food has been reported to be heavily placed in close proximity to settings like schools

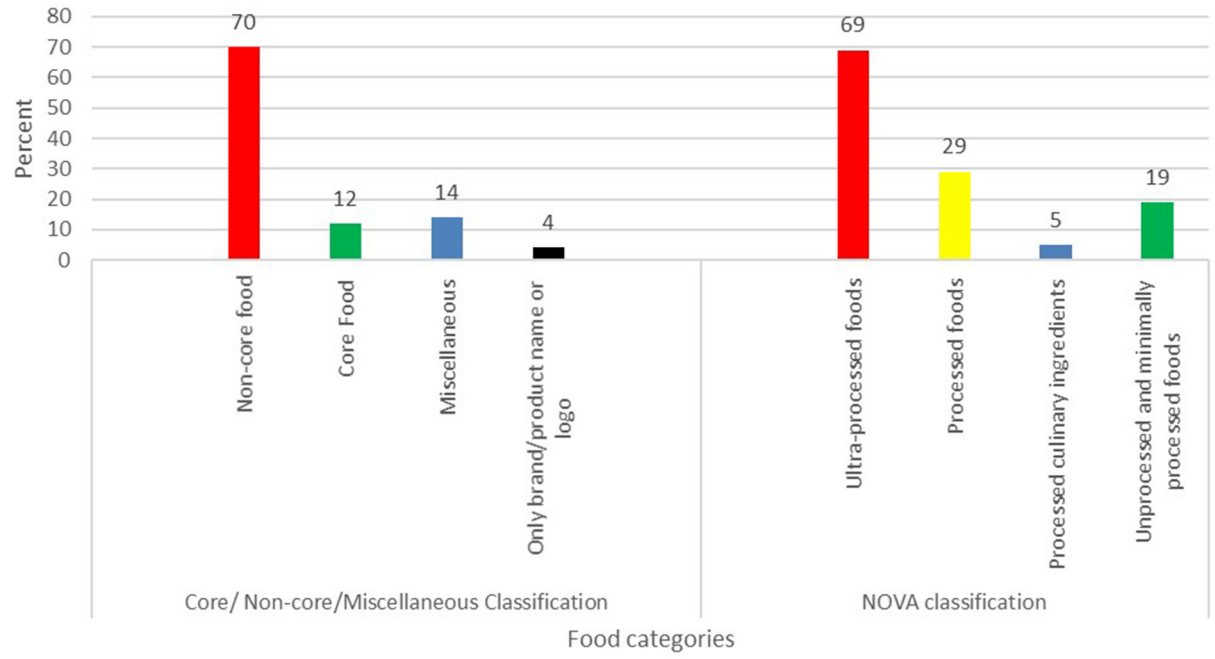

FIGURE 3
The proportion (%) of promoted foods and beverages by food categories.

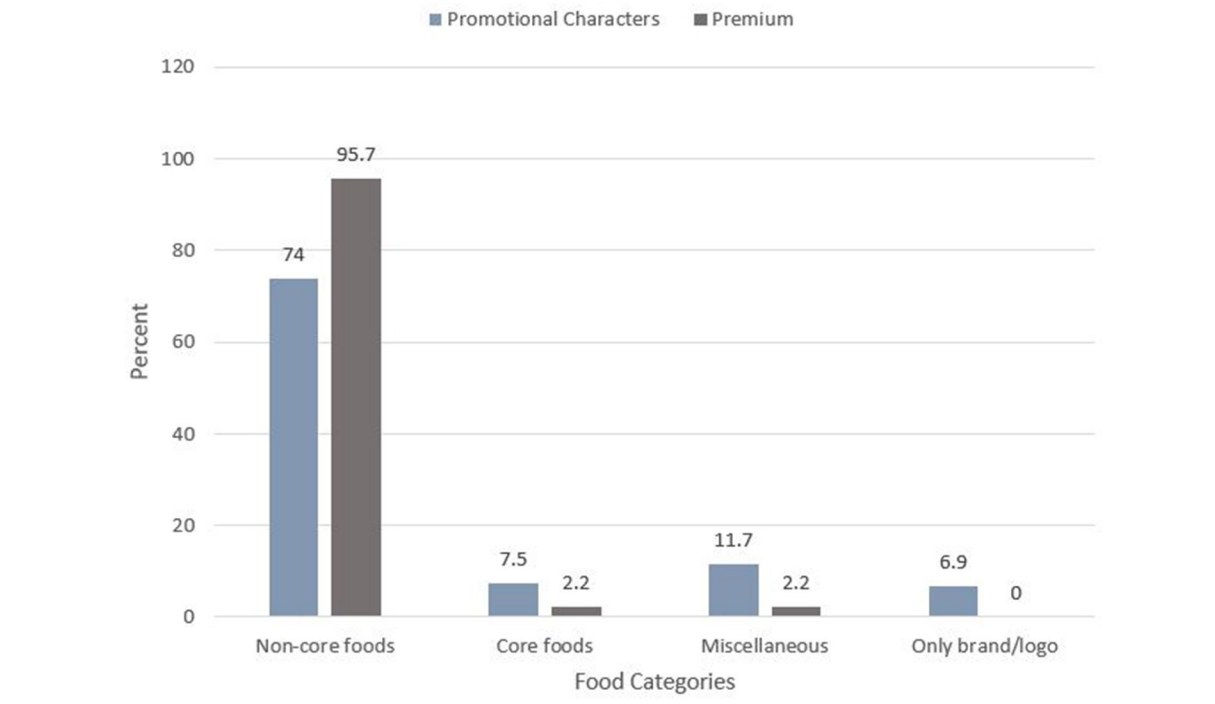

FIGURE 4
Promotional technique used on food advertisements by food categories.

TABLE 4 Median (25-, 75-percentiles) number of food and beverage category advertised by school characteristics.

	Food category		
	Core	Non-core foods	Miscellaneous
School type			
Primary school only (6–11 y)	4 (2, 4)	10 (5, 30)	3 (2, 6)
Junior high school only (12–15 y)	3 (1, 5)	12 (7, 35)	4 (2, 6)
Basic school (6–15 y)	2 (1, 4)	9 (3, 19)	2 (1, 4)
School location			
Accra metropolitan	3 (1, 4)	12 (9, 23)	3 (2, 6)
Ashaiman municipal	4 (2, 9)	4 (2, 9)	2 (1, 10)
Ga south municipal	2 (1, 3)	2 (1, 5)	1 (1, 3)
La Nkwantanang Madina municipal	4 (2, 6)	20 (9, 33)	4 (1, 7)
Kpone Katamanso district	4 (1, 5)	10 (5, 22)	2 (1, 5)
Ningo Prampram district	2 (1, 3)	9 (4, 19)	2 (1, 4)
Location poverty incidence			
High poverty incidence schools	4 (1, 5)	12 (8, 28)	4 (1, 6)
Low poverty incidence schools	2 (1, 3)	3 (2, 9)	1 (1, 4)

and other places where they can be repeatedly seen by large numbers of people (4, 51, 52). For posters in particular, its attributes make them easily placeable onto any surfaces at multiple locations. Marketing researchers see this channel of advertisement as particularly impactful since it is embedded into the physical environment and people cannot avoid being exposed to it easily as compared to advertisements broadcast on platforms like television or radio (53). Therefore, efforts to regulate unhealthy food advertisements must be comprehensive in scope and should cover all advertising channels, including stationary outdoor advertisements.

The present study also showed that over three-quarters of food advertisements were placed at food outlets. This finding is suggestive that marketers exploit food outlets as marketing platforms. Available literature shows that promotional activities, especially in-store advertising at retail outlets, have the ability to influence consumer purchase by providing cues toward certain brands or products (54). Our assessment of in-store advertising is reported elsewhere (55). In their investigation of the retail food store exterior advertisements and the products sold in retail outlets, Barquera et al. found that about 60% of the advertised products were available at the food shops (4). For school children, food outlets within the school vicinity are places frequented during school hours, especially during break periods to purchase foods for consumption (56, 57). The presence of food advertisements at food outlets in the school environment can influence the purchasing behavior and consumption patterns as a result of repeated exposure (10). Children, in particular, are seen as vulnerable to marketing activities since they are not able to recognize the intent behind the advertisements (58, 59). Fernandes et al. reported that unhealthy foods are being sold to Ghanaian children in schools by private or independent vendors (59). Given that not all food outlets provide healthy food, the Ghana Education Service can put in place regulations to restrict the sale and promotion of foods having high sugar and fat content within the premises of the school compound. There is a need to extend this regulation out of the school premises to include the immediate surroundings accessible to school children since there is a chance for students to visit food outlets close to the school premises.

Regarding the link between promotion of unhealthy foods and health outcomes, most evidence relates to the effect of promotion on preferences and choices rather than on the ultimate adverse outcome, such as obesity. Some have, nevertheless, argued that, independent of other factors, exposure to unhealthy food marketing is a modifiable risk factor for obesity (60, 61). Kessler describes how sugar, fat, and salt activate neurons involved in taste perception, reward, and conscious control of eating. He theorizes that "chronic exposure to highly palatable foods changes our brains, conditioning us to seek continued stimulation. Over time, a powerful drive for sugar, fat, and salt competes with our conscious capacity to say no". He identifies dopamine as one of the key neurotransmitters mediating the rewiring of brain circuits in this way.

Contribution to knowledge

Globally, poor diet is a major contributor to overweight and obesity among children and adolescents. Environmental factors influence availability of poor diets, and dietary habits. One such factors is food and beverage marketing. In the literature, food advertising, a form of food and beverage marketing, has been shown to primarily promote products high in fat, sugar, sodium, or salt content. Public health experts and international health organizations have advised governments and policymakers to restrict the marketing of unhealthy foods, particularly to children. However, research and monitoring reports show that unhealthy food marketing persists. Most of the data are from studies conducted in high-income countries. Such evidence is limited in the lower and middle income countries. Context-relevant data are required to inform regional and local guidelines, policies or regulations. The current study investigated the food and beverage advertising landscape in a lower middle-income country, Ghana, focusing on the school environment. The pervasive advertising of sugar-sweetened and alcoholic beverages as recorded in this study demands policy action to limit the exposure to children of unhealthy food advertisements.

Limitations

Having been purposively delimited to the Greater Accra Region, the results from this study may not be generalizable

to other regions of Ghana. Any attempt to extrapolate the findings should recognize this limitation. Cross-sectional in design, this study could not detect seasonal variations in marketing practices.

Conclusion

Overall, the data shows that school children in public sector basic schools in the Greater Accra Region of Ghana are exposed to unhealthy food advertisements, particularly sugar-sweetened beverages. There is a clear need for a national policy that restricts the advertisement of these protects, especially in children's settings.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Ghana Health Service Ethics review committee (Approval # GHS-ERC 005-06-19) and the University of Ghana Ethics Committee for Humanities (Approval # ECH 152-18-19).

Author contributions

All authors listed, have made substantial, direct and intellectual contribution to the work. AL, MH, RA, CA, FZ, MEL, KM, DL, GA, and SV secured funding and contributed to research design. GSA, APA, WQ, SKA, and SN collected and analyzed the data. GSA drafted the manuscript. All authors reviewed and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Dietary diversity, food insecurity and the double burden of malnutrition among children, adolescents and adults in South Africa: Findings from a national survey

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Childhood stunting remains a global public health problem. Many stunted children live in the same household as overweight or obese adults (the so-called double burden of malnutrition), evidence that quality as well as quantity of food is important. In recent years, food security measurement has shifted away from anthropometry (e.g., stunting) to experiential measures (e.g., self-reported hunger). However, given the continued problem of stunting, it is important that national surveys identify malnutrition.

Objectives: To examine the associations between a variety of food security indicators, including dietary diversity, with adult, child (0–4 years) (5–9 years) and adolescent (10–17 years) anthropometry. To estimate the prevalence of double burden households.

Methods: The study utilized cross-sectional data from the South African National Income Dynamics Survey NIDS (2008). We examined the associations between five food security indicators and anthropometry outcomes. The indicators were adult and child hunger in the household, self-reported household food sufficiency, food expenditure>60% of monthly expenditure and household dietary diversity. Multinomial and logistic regression models were employed to examine the associations with adult BMI categories and children's stunting and BMI.

Results: The prevalence of stunting was 18.4% and the prevalence of wasting and overweight was 6.8 and 10.4%, respectively. Children <5 and adolescents with medium dietary diversity were significantly more likely to be stunted than children with high dietary diversity. Among children <5, child hunger and medium dietary diversity were significantly associated with wasting. None of the food security indicators were associated with stunting in children aged 5–9. Among stunted children, 70.2% lived with an overweight or obese adult. Among adults, increased dietary diversity increased the risk of overweight and obesity.

Conclusion: Dietary diversity can be used as a proxy for poor nutritional status among children<5 years and adolescents but the relationship between dietary diversity and adult obesity is more complex. Given the double burden of malnutrition in many low- and middle-income countries, indicators of dietary quality remain important. These tools can be further refined to include an extra category for processed foods. Given the relative simplicity to collect this data, national surveys would be improved by its inclusion.

KEYWORDS

dietary diversity, food security measurement, experiential indicators, stunting, obesity, national surveys, double burden of malnutrition, food expenditure

Introduction

Stunting in children remains an urgent public health problem in low- and middle-income countries (LMIC). Research suggests that stunting is consistently associated with poorer cognitive function, schooling outcomes and reduced earning potential (1–3). However, stunting is a multifaceted problem associated with a variety of factors including chronic malnutrition, infectious diseases in early childhood and adverse birth and pregnancy outcomes like low birthweight and intrauterine growth restriction (3–6).

In many LMIC, there is an obesity epidemic occurring alongside high rates of stunting. This is primarily driven by fundamental changes in the food system including the ease and availability of cheap processed foods, reduced physical activity and the high cost of healthy varied diets (7, 8). Childhood stunting and adult overweight and obesity often occur in the same household, the so called double burden of malnutrition (DBM) (3, 7, 9–12).

In recent years, food security measurement has shifted away from the measurement of anthropometry to self-reported experiential measures. These measures, focused on individual perceptions of hunger and anxiety around access to food (13, 14), are premised on the concept that hunger and food insecurity are universal experiences that exist along a spectrum of severity (15). However, such measures do not capture the nutritional quality of food consumed. One indicator that has potential as an effective proxy for malnutrition are dietary diversity indicators. These have been found to be an effective indicator for overall dietary quality in some studies and are often associated with child anthropometry outcomes (16, 17).

A systematic review of household food insecurity and dietary diversity in relation to stunting in Sub-Saharan Africa (SSA) noted that two thirds of the included studies found that household food insecurity and low dietary diversity were linked to stunting (6). Another systematic review that examined dietary diversity and undernutrition across 32 demographic and health surveys in SSA found that children with adequate dietary diversity had a 12% lower likelihood of being stunted than those with inadequate dietary diversity (18). A study from Nigeria found that children's age, maternal age, and food expenditure were among the significant determinants of children's dietary diversity (19). Although the prevalence of food insecurity, low dietary diversity and stunting are subject to geographical variations, the linkages between them are often observed across regions. These findings suggest that both food insecurity and low dietary diversity are common in Sub-Saharan Africa and have adverse implications for growth and development, particularly among young children.

In South Africa, an estimated 27% of children under 5 years are stunted as a result of chronic malnutrition and a generally deficient growth environment (2, 3). The prevalence of stunting has remained virtually unchanged in the past two decades, despite a decrease in reported hunger in national statistics and one of the largest social protection systems in the world (2, 20, 21). National surveys in South Africa currently rely primarily on experiential measures of food security that measure hunger, skipping meals and running out of money to purchase food (the most severe forms of food insecurity). However, such measures may miss households that don't necessarily experience hunger but where child growth is faltering due to poor quality diets.

The findings from two recent national surveys suggest that food insecurity remains a serious problem in South Africa. Results from the 2017 general household survey (GHS) noted that about 13.4 million households had inadequate or severely inadequate access to food and about 1,6 million households experienced hunger (22). The NIDS coronavirus rapid mobile survey found that a lack of money to buy food remained high in 2020, due to the protracted nature of the COVID-19 pandemic and the subsequent economic and social impact (23, 24).

In this paper we estimate the prevalence of malnutrition among children, adolescents and adults and describe the proportion of double burden of malnutrition (DBM) households. Then, we examine whether different food security indicators are associated with adult BMI categories (normal weight, underweight, overweight or obese) and

child height (normal height or stunted/severely stunted) and child BMI (normal weight, wasted/severely wasted and overweight/obese) and whether dietary diversity is an effective proxy for nutritional status.

Methods

The national income dynamics study

The South African National Income Dynamics Study (SA-NIDS) is a nationally representative panel survey of over 28,000 individuals in 7,300 households across South Africa. A stratified, two-stage cluster sample design was used in sampling the households to be included in the first wave (2008). In the first stage, 400 primary sampling units (PSUs) were selected from Stats SA's 2003 master sample of 3000 PSUs. This master sample was the sample used by Stats SA for its Labor Force Surveys and General Household Surveys between 2004 and 2007. The surveys were conducted on non-overlapping samples drawn within each PSU to ensure that households did not have to participate in both surveys (25). NIDS is a government funded survey to track inequality over time and examines several exposures (e.g., social capital, labor market participation, household composition and structure) in relation to poverty and inequality. Data on health outcomes, fertility and mortality were also collected. The survey is conducted by the Southern Africa Labor and Development Research Unit based at the University of Cape Town. Food security indicators were dropped in subsequent waves of the NIDS study and in this paper, we therefore use data from the baseline wave, conducted in 2008.

Food security indicators

Household hunger

Data on adult and child hunger were collected separately using the following question: In the past year did an adult/child go hungry? never, seldom, sometimes, often, always. These are questions from the Household Food Insecurity Access Scale (HFIAS). We created a binary hunger indicator for adult and child hunger with households that reported never or seldom experiencing hunger scoring a 0 and households that reported sometimes, often or always experiencing hunger scoring a 1, using the same methodology as Statistics South Africa (26).

Food sufficiency

Respondents were also asked a question about household food consumption in relation to the household's needs in the past 12 months. Respondents reported if food consumption was less than adequate, just adequate or more than adequate for household needs. The data was converted into a binary indicator, with households who reported more than adequate or just adequate scored a 0 and households that reported less than adequate scored a 1.

Dietary diversity

We calculated household dietary diversity score (HDDS) from the NIDS data using the Food and Agriculture Organization (FAO) guidelines (27). The HDDS is comprised of 32 individual food types and 12 different food groups with a minimum score of 1 and a maximum score of 12. The 12 food groups are; (i) cereals and grain produces (ii) starchy roots and tubers (iii) Legumes (iv) vegetables (v) Fruits and nuts (vi) Sugars (vii) Meat and poultry (viii) Eggs (ix) Fish and shellfish (x) Milk and dairy products (xi) Oils and fats (xii) Miscellaneous (including beverages). Dietary diversity scores (DDS) was summed up by counting each of the 12-food groups, and classified as low ($\leq$4), medium (5–8) and high (9–12) with high dietary diversity being the reference standard. There is no gold standard for dietary diversity cut-offs and we used these cut-offs based on a recent study that examined stunting and dietary diversity in South Africa (28). We also included dietary diversity as a continuous variable (ascending order from 1 to 12).

Food expenditure

Food expenditure was calculated by dividing the amount spent on food each month by total household expenditure. A cut-off of total monthly expenditure above 60% was used to define a household as food insecure, as recommended by the FAO (29, 30).

Child and adult anthropometry

Child anthropometry for children up to the age of 5 years was classified according to the WHO child growth standards, weight for height, BMI for age, and height-for-age (HAZ) scores. A HAZ score of −2SD of the mean is classified as stunted and a HAZ score of −3SD is classified as severely stunted. Child wasting and overweight/obesity was also classified according to the WHO growth standards with BMI for age below −2SD classified as wasted and BMI above 2SD classified as overweight (31). For children older than 5 years the WHO growth standards for school aged children and adolescents were used as a reference in the calculation of z-scores for height for age, BMI for age (32). Due to the low proportion of children who were severely stunted, we grouped stunted and severely stunted children together in the regression model. We also grouped wasted and severely wasted children together, and overweight and obese children together for the multinomial model. Child anthropometry data were calculated by the NIDS team (25). Children were grouped according to the following age categories: <5 years, 5–9 years

TABLE 1 Prevalence of household food insecurity by each item.

Indicator (*n* households)	Percentage who reported food insecurity% (*n*) (95% CI)
High dietary diversity (9–12)	65.2 (4 724) (64–66%)
Medium dietary diversity (5–8)	30.7 (2 219) (30–32%)
Low dietary diversity (1–4)	4.1 (297) (3–4%)
Food expenditure	17.3 (7 291) (16–18%)
Adult hunger	23 (7 266) (22–24%)
Child hunger	14.5 (5 359) (13%−15%)
Food Insufficiency	38.1 (7 291) (37–39%)

and 10–17 years. People aged 18 and older were classified as adults and their BMI measurements were categorized according to the WHO growth standards and considered underweight (BMI<18.5), normal weight, (BMI 18.5–24.9) overweight (BMI 25–29.9) and obese (BMI >29.9) with normal weight used as the reference standard (33).

Data analysis

Logistic and multinomial regression models were used to examine child stunting and BMI status in relation to food security indicators. The explanatory variables were dietary diversity both as a continuous score and as a categorical indicator, food expenditure >60% of total monthly expenditure, child hunger in the past year and household food sufficiency in the past year. For the stunting model, the response variable was children's stunting status (normal height or stunted/severely stunted). For children's BMI the response variables were normal weight, wasted or overweight/obese. We examined each explanatory variable individually for both the stunting and BMI models (Tables 4, 5). Analyses were clustered at the household level on the assumption that children in the same household had similar access to food.

Multinomial regression models were used to examine adult BMI (underweight, normal weight, overweight and obese) in relation to food security indicators. The explanatory variables for both models were identical to the child variables except for hunger. The adult model used adult hunger as an explanatory variable in place of child hunger. For adult BMI, the response variable was adult BMI status. These results are presented in Table 6.

Food security indicators and outcome categories were generated from datasets with imputation values created by the NIDS data team (25). All analyses were conducted using Stata 15.1 (Stata Corporation, College Station, TX).

TABLE 2 Prevalence of childhood stunting by age category.

Category	>5 years % (*n*)	5–9 yrs % (*n*)	10–17 yrs % (*n*)	Total % (*n*)
Normal height	73.8 (1 526)	86.5 (2 156)	82.1 (3 457)	81.3 (7 139)
Stunted/severely stunted	28.2 (543)	13.5 (338)	17.9 (757)	18.7 (1 638)
Total	100 (2 069)	100 (2 494)	100 (4 214)	100 (8 777)

Results

Insufficient food over the past 12 months was the most frequently reported food insecurity indicator (38.1%) followed by medium household dietary diversity scores (30.7 %). Low dietary diversity scores were the least common indicator (4.1%) followed by child hunger in the past 12 months (14.9%). These findings are presented in Table 1.

Height for age scores were available for 8 777 children across 3 831 household clusters. Children of normal height ($n = 7\,139$) were the reference category. A total of 18.66% of children ($n = 1\,638$) were classified as stunted as seen in Table 2. Children aged <5 years had the highest proportion of stunting (28.2%) followed by adolescents (17.9%). Children in the 5–9-year age category had the lowest prevalence of stunting (13.5%). These findings are presented in Table 2.

BMI scores were available for 7 385 children across 3 559 household clusters. Children of normal weight ($n = 6118$) were the reference category. A total of 6.8% of children were classified as wasted or severely wasted ($n = 500$) and 10.4% of children were classified as overweight or obese ($n = 767$). The prevalence of wasting was highest among adolescents (7.7%) while the prevalence of overweight and obesity was highest among children aged <5 years (17.5%). These findings are presented in Table 3.

For the full sample, each unit increase of dietary diversity offered a protective effect against stunting and reduced the risk of stunting by 5%. Children and adolescents children with medium dietary diversity were significantly more likely to be stunted than children with high dietary diversity (OR 1.35). When we stratified the children by age group, medium dietary diversity was significantly associated with stunting for children aged <5 years and adolescents. Low dietary diversity scores were associated with stunting among adolescents but not among other age groups. However, the prevalence of low dietary diversity was only 3.9% in this sample which likely contributed to the null finding. Medium dietary diversity and food expenditure >60% of monthly expenditure were associated with stunting among the adolescent group. None of the experiential indicators (child hunger and household food insufficiency) were associated with stunting for any age group in the sample. These findings are presented in Table 4.

Medium dietary diversity and child hunger was associated with wasting in children <5. Child hunger represents the most severe form of food insecurity and households that reported

TABLE 3 Prevalence of childhood wasting and overweight by age category.

Category	<5 years % (*n*)	5–9 yrs % (*n*)	10–17 yrs % (*n*)	Total) % (*n*)
Normal weight	77.2 (1 373)	85.7 (1 756)	84 (2 989)	82.8 (6 118)
Wasted/severely wasted	5.3 (95)	6.5 (133)	7.7 (272)	6.8 (500)
Overweight/obese	17.5 (311)	7.8 (160)	8.3 (296)	10.4 (767)
Total	100 (1 779)	100 (2 049)	100 (3 557)	100 (7 385)

TABLE 4 Logistic regression model of food security in relation to childhood stunting.

Indicators	Odds ratio of being stunted (*p*-Value) Bivariate regressions			
	<5 years *n* = 2,069	5–9 years *n* = 2,494	10–17 years *n* = 42,14	Full sample *n* = 8,777
Dietary diversity (continuous)	0.97 (0.195)	0.96 (0.153)	**0.91 (*P* < 0.000)**	**0.94 (*P* < 0.000)**
Medium dietary diversity (5–8)	**1.27 (0.028)**	1.12 (0.386)	**1.53 (*P* < 0.000)**	**1.35 (*P* < 0.000)**
Low dietary diversity 1–4	0.86 (0.628)	0.87 (0.667)	**1.88 (0.002)**	1.29 (0.115)
Food expenditure (>0.6)	1.26 (0.056)	1.09 (0.576)	**1.24 (*P* < 0.000)**	**1.24 (*P* < 0.000)**
Child hunger	0.97 (0.774)	0.99 (0.926)	0.97 (0.713)	0.97 (0.642)
Food insufficiency	1.08 (0.453)	0.89 (0.380)	1.14 (0.100)	1.07 (0.276)

Bold values indicate to highlight statistically significant results.

TABLE 5 Multinomial regression model of food security in relation to childhood wasting and overweight.

Indicators	<5 years *n* =1,779	5–9 years *n* = 2,049	10–19 years *n* = 3,557	Full sample *n* = 7 385
Relative risk ratio of being wasted or severely wasted (*n* = 500)				
Dietary diversity (continuous)	0.93 (0.145)	0.96 (0.387)	**0.93 (0.017)**	**0.94 (0.008)**
Medium dietary diversity (5–8)	**1.76 (0.014)**	0.88 (0.541)	1.23 (0.160)	1.22 (0.086)
Low dietary diversity (1–4)	2.28 (0.071)	1.05 (0.802)	1.37 (0.389)	**1.88 (0.011)**
Food expenditure>0.6	1.51 (0.087)	0.81 (0.387)	0.81 (0.244)	0.92 (0.594)
Child hunger	**2.0 (0.003)**	1.11 (0.651)	0.97 (0.842)	1.17 (0.216)
Food insufficiency	1.0 (0.984)	1.16 (0.444)	0.95 (0.690)	1.01 (0.945)
Relative risk ratio of being overweight or obese (n =767)				
Dietary diversity (continuous)	0.98 (0.496)	1.06 (0.147)	1.05 (0.088)	1.03 (0.143)
Medium dietary diversity (5–8)	0.96 (0.782)	0.83(0.329)	0.87 (0.330)	0.89 (0.183)
Low dietary diversity (1–4)	1.35 (0.352)	0.84 (0.335)	0.93 (0.841)	1.04 (0.883)
Food expenditure>0.6	1.21 (0.189)	0.89 (0.607)	0.75 (0.098)	0.98 (0.841)
Child hunger	0.87 (0.392)	**0.50 (0.005)**	**0.56 (0.002)**	**0.66 (*P* < 0.000)**
Food insufficiency	0.92 (0.541)	**0.63 (0.011)**	**0.62 (0.001)**	**0.74 (*P* < 0.000)**

Bold values indicate to highlight statistically significant results.

children going hungry in the past year likely represent the most poor and deprived households. Each unit increase of dietary diversity decreased the risk of wasting in adolescents. Child hunger and food insufficiency decreased the risk of obesity among children in the 5–9-year age group and adolescents. These findings are presented in Table 5.

Anthropometry measurements were available for 12 199 adults aged 18 and above across 6 483 household clusters. The prevalence of underweight, overweight and obesity was 7.6, 23.4 and 26.3%, (respectively). Adult hunger and household food insufficiency were the indicators most strongly associated with an increased risk of underweight (RR 1.25 and 1.34).

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TABLE 6 Multinomial regression model of food security in relation to adult anthropometry.

Indicators	Relative risk ratios (95% CI) Bivariate regressions	*p*-Value
Relative risk ratio of being underweight ($n = 927$)		
Dietary diversity (continuous)	0.98 (0.96–1.01)	0.214
Medium dietary diversity (5–8)	1.09	0.321
Low dietary diversity (1–4)	0.94 (0.89–1.17)	0.730
Food expenditure>0.6	0.99 (0.85–1.19)	0.942
Adult hunger	**1.25 (1.10–1.45)**	**0.007**
Food insufficiency	**1.34 (1.10–1.43)**	***P* < 0.000**
Relative risk ratio of being overweight ($n = 2,857$)		
Dietary diversity (continuous)	**1.05 (1.03–1.07)**	**P<0.000**
Medium dietary diversity (5–8)	**0.86**	**0.003**
Low dietary diversity (1–4)	**0.70 (0.76–0.92)**	**0.004**
Food expenditure>0.6	0.90 (0.81–1.01)	0.087
Adult hunger	**0.67 (0.61–0.75)**	***P* < 0.000**
Food insufficiency	**0.81 (0.74–0.90)**	***P* < 0.000**
Relative risk ratio of being obese ($n = 3,219$)		
Dietary diversity (continuous)	**1.11 (1.07–1.14)**	***P* < 0.000**
Medium dietary diversity (5–8)	**0.69**	***P* < 0.000**
Low dietary diversity (1–4)	**0.57 (0.52–0.65)**	***P* < 0.000**
Food expenditure>0.6	**0.81 (0.71–0.91)**	**0.001**
Adult hunger	**0.71 (0.64–0.78)**	***P* < 0.000**
Food insufficiency	**0.90 (0.80–0.96)**	**0.022**

The reference category was adults of normal weight N = 5,229. Bold values indicate to highlight statistically significant results.

Other food security indicators followed a similar pattern with an increased risk for underweight among adults and a decreased risk for overweight and obesity. However, each unit increase of dietary diversity increased the risk of overweight and obesity, but a reduction in dietary diversity was not associated with being underweight. These findings are presented in Table 6.

There was a total of 3,720 households that had anthropometry measurements for both adults and children in the household and 850 (22.8%) of these households included stunted children as well as obese adults (Table 7). The DBM describes the coexistence of overnutrition (overweight and obesity) with undernutrition (stunting). In this sample, among households with stunted children, 70.2% of stunted children lived with overweight or obese adults. For ease of interpretation, we have grouped overweight and obese adults together as well as stunted and severely stunted children. When examining the double burden of malnutrition, households with one or more stunted child and one or more overweight or obese adults were classified as double burden households while households with stunted children and normal weight adults were classified as single burden households.

Discussion

Our results show that 18.43% of children are stunted, and that the double burden of malnutrition is evident in our sample with over 70% of stunted children living in the same household as an overweight or obese adult. Among children aged <5 years, children with medium dietary diversity are significantly more likely to be stunted than children with high dietary diversity. Among adolescents, medium dietary diversity, low dietary diversity and food expenditure are associated with stunting. Child hunger in the household and medium dietary diversity are significantly associated with wasting among children aged <5 years.

We did not find any of the food security indicators to be associated with stunting in children aged 5–9 years. There are several potential reasons for this. Children aged 5–9 had the lowest prevalence of stunting (13.5%) across age groups, with 28.2% of children <5 yrs and 18.6% of adolescents classified as stunted. The primary drivers of stunting among <5 yrs may be different (i.e., diarrhea and other infectious diseases or babies born small for gestational age) to those among older children. Moreover, stunting is a cumulative process and the

TABLE 7 Prevalence of the double burden of malnutrition by household.

Category	Normal/underweight BMI	Overweight/obese adult	Total
	% (*n*)		
Normal height child/ren	24% (602)	76% (1 908)	100 (2 510)
Stunted or severely stunted child/ren	29.8% (360)	**70.2% (850)**	100 (1 210)
Total	25.9% (962)	74.1 (2 758)	100 (3 720)

Bold values indicate to highlight statistically significant results.

consequence of chronic malnutrition and a deficient growth environment over time (3), hence the greater prevalence among adolescents. Thus, stunting in adolescence is a continuation from stunting in early childhood for most stunted adolescents. Adolescence is a critical period of development as 15–20% of total height is achieved during this phase. This may present the final opportunity to increase adult height but there is a lack of high-quality longitudinal evidence on whether catch up growth during adolescence is even possible (34). A South African cohort study found that found that <2% of children experienced late incident stunting between the ages of 2 and 5 (35). In other words, most of the linear growth deficit had already occurred by the age of 2 years. In addition, only a quarter of children who were stunted at age 2 experienced enough catch up growth to no longer be stunted by age 5 (35). Interventions to increase dietary diversity among vulnerable groups can still improve nutritional outcomes and wellbeing but this may not necessarily translate into a meaningful reduction in stunting (36).

Neither hunger nor food insufficiency were associated with stunting for any age group, highlighting the limitations of experiential indicators in relation to stunting. The South African General Household Survey (GHS) uses the Household Food Insecurity Access Scale (HFIAS), an experiential scale which classifies households into three separate categories of severity (food secure, moderately food insecure or severely food insecure) for monitoring food security at a population level (37, 38). The HFIAS was originally developed for food security surveys in the US population, where child stunting is very low and not considered a public health problem, unlike South Africa. Furthermore, responses to experiential scales like the HFIAS may vary dependent upon cultural and social contexts and this limits comparison of food insecurity prevalence across countries (16, 39). However, there is substantial evidence for the protective effect of household dietary diversity against childhood stunting and this has been observed in numerous studies from LMIC (6, 17, 40, 41). We found that medium dietary diversity was moderately associated with stunting among children <5 years and strongly associated with stunting among adolescents (OR 1.27 and 1.53). This suggests that children in the low to medium dietary diversity category are more likely to be malnourished and dietary diversity is an effective proxy for malnutrition.

While we did find that high proportion of food expenditure was associated with stunting among adolescents and reduced the risk of obesity among adults, expenditure data has several limitations as an indicator. These include that it is challenging to collect, and may be subject to recall bias and lacks generalizability across different regions and currency systems (16). However, food expenditure is associated with both children's linear growth and dietary diversity in a number of studies (19, 42). Furthermore, such data are routinely included in national surveys in many LMIC and so the association between longitudinal household food expenditure patterns, dietary diversity and children's linear growth could be the subject of more detailed research.

Although South Africa does not have public policies designed specifically to address childhood stunting, South Africa has an extensive Child Support Grant (CSG) program with over 12 million monthly disbursements to the caregivers of children aged 18 and under. The CSG is an unconditional cash transfer of R 400 (25 USD) per month to the primary caregiver. The CSG is intended to purchase food, school supplies and other essentials for low-income children. However, the CSG has not been effective in reducing the burden of stunting in South Africa. One potential reason for this is that the funds are insufficient to purchase even a basic food basket or that the funds are not used to purchase food (43, 44). However, some studies have found that when coupled with maternal education (grade 8 or higher) the CSG has a small but significant impact on increasing children's HAZ scores (45). These findings suggest that the CSG may be more effective over time if maternal education levels improve. A study from Mexico also found that maternal education mitigated the effects of child stunting and maternal overweight in a rural area (46).

However, the existing evidence suggests that even if they do experience catch up growth, children who were stunted at age 2 years perform almost as poorly in cognitive tests as children who remained stunted (35). This suggests that the first 2 years of life are critical for both linear growth and cognitive development and reinforces the need for interventions that can mitigate stunting in the first 1,000 days of life (35). Thus, improvements

in household dietary diversity may reduce stunting during this critical period of development. However, dietary diversity needs to be consistently measured at the population level if policymakers are to identify vulnerable groups and develop effective interventions.

The double burden of malnutrition (DBM) is particularly common in LMIC countries like South Africa that have undergone a nutrition transition characterized by rapid changes in the food system and the availability of cheap and highly processed foods (7, 47). Of the stunted children in this study, over 70% lived in households with overweight or obese adults (Table 7). Many stunted children may not experience hunger but will still be malnourished by a nutrient poor diet that consists primarily of starchy staples. This "hidden hunger" may also extend to many of their overweight or obese parents. The double burden of malnutrition is also visible among stunted children who are also overweight or obese. Although this study found that *low* dietary diversity was associated with stunting, we also found an inverse relationship with adult BMI whereby *increased* dietary diversity was associated with being overweight or obese. However, increased dietary diversity did not increase the risk of overweight/obesity among children or adolescents. As the direction of the associations go in opposite directions for stunting and obesity, further research is also needed to elucidate the relationship between dietary diversity and anthropometry across the full income range.

A longitudinal analysis of NIDS data that examined changes in BMI found that higher household income per capita was associated with a higher rate of change in weight gain (48). Thus, an improvement in living standards and economic progress is also a driver of the obesity epidemic in South Africa. Cultural preferences around different body types, sedentary lifestyles as well as a lack of knowledge and education around healthy foods and nutrition also play a role (49–52). Discerning to what extent rising obesity rates are driven by higher income and broader choices of food, or food insecurity coping strategies such as increased consumption of cheap processed foods requires rigorous longitudinal research (7, 47).

Limitations

While dietary diversity is a good proxy for dietary quality and micronutrient adequacy, it also has limitations, as most dietary diversity measures do not include a separate category for processed foods, an important risk factor for overweight and obesity (16, 17, 53). In addition, dietary diversity does not capture the quantities of the diverse foods consumed and there is a lack of formal cut-offs or theory that links a number of food groups consumed to nutrient adequacy or overall sufficient quantity of food (13). Currently, there is no gold standard dietary diversity measure and the most widely used scales vary from between 7 and 15 food different food groups (16).

Conclusion

Stunting is a cumulative process and interventions to mitigate stunting at the beginning of the life course may be most effective for long term growth and developmental outcomes. Accurate monitoring of food and nutritional security at a population level is essential if LMIC hope to improve nutritional outcomes, particularly among vulnerable children. However, measures that are focused on hunger fail to capture important dimensions of dietary quality. Given the time and budget constraints of conducting large surveys, household dietary diversity data are relatively simple to collect and national surveys would be improved by their inclusion in addition to existing measures of food security.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: http://www.nids.uct.ac.za/nids-data/data-access.

Ethics statement

The studies involving human participants were reviewed and approved by the University of Cape Town (UCT) Commerce Faculty Ethics Committee. Approval for this secondary analysis of the NIDS data was approved by the Humanities Research Ethics Committee at the University of the Witwatersrand Research Ethics Committee (protocol number M1909101). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

AH, SM, and AR were involved in conceptualizing the study design. AH performed the analyses while EC provided statistical oversight. WS assisted with data management and merging datasets across waves. AH, JG, and SM contributed to writing the article. All authors read and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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"Some are healthy and others not": Characterization of vended food products by Accra-based food retailers

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Background and objectives: Increasing the availability of healthy foods within food retail outlets can improve consumers' food environments. Such actions or inactions by food retailers may affect people's food purchasing and consumption behavior. This study explored Accra-based food retailers' perceptions and appreciation of "healthiness of food" as a concept. It also documented measures that food retailers adopt to encourage healthy food choices.

Methods: In-person semi-structured interviews were conducted with owners and managers of Accra-based supermarkets (n = 7) and corner stores (n = 13) in March 2021. The interviews were recorded, transcribed, coded, and analyzed thematically.

Results: The retailers' understanding of healthy food, or lack thereof, is exemplified by such expressions as "health, absence of disease, longevity, balanced diet, diversity, sanitation, and certification." A handful of retailers described what they sell as "products that meet consumer needs," "harmless," or "generally good." Very few retailers described the food they sell as "junk," high in sugar, fat, and salt, or energy-dense but nutrient poor foods, or as food that could pose some health risk to consumers. However, some retailers indicated that they advise their customers against the overconsumption of some foods.

Conclusion: Overall, Accra-based retailers have a fair understanding of what constitutes healthy food – exhibiting limited knowledge of the connection between very salty, very sugary, and very fatty foods and health outcomes. Retailers in Accra require interventions that improve their food, health, and nutrition literacy. Improving retailers' food and nutrition literacy may improve the availability of healthier options in food retail outlets in Accra.

KEYWORDS

food acquisition, food environment, food retailers, Ghana, overweight/obesity

Introduction

The world, and particularly resource-constrained settings, are experiencing multiple forms of malnutrition (characterized by micronutrient deficiencies, childhood undernutrition, and an unprecedented surge in overweight and obesity). In 2016, 70% of the global burden of overweight/obesity was found in Low Middle-Income Countries (LMICs) (1). Agyemang et al. (2) reported an increase in the prevalence of overweight individuals increased by 70% in West Africa between 1990 and 2015. In 2014, the Ghana Statistical Service estimated that over 40% of Ghanaian adults were either overweight or obese (3) with the prevalence of overweight and obesity among Ghanaian children between 9 and 15 years being equally high at 17% (4).

Poor diets are the leading cause of overweight/obesity (5). Itself a non-communicable disease (NCD), obesity is a risk factor for other NCDs such as coronary heart diseases, hypertension, stroke, and diabetes (6, 7). Nutrition transition, characterized by a shift in people's diets from less processed toward highly processed energy-dense foods coupled with reduced physical activity (8), is acknowledged as a contributory factor (2, 9–13).

Poor diets, or nutrition transition, are influenced by food environments. Defined as the collective physical, economic, political, and sociocultural surroundings, opportunities, and conditions that influence people's food and beverage choices and nutritional status (14), food environments include food availability and physical access (proximity); economic access (affordability); promotion, advertising, and information; and food quality and safety. The food environment can be an important entry point for interventions aimed at improving people's diet (15–18). One of the key dimensions of the food environment is the retail food sector – grouped under the typology of built food environment (15). A retail food establishment can be informal or formal depending on whether they are regulated through formal governance structures (19). Typical examples of informal food retail include wet markets, street vendors, kiosks, mobile vendors, and some corner stores. The formal market environments include those regulated through formal governance and typically include supermarkets and hypermarkets (15, 16). Both formal and informal establishments provide the majority of foods that consumers are able to access within the built food environment (20).

Evidence suggests that most supermarkets in Ghana offer highly processed food such as corn flakes, biscuits, cake, and cookies (21); packaged foods such as pasta, sugar, edible oil, coffee, tea, and cocoa drinks; beverages such as sodas, beer, wine, and evaporated and condensed milk; condiments; confectioneries; and minimally processed foods such as maize, flour, or whole wheat bread (21–23). The few supermarkets in Ghanaian cities that offer fresh animal and plant-based food often allocate little shelf or storage space to less healthy food options (21, 24). Other types of retail outlets, such as traditional markets and corner stores, also offer both ultra-processed and fresh food products (23, 24).

The food retail space is expanding rapidly in Ghana, particularly in urban settings (22). However, informal shops and small mobile retailers dominate the retail sector in Ghana. Kroll et al. (23), upon mapping out retail outlets in Ghana's second city Kumasi, reported that formal retailers (i.e., supermarkets) constituted only 7% of retail outlets, while informal shops, stalls, and mobile traders each constituted about 24% of the sample.

Policy actions to improve consumers' food environment by reducing unhealthy diets and increasing the availability of healthy foods within food retail outlets are ongoing in Ghana. These policy actions were considered by the Ministry of Health during a consultative meeting on 30th September 2021 with academics and other experts (25). Knowing the role that food retailers play in influencing people's food purchasing behavior and consumption, it is important that such policy actions are evidence-informed. This study explored Accra-based food retailers' perceptions and understanding of healthy food as well as the measures they adopt to encourage healthy food choices.

Materials and methods

Design

This study was cross-sectional and was part of the Measurement, Evaluation, Accountability, and Leadership Support (MEALS4NCDs) project which assessed and supported public sector actions that create healthy food marketing, retail, and provisioning environments in Ghana. Details about the MEALS4NCDs project design and methods are published elsewhere (26).

Study setting

Interviews were conducted with managers or owners of food retail outlets in the Accra Metropolitan Assembly (AMA) of the Greater Accra Region of Ghana. The Greater Accra Region is the most populous and urbanized region of Ghana and hosts the political capital city Accra. Although the AMA is one of the 29 Metropolitan, Municipal, and District Assemblies (MMDAs) in the Greater Accra Region (27), it is the most urbanized, most populous, and one of the most active sub-administrative districts and business centers. The AMA is home to over 1,800,000 people (28) and receives an influx of over 2,000,000 people daily for socio-economic reasons (27).

Study population, sampling, and consent procedures

Key Informants (owners or managers) were identified from a list of supermarkets provided by the district (AMA) administrator. The provided list was supplemented with a list of retail shops obtained from Google Maps. The Google search was restricted to three sub-districts in the AMA (Ashiedu Keteke, Okaikoi South, and Ablekuma South) that were purposively selected for the study. The three sub-districts were selected on the basis of level of urbanity population density and level of economic/retail activity relative to other sub-districts. A previous study implemented in the AMA identified these sub-districts as some of the most food retail-dense neighborhoods, with up to 76 street food retailers per sqkm (29).

The initial Google search identified 388 retail outlets. The initial screening and collation eliminated 216 duplicates: 102 without contact details and 41 not meeting our supermarket or comer-store definitions. For this study, a supermarket was defined as a formal food retailer, measuring between 100 and 200m^2 floor space, with at least one modern cash till, clear aisles, and permitted self-service, while a corner-store was defined as a potentially informal food retailer, measuring 1–5 m^2 floor space, and only offering over the counter type of service [adapted from (30)]. The distinction between a formal and an informal food establishment was made following the descriptions from Turner et al. (16) and Downs et al. (15). Nine retailers/retail outlets refused to participate in this study. Eventually, 20 Key Informants from seven supermarkets and 13 corner-stores managers/owners were interviewed.

To be interviewed, participants had to be at least 18 years of age and either have ownership of the shop or occupy a managerial position or any position with store-level decisions making capabilities. Informed consent was obtained prior to all interviews.

Data collection

The interviews were conducted in English either in-person at the retail sites or on the phone depending on the Key Informant's schedule. The interviews were facilitated by two trained field researchers (SN and AA) with prior experience in conducting Key Informant Interviews (KIIs). Interviews lasted between 15 and 45 min.

The Interview guide was divided into 3 sections. **Section A: Knowledge** - consisted of questions relating to what retailers considered healthy food and how they think healthy food contributes to consumers' health. **Section B: Perception** - contained questions on how retailers considered the food they provide in their shop in terms of healthiness. **Section C: Measures** - focused on approaches –if any- retailers have adopted to nudge healthy food choices. The measures recorded were those that apply directly to consumers in the specific retail shop where the interview was conducted.

Analysis

Each KII was recorded and transcribed verbatim. The transcripts were analyzed using a multistage thematic analysis method (31). Two trained research assistants separately read each transcript to identify themes (see Tables 2–4 for all coding themes and examples). The themes were coded inductively. Coding discrepancies were resolved with a third coder, co-Author AL. All final coding was completed and analyzed in Excel. The coders analyzed each code to identify similarities and differences and to group each code under specific contexts.

Results

Characteristics of retail outlets and key informants

Table 1 presents the sociodemographic characteristics of the study respondents. Females represented 60% of the 20 key informants, most of whom are Ghanaians. Corner stores represented 65% of all the retail outlets visited, compared to 35% which were supermarkets. Four of the key informants were owners of their food outlets ($n = 3$ for non-Ghanaian owners). All but one of the corner stores were owned by Ghanaians.

What do retailers in Accra consider to be "Healthy food"?

In Table 2, we present what Accra-based retailers consider to be healthy food. They associate healthiness with origin or locality; products of Ghanaian origin or those associated with Ghanaian traditions or cultures were rated highly.

> *"There's this local food in Ghana called Abom, made with plantain, yam and the stew is made with Kontomire leaves (Cocoyam leaves). This is a typical example [of a healthy food]".*[**Ghanaian male owner of a supermarket**]

Some retailers indicated that food is considered healthy if it brings some positive health benefits to consumers e.g. *"You get good blood circulation, you feel healthy, you feel*

TABLE 1 The sociodemographic characteristic of the respondents.

Variables	Frequency ($n = 20$)	Percentage
Sex		
Male	8	40%
Female	12	60%
Nationality		
Ghanaian	17	85%
Foreigners (Indian and Lebanese)	3	15%
Position		
Manager of a supermarket	3	15%
Manager of a corner store	1	5%
Owner of a supermarket	4	20%
Owner of a corner store	12	60%
Type of establishment		
Corner store	13	65%
Supermarket	7	35%

good." [**Ghanaian female owner of a corner store**]. It was unanimous among retailers that healthy food must not pose any harm to consumers e.g., *"Healthy food is any food that when eaten gives no health problems – now or in the near future."* [**Ghanaian male owner of a supermarket**]**.** Retailers in Accra also believe healthy food should have some protective attributes:

> *"When we eat healthy food, it prevents diseases. Sometimes when you go for [a medical] check-up you may discover that you have excess cholesterol, or obesity. But when you eat healthy food, it limits these things [diseases]. It doesn't eliminate them totally, but it limits them. It [healthy food] gives you a healthy body. Recently I had a problem and when I went for medical check-up, they [the doctors] said it was cholesterol. The advice I was given was to check on my diet and the way I eat. So, I began to check my diet and I realized that indeed I wasn't eating well".* [**Ghanaian male manager of a corner store**]

The retailers equate healthy food to a balanced diet. Balanced diet and diet diversity were used interchangeably by retailers. *"Healthy food is food that contains all the necessary nutrients that the body needs proportionally. If you have rice, then you add "kontomire" stew, a little bit of fish like "tuna". I think you are good to go."* [**Ghanaian female owner of a corner store**].

Retailers also indicated that healthy food should provide a limited amount of carbohydrates:

> *We are not supposed to eat too much because too much eating will lead to obesity and all those things [diseases]. Also, too much sugar will cause diabetes. That is what I know'* [**Ghanaian female owner of a corner store**]

Retailers in Accra associated healthy food with safety as they mentioned terms to reference to certification. A key informant noted:

> *"It [the food] must be approved by the Ghana Health Service and I know that the Ghana Health Service has developed some standards that they use to teach those [retailers] responsible for handling food stuff and other food items for sale to the public."* [**Ghanaian Male owner of a corner store**]

Their understanding of healthy food was also described in relation to hygiene.

> *"If the food is not healthy, those who consume it are bound to fall sick. For example, [from] cholera and other infectious diseases. If the food is not properly handled, it [the disease] may spread through poor handling of food. If those who sell food are infected, they may transmit such diseases to other people. So, it is appropriate that food is properly handled so it wouldn't affect the health of consumers."* [**Ghanaian male owner of a corner store**]

How do retailers in Accra describe the food they sell with respect to healthiness?

Table 3 presents the opinions of and depictions by Accra-based retailers of the various foods that they provide in their shops. Retailers in Accra describe what they provide as healthy because they are locally obtained.

> *"Most of them [the food on sale] are healthy because they are locally made. We know those who make them. We know the type of stuff we provide to consumers"* [**Ghanaian male owner of a supermarket**].

Other retailers consider what they sell healthy because of the deliberate efforts they invest in displaying the foods attractively. *"I consider them healthy because of the way they are arranged. Over here [in her shop], you can see the arrangement and the cleanliness [of the food]. The food is either in a tin or in a bottle."* [**Ghanaian female owner of a corner store**]

Some of the retailers claimed that the food they provide is therapeutic:

> *"There is this tea, locally made tea, on one of the shelves that is recommended for people who want to lose weight. They people come back with positive feedback. So, I honestly think that it is working. If it was not working, nobody would come*

TABLE 2 A landscape of retailers' understanding of healthy food, in Accra.

Context	Theme	Example of evidence
Food Accessibility	Locally available food	"*There's this local food in Ghana called Abom, made with plantain, yam and the stew is made with Kontomire leaves (Cocoyam leaves). This is a typical example [of a healthy food]".*[**Ghanaian male owner of a supermarket**]
Health	Activity/vitality	*"When you have all the nutrients in you and everything is balanced and you are [able to] exercise well. I mean you will be fine."* **[Male, Ghanaian manager of a supermarket]**
	Not damaging to health	*"Healthy food is any food that when eaten gives no health problems – now or in the near future".* [**Ghanaian male owner of a supermarket**].
	Contributing to long life	*"If you eat healthy food you live long, you grow old. It is very good for you to be on a healthy diet. That is the keto diet."* [**Ghanaian male manager of a supermarket**]
	Positive impact on health	*"You get good blood circulation, you feel healthy, you feel good."* [**Ghanaian female owner of a corner store**].
	Protecting health	*"When we eat healthy food, it prevents diseases. Sometimes when you go for [a medical] check-up you may discover that you have excess cholesterol, or obesity. But when you eat healthy food, it limits these things [diseases]. It doesn't eliminate them totally, but it limits them. It [healthy food] gives you a healthy body. Recently I had a problem and when I went for a medical check-up, they [the doctors] said it was cholesterol. The advice I was given was to check on my diet and the way I eat. So, I began to check my diet and I realized that indeed I wasn't eating well".* [**Ghanaian male manager of a corner store**]
	Therapeutic	*"For example! Diabetes is when your sugar level is up which means you are not eating properly. But, if you eat properly, your cholesterol level will be normal, your diabetes and your sugar level will be normal, and your blood pressure will also be normal."* [**Ghanaian male owner of a supermarket**]
Nutrition	Balanced diet	*"Healthy food is food that contains all the necessary nutrients that the body needs proportionally".*[**Ghanaian female owner of a corner store**].
	Diet diversity	*"If you have rice, then you add "kontomire" stew, a little bit of fish like "tuna." I think you are good to go."* [**Ghanaian female owner of a corner store**].
	Limited carbohydrate intake	*"We are not supposed to eat too much because too much eating will lead to obesity and all those things [diseases]. Also, too much sugar will cause diabetes. That is what I know"* [**Ghanaian female owner of a corner store**]
	Controlled consumption	*"Food that is high in fat and sugar doesn't really have all the nutrients in them. You don't get anything from them. I can cite pizza for instance. It is more of carbohydrates and just meat."* [**Ghanaian female owner of a corner store**]
Safety	Food certified by local authorities	*"It [the food] must be approved by [the] Ghana Health Service and I know that [the] Ghana Health Service has developed some standards that they use to teach those [retailers] responsible for handling food stuff and other food items for sale to the public."* [**Ghanaian Male owner of a corner store**]
	Food hygienically handled	*"If the food is not healthy, those who consume it are bound to fall sick. For example, [from] cholera and other infectious diseases. If the food is not properly handled, it [the disease] may spread through poor handling of food. If those who sell food are infected, they may transmit such diseases to other people. So, it is appropriate that food is properly handled so it wouldn't affect the health of consumers."* [**Ghanaian male owner of a corner store**]
	Organic food	*"According to me, food like organic food is fresh food."* [**Indian male owner of a supermarket]**
	Sanatory environment	*"I expect the place to be kept neat. The environment should be neat and clean. That is what I consider."* [**Ghanaian female owner of a corner store**]
	Food free from contaminants	*"The food must be free of contamination and should be wholesome. If the food has expired, it shouldn't be sold to consumers. Food must be maintained under appropriate temperature to prevent spoilage*" [**Ghanaian male owner of corner store**]

TABLE 3 How retails in Accra describe the food they sell with regard to healthiness.

Context	Theme	Example of evidence
Food Accessibility	Locally available food	"*Most of them [the food on sale] are healthy because they are locally made. We know those who make them. We know the type of stuff we provide to consumers*" [**Ghanaian male owner of a supermarket**].
	Attractively displayed	"*I consider them healthy because of the way they are arranged. Over here [in her shop], you can see the arrangement and the cleanliness [of the food]. The food is either in a tin or in a bottle.*" [**Ghanaian female owner of a corner store**]
Health	Not damaging to health	*"There is no side effect compared to the normal things [food]. There are no side effects."* [**Ghanaian male manager of a supermarket**]
	Positive impact on health	*"We offer mixed spices with cinnamon and you know that cinnamon is very good for the system [the body]. This is not the regular spices. This is a special one."* [**Ghanaian Male manager of a supermarket**].
	Therapeutic	*"There is this tea, locally made tea, on one of the shelves that is recommended for people who want to lose weight. They people come back with positive feedback. So, I honestly think that it is working. If it was not working, nobody would come back. They the consumers say. The thing is working fine, my weight is reducing, my appetite is better now".* [**Ghanaian male owner of a supermarket**]
Nutrition	Balanced diet	*"… they supply the body with proteins, calcium, magnesium, vitamins, all of them."* [**Lebanese female owner of a supermarket**]
	Both healthy and unhealthy	*"What I can say, some are healthy and others not."* [**Ghanaian female owner of a corner store**]
	Energy-dense/Junk food	*"Our generation is moving towards junk food. Now we can't do anything because people have changed their habits. They drink coke and all these things a lot. But we are trying to sell diet coke which is good for health. It is better compared to normal coke." [***Indian male owner of a supermarket***]* *"In my shop, we offer more of the … [unhealthy] ones. You can't describe them as healthy food because what we sell here are more of snacks and it is just to support you during the course of the day. That shouldn't be your main meal. What we offer here is more of sugar and glucose, which gives energy. But, putting rice and oil together [for example] can give you a balanced diet. So, If you combine food together to have a balanced diet, then you are getting a healthy meal. But if you only rely on food [snacks] such as juice and biscuits, no!"* [**Ghanaian female owner of a corner store**]
	Low in carbohydrate	*"We offer diet coke which has no sugar. Our Tampico for instance is sugar free. So, you can choose this and other natural juices."* [**Ghanaian Female owner of a corner store**].
	Plant-based	*"I sell oat, cereal, apple, grapes and we have some mixture of almond and sunflower seed. They are good. When I eat those, I feel good. Sometimes I can't even [stop], I think it's good. But they are expensive and you can't continue eating because of money matter. The cereal costs 50 Ghana cedis (about 4 United States Dollars) which you could use to buy fufu* [a local energy-dense nutrient rich meal]*."* [**Ghanaian female owner of a corner store**]
	Controlled consumption	"*Drinking too much sugary products can be harmful. Taking too much energy drink can also affect your health. Taking too much alcohol too can also affect your health."* [**Ghanaian female owner of a corner store**]
	Healthy when combined with other food	*"Yes! [they are healthy]. Oh! I sell rice [raw rice] and rice is a healthy food when you prepare it and add some salad. It is healthy food."* [**Ghanaian female owner of a corner store**]
Safety	Approved by the retailers themselves	*"I eat some. So, I assumed it is good. But I can't tell where if you eat this one it will be good for you."* [**Ghanaian female owner of a corner store**]
	Certified by local authorities	*"Well, they are healthy because I believe there are representatives in this country who were given the assignment to approve things [food] that are healthy for supermarkets to be able to sell. The supermarket has a policy that if you are not registered with the FDA you can't come to us for any business. Based on that, I think what we are selling is healthy."* [**Ghanaian female owner of a corner store**]
	Has caused no complaint yet	*"I will be worried if I get complaints. But no complaint so far for so many years. They [consumers] have come and bought things here, but no one has come and complained. And since it is a supermarket, it is being checked. It is not like a regular store that [is not checked]."* [**Ghanaian male manager of a supermarket**]

(Continued)

TABLE 3 (Continued)

Context	Theme	Example of evidence
	Organic/natural	*"They are organic and healthy for the system."* [**Ghanaian Male manager of a supermarket**]
	Risky to health	*"The effects are not immediate. Maybe [in] your 60s then the food will give you sugar [diabetes], blood pressure and so other many things. That is what the doctor told me. He asked me why do I like Lucozade? [an energy drink]. He asked me to stop and now I have stopped. Once somebody [the doctor] told me that it is not good, it is [not] good."* [**Ghanaian female owner of a corner store**]
	Sold in sanitary conditions	*"I think it is ok! They are kept in a neat [environment], and those who bring the bread put them in plastic bags. So, they are protected."* [**Ghanaian male owner of corner store**]
	Sold as wholesome	*"They are healthy because, as a supermarket, we check where they come from. We check the expiring date of the products we sell here. When they are about to expire we know it's no longer good for consumption, so, we remove them from the shelf. We alert the supplier and they come for it. So, we don't sell things that are not healthy here."* [**Ghanaian female owner of a corner store**]
Unclear responses	Fitting consumers' needs	*"You can't tell anybody what he should be eating. You can't blame anybody for their choices. We do prefer them to buy more healthy food like fruit juices which are good for health. But it is up to their choice."* [**Indian male owner of a supermarket**]
	Generally good	*"Topnotch" local, and quality. Three [terms]."* [**Ghanaian male owner of a supermarket**]
		"It is very healthy ……." [**Ghanaian Male manager of a supermarket**]
		"They are healthy!" [**Ghanaian female owner of a corner store**]

> *back. They the consumers say, "The thing is working fine, my weight is reducing, my appetite is better now"".* [**Ghanaian male owner of a supermarket**]

Some retailers claimed that what they sell contributes positively to health: *"We offer mixed spices with cinnamon and you know that cinnamon is very good for the system [the body]. This is not the regular spices. This is a special one."* [**Ghanaian Male manager of a supermarket**]. Other retailers described what they sell as plant-based and healthy, but have presented the cost of such food as unaffordable and inaccessible to consumers.

> *"I sell oats, cereal, apple, grapes, and we have some mixture of almond and sunflower seeds. They are good. When I eat those, I feel good. Sometimes I can't even [stop], I think it's good. But they are expensive and you can't continue eating because of money matters. The cereal costs 50 Ghana cedis (about 4 United States Dollars) which you could use to buy fufu* [a local energy-dense nutrient rich meal]*."* [**Ghanaian female owner of a corner store**]

Further, retailers described what they sell as low in added sugar: *"We offer diet coke which has no sugar. Our Tampico for instance is sugar free. So, you can choose this and other natural juices."* [**Ghanaian Female owner of a corner store**].

Other retailers consider the food they sell healthy because they have not yet received complaints about that food from consumers.

> *"I will be worried if I get complaints. But no complaint so far for so many years. They [consumers] have come and bought things here, but no one has come and complained. And since it is a supermarket, it is being checked. It is not like a regular store that is not checked]."* [**Ghanaian male manager of a supermarket**]

A few retailers indicated that their foods may have negative outcomes on consumers' health and described what they sell as junk food:

> *"Our generation is moving towards junk food. Now we can't do anything because people have changed their habits. They drink coke and all these things a lot. But we are trying to sell diet coke which is good for health. It is better compared to normal coke."* [**Indian male owner of a supermarket**]

Some retailers described what they sell as having potential health risks to consumers.

> *"The effects are not immediate. Maybe [in] your 60s then the food will give you sugar [diabetes], blood pressure, and so [many other] things. That is what the doctor told me. He asked me why do I like Lucozade? [an energy drink]. He asked me to stop and now I have stopped. Once somebody [the doctor] told me that it is not good, it is [not] good."* [**Ghanaian female owner of a corner store**]

Another retailer described the food she sells as unhealthy but when combined with other food can be considered healthy.

> *"In my shop, we offer more of the . . . [unhealthy] food. You can't describe them as healthy food because what we sell here are more of snacks and it is just to support you during the course of the day. That shouldn't be your main meal. What we offer here is more of sugar and glucose, which gives energy. But, putting rice and oil together [for example] can give you a balanced diet. So, if you combine food together to have a balanced diet, then you are getting a healthy meal. But if you only rely on food [snacks] such as juice and biscuits, no!"* [**Ghanaian female owner of a corner store**]

Some retailers advised against overconsuming the foods they sell: "*Drinking too much sugary products can be harmful. Taking too much energy drink can also affect your health. Taking too much alcohol too can also affect your health."* [**Ghanaian female owner of a corner store**]

What measures have retailers in Accra put in place to nudge healthy food choices?

Finally, Table 4 presents the measures retailers indicated implementing at the shop level to encourage healthy food purchases. Most retailers in Accra provide oral advice to nudge consumers towards adopting healthy food choices.:

> *"Normally when they come, somebody will come and tell you, maybe "I want a sugar-free drink" and I tell them maybe you can get "cerees" because it is sugar-free. But I think "purejoy" at times they add a little sugar, not 100% sugar."* [**Ghanaian female owner of a corner store**]

Some retailers indicated providing advice to consumers only upon request by consumers. *"Some people would say they don't want a drink that contains lots of sugar. So, if you have the one [in which] the sugar is less, you recommend it to them. They normally ask."* [**Ghanaian Female owner of a corner store**]

Some retailers indicated refusing to sell some food items to some consumers when they realize that those consumers overconsume the food they sell. e.g. *"When I see that you are taking it too much, I don't sell it to you again. That is what I do. When they come, I don't sell it? That is what I do."* [**Ghanaian female owner of a corner store**].

Some retailers demonstrated proactiveness as they indicated making efforts to carefully select the food products they believe are healthy for their customers:

> *"We go to the market every day and try to find locally made stuff that we know their origin or source. For example, we know that this is made of "sesame seed" product and it's from China. We try to go to the local market to find out if we can get "sesame seed" product that is locally made before we know the exact process it went through before coming to us. We are making endless efforts, my team and I."* [**Ghanaian male owner of a supermarket**]

Some retailers indicated making attempts to display what they consider healthy food in an attractive way. "Displaying **plays** a big role. As you see the dates, **for instance, we** are selling plenty [of] dates every day because we are displaying **them** in a very attractive way. It can attract the customer **e**ven if he doesn't need it, he will buy it. So, displaying has a big role. Also, if the customer, as I told you, need**s** our advice we will give him the real advice" [**Lebanese female owner of a supermarket**].

Discussion

This study aimed to elucidate retailers' understanding of healthy food, their perceptions of the healthiness of the food they vend, and the measures that they adopt to encourage healthy food choices. Overall, Accra-based food retailers' characterization of what they sell is similar to the current scientific depictions of healthy food. The retailers described healthy food as edible substances that provide positive health outcomes to consumers and which should not cause or contribute to illness. In their descriptions, they mentioned terms like "balanced diet" and "diversity," or referred to the nutrient profile that a healthy food should have. Currently, some of the science-based models for classifying food as healthy or unhealthy are nutrient-based (32, 33), food-based (34), or based on the level of processing (35).

To illustrate, in the US, the FDA defines healthy food as based on the nutrition profile of the food. They consider healthy food to be food products low in total fat and saturated fat, and which provide at least 10% of the recommended daily intake of certain vitamins and minerals (36)**.** The International Network for Food and Obesity/Non-communicable Diseases Research, Monitoring and Action Support (INFORMAS) classifies foods as healthy based on their nutrient profile. INFORMAS has developed five food groups considered "core": grains and grain products; vegetables and legumes/beans; fruits; milk and milk products; lean meat, fish, poultry, eggs, nuts, and legumes (37). Foods considered less healthy are referred to as non-core and included sweet breads, cakes, sweet biscuits, high fat savory biscuits, pastries, tinned meats, sweet snack foods, chips, extruded snacks, ice cream, etc. A third category, miscellaneous, includes foods such as recipe additions e.g., cubes, oils, dried herbs, tea, and coffee (excluding sweetened powder-based teas and coffees), etc., (37).

Retailers in Accra associated healthy food with safety, origin, and accessibility. They mentioned dimensions such as sanitation, hygiene, certification, and country of origin as important. Food safety concerns affect consumer behaviors and diets in low and middle-income countries (38) and those

TABLE 4 What measures retailers in Accra have in place to nudge healthy food choices.

Context	Theme	Evidence of example
Retailers take no action	Costumers exercise caution when shopping	*"You know in "Tesanon" [neighborhood] here, our consumers are educated. So, sometimes they can google the product and find [out] if the product is registered. So, we don't have that much challenges because most of the consumers are very educated. At times if it a product is getting close to its expiry date they [the costomers] mostly inform us. So, at times they draw our attention. So we don't find that difficulty with that."* [**Ghanaian male manager of a supermarket**]
Proactive retailers acting driven by their own initiative	Outsource for local food	*"We go to the market every day and try to find locally made stuff that we know their origin or source. For example, we know that this is made of "sesame seed" product and it's from China. We try to go to the local market to find out if we can get "sesame seed" product that is locally made before we know the exact process it went through before coming to us. We are making endless efforts, my team and I."* [**Ghanaian male owner of a supermarket**]
	Provide health related advice	*"Sometimes when I warn them, they say "this one has no sugar added" and when they talk like that, some of them say "my doctor said I should take it" because coke some has no-sugar."* [**Ghanaian female owner of a corner store**]
	Attractively display the food products	"Displaying plays a big role. As you see the dates for instance, we are selling plenty dates every day because we are displaying them in a very attractive way. It can attract the customer even if he doesn't need it, he will buy it. So, displaying has a big role. Also, if the customer as I told you, needs our advice we will give him the real advice" [**Lebanese female owner of a supermarket** *"This shelf is healthy. This stand is all zero sugar items. They don't contain sugar. The beans also, are all healthy for the body. But the chocolate stands are mostly the sugar stand. But people like them. They select from the stand according to their need and their demand."* [**Lebanese female owner of a supermarket**]
Retailers Reacting only to consumers' demands	Restrict the purchase of certain food	*"When I see that you are taking it too much, I don't sell it to you again. That is what I do. When they come, I don't sell it? That is what I do."* [**Ghanaian female owner of a corner store**].
	Provide advice on healthy food options	*"Normally when they come, somebody will come and tell you, maybe "I want a sugar free drink" and I tell them maybe you can get "cerees" because it is sugar-free. But I think "purejoy" at times they add a little sugar, not 100% sugar."* [**Ghanaian female owner of a corner store**] *"Some people would say they don't want a drinks that contain lots of sugar. So, if you have the one that the sugar is less, you recommend it to them. They normally ask."* [**Ghanaian Female owner of a corner store**] *"Quite a few of them ask question [express need for advice]. When they enter they [ask] "can you help me shop?" and as you are going with them you advise them" I heard this is good. How good is it?" you are helping him. Only a few ask."* [**Ghanaian male manager of corner store**] *"We have drinks that do not contain sugar and so, some people when they come, they request for sugar-free things. For example, if we has sugar-free biscuits and sugar-free drinks. So, when they come and request for sugar free foods, we offer them here." [**Ghanaian female owner of a corner store**]*

based in Accra as well (13). According to Liguori et al. (38), such concerns include fear of pesticides, hygiene in/around food outlets, unhygienic vendor practices, and household storage/preparation methods. These concerns may increase the stocking, vending, and consumption of less healthy starchy staples and processed/packaged foods compared to fresh fruit and vegetables.

Accra-based food retailers did not consider the extent of processing as a criterion for healthiness. The NOVA System classifies food based on the extent of processing (35). Although this classification system does not directly make any distinction about what food is healthy or not, individuals can use it to make important health-related decisions. Classifying foods from unprocessed/minimally processed foods (relatively healthier) through to ultra-processed foods (relatively less healthy), the NOVA system recommends that consumers limit their intake of ultra-processed foods compared to unprocessed and minimally processed foods.

As to the extent of availability and stocking of ultra-processed foods in food retails outlets of Accra, a related study conducted in Accra provides evidence (21). The study estimated that, for every 1 m^2 of shelf space allotted to healthy foods,

there was 6 m^2 equivalent of space allocated to less healthy foods or ultra-processed foods. It is possible that these stocking practices observed in the supermarkets or retail shops in Accra may be a response to consumers' demand for less healthy food. Indeed, respondents in the current study mentioned that their food stocking practices correlated with consumer demand.

Some retailers in Accra adopt limited measures to encourage consumers to adopt healthy food choices. Some of their efforts include sourcing foods from local wet or open markets for healthy food. Most retailers indicated providing guidance on healthier food options they have, but only if their customers expressed the need.

Globally, scholars and practitioners are now suggesting encouragement as a promising intervention to increase healthy food consumption (39). The potential of encouragement to increase healthy food decisions was underscored by Arno and Thomas (40) who showed that this leads to an overall increase in healthier food choices by 15.3%. Van Gestel et al. (41) also reported that repositioning healthy food products at the checkout counter increases the sales of those healthy food products. Their findings imply that there are clear opportunities to improve food choices by acting directly on the retail sector (15). Those opportunities can be seized by deploying a mix of high agency interventions that improve nutrition literacy and healthy food choices through nudges or counter-marketing strategies as well as low agency interventions zoning regulations, food-related fiscal policies, and improvement of food retail environments. To clarify, intervention agency usually refers to the resources (e.g., personal, psychological, cognitive, financial, material) on which individuals draw to engage successfully with an intervention (42). Those interventions that require individuals to invest fewer individual personal and psychological resources are described as low agency (fortification of food with micronutrients, marketing restrictions, fiscal policies, and product reformulations). In contrast, high agency interventions such as educational interventions, mass media campaigns, or front of pack labelling require substantial agency in terms of accessing, understanding, and applying the information provided (42).

Limitations

Our study is not flawless. Participating stores were identified and recruited from a purposive sample rather than through a probabilistic sampling approach. It is also possible that managers/owners who agreed to participate in the study were those with a predilection for healthy food retail. A large proportion of our sample were corner stores and a small fraction consisted of independent supermarkets. No chain supermarkets were included in our study. This limits the generalizability of our findings to other types of supermarkets and food retail outlets. Besides, this study did not cover rural settings/communities in Ghana. Such areas may have unique challenges not captured in our study. Therefore, the findings of this study need to be interpreted or extrapolated with the stated limitations and delimitations in mind.

Conclusions

The Accra-based retailers included in this study have a fair understanding of what constitutes healthy food. Some of the retailers employ limited measures to encourage healthy food stocking and choices. There is an opportunity for policy and interventions in the food retail sector in Ghana. Such interventions may improve consumers' dietary choices.

Recommendations

We recommend nutrition literacy interventions targeted at food retailers as well as retail-level training programs that seek to inculcate healthy retail strategies, such as nudging, to retailers. Given that Ghana is in the middle of a food environment policy reform, addressing these gasps in the retail sector will further enhance the anticipated success of the food environment transformation in Ghana.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation, and upon reasonable request.

Ethics statement

The studies involving human participants were reviewed and approved by the Ethics Review of the Humanities, University of Ghana (Approval # ECH 152-18-19), and the Ghana Health Service Ethical Review Committee (Approval # GHS-ERC 005-06-19). The patients/participants provided their written informed consent to participate in this study.

Author contributions

AL conceived and led the design of the study. SN, AA, and GA contributed to the design. AL and GA supervised the implementation of the fieldwork. SN and AA conducted the interviews with retailers and transcribed and coded them. GA supported data management and analysis. SN drafted the manuscript and received significant and relevant inputs from AL. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Availability of healthy and unhealthy foods in modern retail outlets located in selected districts of Greater Accra Region, Ghana

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Background: Intake of unhealthy foods is linked to the onset of obesity and diet-related non-communicable diseases (NCDs). Availability of unhealthy (nutritionally poor) foods can influence preference, purchasing and consumption of such foods. This study determined the healthiness of foods sold at modern retail outlets- supermarkets and mini-marts in the Greater Accra Region of Ghana.

Methods: All modern retail outlets located in six districts of Greater Accra were eligible. Those <200 m² of floor area and with permanent structures were categorized as mini-marts; and those ≥200 m² as supermarkets. Shelf length of all available foods were measured. Healthiness of food was determined using two criteria - the NOVA classification and energy density of foods. Thus, ultra-processed foods or food items with >225 kcal/100 g were classified as unhealthy. The ratio of the area occupied by unhealthy to healthy foods was used to determine the healthiness of modern retail outlets.

Results: Of 67 retail outlets assessed, 86.6% were mini-marts. 85.0% of the total SHELF area was occupied by foods categorized as unhealthy (ranging from 9,262 m^2 in Ashiaman Municipality to 41,892 m^2 in Accra Metropolis). Refined grains/grain products were the most available, occupying 30.0% of the total food shelf space, followed by sugar-sweetened beverages (20.1% of total shelf space). The least available food group–unprocessed staples, was found in only

one high income district, and occupied 0.1% of the total food shelf space. Retail outlets in two districts did not sell fresh fruits or fresh/unsalted canned vegetables. About two-thirds of food products available (n = 3,952) were ultra-processed. Overall, the ratio of ultra-processed-to-unprocessed foods ranged from 3 to 7 with an average (SD) of 5(2). Thus, for every healthy food, there were five ultra-processed ones in the studied retail outlets.

Conclusion: This study reveals widespread availability of ultra-processed foods in modern retail outlets within the selected districts. Toward a healthier food retail environment, public health and food regulators, in partnership with other stakeholders need to institute measures that improve availability of healthy foods within supermarkets and mini-marts.

KEYWORDS

ultra-processed food, modern retail outlets, supermarket, non-communicable diseases, Ghana

Introduction

Obesity is a major public health issue that contributes to the development of other diet-related non-communicable diseases (NCDs) such as diabetes, hypertension, cardiovascular disease (CVD) and some cancers (1). Several policies and programmes have been recommended to limit the intake of unhealthy ultra-processed, energy-dense and nutrient-poor foods rich in calories, salt, sugar, and fat but poor in beneficial nutrients such as fiber, protein, and micronutrients (2, 3). This policy response to improve food environments are informed by evidence that suggests that availability of these foods in the individual's environment and individual factors such as attitudes, taste, income and food affordability influence food consumption, including within Africa (4, 5). This implies that limiting the availability of unhealthy foods, while increasing the availability of healthier foods can motivate healthier food acquisition or consumption, and may thus contribute to preventing obesity. To that end, many calls exist for creating and promoting healthier food environments while eliminating so called "obesogenic environments" that encourage unhealthy food consumption (5, 6).

Urbanization, poverty, globalization, industrialization, climate change and the emergence of a concentrated corporate food regime (1–3) are converging and mutually reinforcing global transitions such as the dietary transition (4). In Ghana, such transformations of global food systems understood as the web of processes, actors and infrastructure that govern food production, processing, distribution, and sale have contributed to a changing quality of diets and the rise in obesity and nutrition-related NCDs (5). Ghana is at an advanced stage of the nutrition transition, experiencing rapid urbanization, and increasing overweight/obesity and related NCDs (5, 6). This entails increasing consumption of ultra-processed, energy-dense and micronutrient-poor foods, compounded by sedentary lifestyles with reduced physical activity. The transformation of systems of food production toward industrial mass-production of ultra-processed food has been mirrored by other structural changes including the transformation of food retail (2).

Ghana has recently been ranked as highly attractive for retail investment in Africa and globally based on the Global Retail Development Index, which studies the global retailing landscape based on 25 criteria (including country risk, market attractiveness, market saturation, and national retail sales) (7). Ghana has also been described as the new "bright spot" of Africa, driven by increased foreign and public investment as well as urbanization of the population. As a result, modern retail in Ghana is gradually emerging, especially in the capital, Accra (7), therefore impacting on food environments. These changes have included more direct contractual connections between large-scale producers and suppliers, with centralized and consolidated procurement and distribution systems. These "upstream" trends are mirrored by the "downstream" diffusion and penetration of "supermarkets for the poor" into areas previously dominated by traditional and informal markets (8). In Ghana, not only has the number of modern retail outlets increased, but also the penetration of ultra-processed foods in traditional food retail outlets—including informal ones (9). Monteiro et al. (3), defined ultra-processed foods as industrial products consisting of various processed ingredients, including sugar, starches, emulsifiers or colors, salt and other additives that enhance the shelf life or modify the food's taste, texture and color. Typical examples consumed in Ghana are sweets and biscuits, fried sausage and instant noodles (10).

The NOVA framework categorizes food into four groups (ultra-processed foods and three others) based on their nature, purpose, and degree of processing (3). Ultra-processed food

consumption reduces the likelihood of consuming fiber, protein and many micronutrient-rich foods that promote wellbeing, while increasing free sugar, sodium and unhealthy fats intake (3). Several studies have demonstrated a correlation between consumption of ultra-processed foods and increased risk for obesity and other NCDs (11–13). These studies and others indicate that not only are they available in retail outlets, they are also widely marketed, including in Ghana (14–16). Such wide availability and concerted marketing of ultra-processed foods a role in the purchasing and consumption of these foods (17).

Shelf space has been shown to have a substantial influence on the sales of a variety of food items (both healthy and unhealthy), indicating that the accessibility and prominence of potentially unhealthy foods in the supermarket, such as sugar sweetened beverages and salty snacks can also have an impact on the healthiness of customers' diets (18). Likewise, a classic marketing study showed that with a doubling of shelf space, sales of fruits and vegetables rose by about 40% (19). Elsewhere, studies that aimed to assess the healthiness of supermarket food environments have measured the shelf length of foods available for sale in food retail outlets and categorized them as healthy or unhealthy [e.g., (20, 21)]. These studies showed that simple measurements of shelf space can be used by researchers to characterize the healthfulness of the food environment and by policymakers to establish criteria for favorable policy treatment of stores (20, 21). Vandevijvere et al. (21) for instance reported that for every 1 m of shelf length for unhealthy foods, there was 42 cm of shelf length for healthy foods on average, with large variations between stores. The shelf length ratio was significantly lower in the most compared to the least/medium deprived socioeconomic areas.

In Ghana, while research on food retail environments is increasing in both scope and level of innovation (6, 15, 16, 22, 23), none has measured the amount of shelf space used for healthy and unhealthy foods in-store. Shelf space measurement is a useful measure of the in-store availability of healthy vs. less foods. The measure is a good proxy for product availability in food retail outlets. The current study determined the availability of food types sold at modern retail outlets according to their level and purpose of food processing and energy density through measuring shelf length located in the Greater Accra Region of Ghana.

Methods

Study design and site

This study is part of the Measurement, Evaluation, Accountability, and Leadership Support for NCDs Prevention Study (MEALS4NCDs) Project, which was implemented in the Greater Accra Region (GAR) of Ghana in 2019-2022 (24). MEALS4NCDs's overarching aim was to measure and support public sector actions that create healthy food marketing, retail, and provisioning environments for Ghanaian children, using adapted methods from the International Network for Food and Obesity/NCDs Research Monitoring and Action Support (INFORMAS) (25). The MEALS4NCDs project adopted a cross-sectional study design that applied both quantitative and qualitative methods. The study deployed a multistage sampling approach to select six administrative districts in the Greater Accra Region of Ghana (Figure 1). The first stage of the sampling process entailed purposively selecting the Greater Accra Region, which hosts the national capital, was/and remains the most urbanized and most marketed to, region of Ghana. The region was sub-divided into 16 administrative districts categorized as Metropolitan, Municipal, and Districts Assemblies (MMDAs). A representative sample of six districts (one metropolitan, three municipals and two districts) were selected using both probabilistic and non-probabilistic sampling approaches. Details about the sampling is reported elsewhere (24).

All modern retail outlets located in these six districts were eligible to participate in the study.

Modern food retail outlet identification

An eligible "retail outlet" was defined as a self-service modern retail outlet (with aisles accessible to customers) that had at least one staffed checkout aisle or cash register. In this study, "modern food retail outlets" encompass supermarkets and mini-marts. All eligible 'retail outlets with <200 m^2 of floor area were categorized as a "mini-mart" as opposed to supermarkets that were much larger in size. Of note, the 200 m^2 criterion was not decided a priori. Its relevance came to the fore when the need arose to discriminate between usual supermarkets and "smaller marts/hypermarkets that were included in the assessment." The derivation of the criterion was informed by the study team's collective knowledge and lived experiences. The criterion was deemed sensitive enough to discriminate between these two kinds of outlets. While local district offices were able to provide list of modern retail outlets found within their jurisdictions, field data collectors were trained to identify and map those that may not have been captured in the district database.

Summary of field procedures

Data were collected from July to August, 2020. Permission was obtained from retail outlet managers and owners to conduct in-store measurements. An in-store measurement tool adapted from INFORMAS was used to determine the total shelf length/breadth of foods available in the supermarkets—consistent with previous studies (20, 26). The shelf length and breadth for all food groups were measured: sugar-sweetened beverages, refined grains and refined grain products, whole grain

FIGURE 1
A map of the Greater Accra Region of Ghana highlighting the six selected districts and their poverty incidence.

cereal, legumes, fresh meat, processed meat/fish, milk product, eggs, fresh fruits and fresh fruit juice, fresh vegetables, fats and oil products, water, alcoholic beverages, unsweetened coffee, sweet foods and toffees, salted snack and vegetables, unprocessed staples, processed staples and condiments. When a food item type (e.g., sugar-sweetened beverage) was found in several places in the retail outlet, each location was measured separately and recorded in the in-store measurement tool. The total shelf area was added, once all measurements had been conducted. The total floor space was also determined by measuring the retail outlet's floor length and breadth. Digital photographs of all food products in-store were taken to facilitate their classification.

Each district had a team of two trained research assistants who conducted the in-store assessment (shelf space measurement with a tape measure and taking photographs). The research assistants went through several workshops to ensure clarity and consistency of comprehension. The data collection tool was pretested and validated before being used finally to collect data. The pretesting was done in La Nkwatanang-Madina Municipal Assembly. Based on the results obtained from the pretesting, necessary updates were done to the data collection tool.

Healthiness of food products

The foods were categorized according to the extent and nature of processing using the NOVA classification system (3). The NOVA food classification model categorizes foods into four groups—unprocessed/minimally processed foods, processed culinary ingredients, processed foods, and ultra-processed foods. In this study, unprocessed or minimally processed food were deemed healthy, whilst ultra-processed foods were not. Given our interest in calorie density of foods, food products were secondly categorized as healthy or unhealthy foods depending on calorie density. The NOVA classification does not specifically classify foods using calorie density. Foods that were energy-dense (>225 kcal/100 g) according to the (27) classification, were nutrient-poor, or were high in free/added sugar, sodium, and saturated fat were classified as unhealthy; healthy foods on the other hand were those that are nutrient dense. Details of the process of categorizing are given in our previously published paper (10). Other food categories including condiments/culinary ingredients were classified as miscellaneous. For every retail outlet we computed the ratio of all unhealthy to all healthy products, as well as ultra-processed food to minimally processed/unprocessed foods.

Healthiness of retail outlets

The ratio of total area of shelf space occupied by unhealthy vs. healthy food types available in retail outlets was calculated. In this study, a modern food retail outlet with a ratio less than one (<1) was considered to be healthier; a ratio greater than or equal to one (≥1) was considered less healthy. Similarly, an outlet was scored based on the ratio of NOVA Class four (ultra-processed food) to NOVA Class one (unprocessed/minimally processed). Again, a ratio <1 was considered as a healthier supermarket (<1). A ratio ≥1 was considered less healthy.

Data analysis

Descriptive analyses were performed using Microsoft Excel Worksheet 2010 and IBM SPSS Version 21 to generate total areas occupied by the various food groups and the ratio of healthy to unhealthy foods. Descriptive statistics such as means, standard deviations and percentages were estimated for the features of the retail outlets and the relative availability of unhealthy foods.

Results

Within the six districts selected, 113 eligible modern food retail outlets were identified. Assessments were conducted in 67/113 (59%) of the food outlets in operation. Assessments were not conducted in the remaining retail outlets primarily because their managers did not grant permission for measurements or for pictures to be taken. Also, a few others were not operating and could not be accessed. The attributes of the retail outlets are shown in Table 1. We adopted Ghana Statistical Service's categorization of the districts by poverty incidence (also referred to as poverty headcount and defined in Table 1). La Nkwatanang Madina (LANMA) had the highest number of retail outlets assessed (22) and also the highest mean outlet floor size (207 m^2). The sizes of the retail outlets differed by district. 86.6% of the retail outlets assessed were mini-marts (floor area <200 m^2). About 80% of the retail outlets were found in districts with low poverty incidence ($\leq$ 10% poverty incidence). The average floor size of the supermarkets found in LANMA, one of the districts in the Greater Accra Region with low poverty headcount (2.8%) was 207 m^2, followed by AMA (104 m^2) whilst Ningo Prampram, a district with high poverty headcount - more than four times the regional average (poverty headcount of 31.2%), had an average outlet floor size of 63 m^2. Ga South Municipal, a district with the highest number of poor persons (61,347) in the region had the least average supermarket floor size (46 m^2).

Food items available in the modern retail outlets

Refined grain/grain products such as noodles, cornflakes, biscuits, cake and cookies were the most available food groups in the retail outlets within the selected districts, except Ga South, where alcoholic beverages occupied the majority of the shelf area dedicated to foods in retail outlets (40.0%) (Figure 2). This was followed by sugar-sweetened beverages in all the districts except Ga South, where refined grains and refined grain products were the second most available food group (23%). Fresh vegetables and unsalted canned vegetables were not found in any of the retail outlets assessed in Ashaiman. No retail outlet assessed in Ga South sold fresh fruit. Additional data (Appendix 1) shows the availability [measured by shelf area (m^2)] of the different food items in the retail outlets assessed in the six districts.

Availability of healthy vs. unhealthy foods

Over eighty percent (83.1%) of the shelf space occupied by healthy foods were found in retail outlets located in low poverty incidence districts (Table 2). Overall, 78.7% of the area occupied by food products in both the mini-marts and supermarkets was allocated to "unhealthy" foods; about 20% of these were sugar-sweetened beverages (Appendix 1). Using the NOVA classification system, 68% (2669) food products identified in the food outlets were categorized as ultra-processed, 9% (337) were processed foods, 5% (211) were processed culinary foods and 18% (705) were unprocessed or minimally processed foods (Figure 3).

Healthiness of supermarkets

As per Table 3, overall, the ratio ($\pm$SD) of the shelf area for unhealthy-to-healthy foods is 4 (2). From the table, all retail outlets assessed in the six districts were found to be less healthy. The ratio of ultra-processed to unprocessed or minimally processed foods was also 4.8 with a standard deviation of 1.4.

Discussion

Most of the modern retail outlets assessed were mini-marts. The most available food groups in the retail outlets were refined grains /grain products followed by sugar-sweetened beverages. Unprocessed staples, fresh meat, fish and poultry products, fresh vegetables and unsweetened beverages each occupied $<1\%$ of the total shelf area allotted to food. Eighty-five percentage of the area occupied by food products in the modern retail outlets was allocated to unhealthy food categories. Almost ¾ of the food products were categorized as ultra-processed foods. Per ration of unhealthy-to-healthy foods or ultra-processed-to-unprocessed/minimally processed foods, all the retail outlets assessed were found to be unhealthy.

It has been previously reported that unhealthy foods are widely available in Ghana (9, 16, 28). As all outlets were assessed to be unhealthy overall, these outlets contribute to making ultra-processed and other unhealthy energy-dense, nutrient-poor foods more available. Notably, this study is cross-sectional and thus the findings of this study reflect the situation at a given time. However, all the retail outlets were assessed in a short period of time, so the findings are comparable within the sampled retail outlets.

TABLE 1 Attributes of identified retail outlets located within the study districts.

District	Number of retail outlets identified (N)	Number of retail outlets assessed (%)	Range of retail outlets area (m^2)	Mean retail outlet area (m^2)	Mini marts (%)	Supermarkets (%)	Poverty headcount* (%)	Poverty profile
Accra Metro	24	58.3	13–334	104	78.6	21.4	2.6	Low
Ashaiman	10	60.0	28–109	63	100.0	0.0	4.4	Low
Ga South	11	81.8	16–91	46	100.0	0.0	15.2	High
La Nkwantanang	32	68.8	26–864	207	72.7)	27.3	2.8	Low
Kpone Katamanso	22	27.3	24–181	85	100.0	0.0	3.5	Low
Ningo Prampram	14	71.4)	26-90	63	100.0	0.0	31.2	High

*Poverty incidence or headcount is defined as the ratio of the number of people in a district whose income falls below the poverty line. Low poverty incidence ≤ 10% poverty incidence.

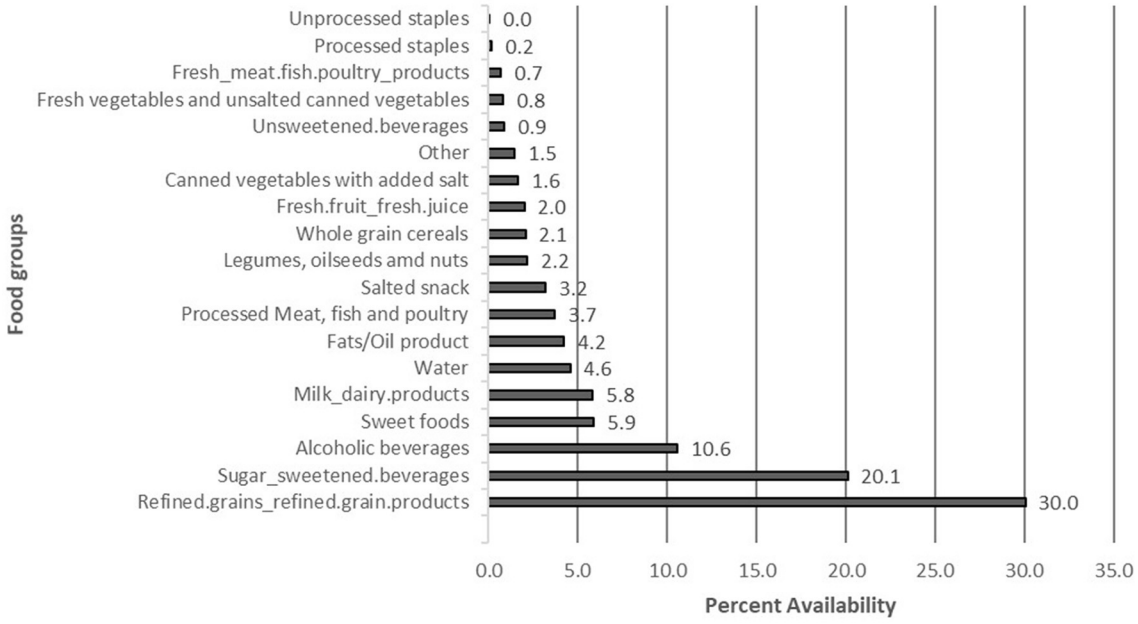

FIGURE 2
Availability (measured by proportion of total shelf area [%]) of different types of food items in modern retail outlets within the study districts.

Comparison of retail outlets and socio-economic status of districts using poverty headcount levels from the Ghana Statistical Service (29) shows important differences between the districts assessed. Although all the districts assessed in this study are located in the Greater Accra Region of Ghana, the most urbanized region of Ghana, the degrees of poverty incidence are clearly different. The number of supermarkets and mini-marts in Ga South (n = 11), a district with high poverty headcount, was modest compared to that in LANMA (n = 32), a district with low poverty incidence. A study conducted in Brazil (30) presented similar findings where lower socially deprived neighborhoods presented greater density of supermarkets. This may be because higher poverty incidence districts are less likely to attract high-end commercial establishments with a variety of food options because of their unstable urban infrastructure and lower consumer purchasing power.

In all the retail outlets assessed in Ga South, fresh fruits were not sold. Likewise, in Ashaiman, fresh vegetables and unsalted canned vegetables were not sold. This is similar to an earlier study in Ghana, where only five out of 13 supermarkets sold any fresh fruit or vegetables (23). Logistics such as transportation, preservation and storage of fresh food may be a barrier to the availability of fresh fruit and vegetables in the modern retail outlets assessed. Another explanation could be the status of

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TABLE 2 Shelf area occupied by healthy and unhealthy foods in retail outlets by districts, outlet size, and district poverty level.

Characteristic	Healthy foods (m^2) Mean (SD)	Unhealthy foods (m^2) Total mean (SD)	Miscellaneous/culinary ingredients (m^2) Total mean (SD)
District			
Accra Metro	973 (707)	2992 (2472)	143 (144)
Ashiaman	250 (110)	1547 (397)	12 (19)
Ga South	230 (82)	1667 (1678)	13 (12)
La Nkwantanang	872 (1602)	4557 (6886)	310 (582)
Kpone katamanso	1300 (2887)	3027 (6078)	2 (5)
Ningo Prampram	585 (1097)	2404 (1718)	10 (26)
Outlet type			
Mini-mart (m^2)	618 (1024)	2159 (2295)	52 (89)
Supermarket (m^2)	1818 (2445)	10199 (9558)	705 (851)
Poverty profile			
Low poverty incidence districts SES (m^2)	877 (1499)	3533 (5279)	195 (442)
High poverty incidence districts (m^2)	427 (323)	2055 (1694)	12 (20)

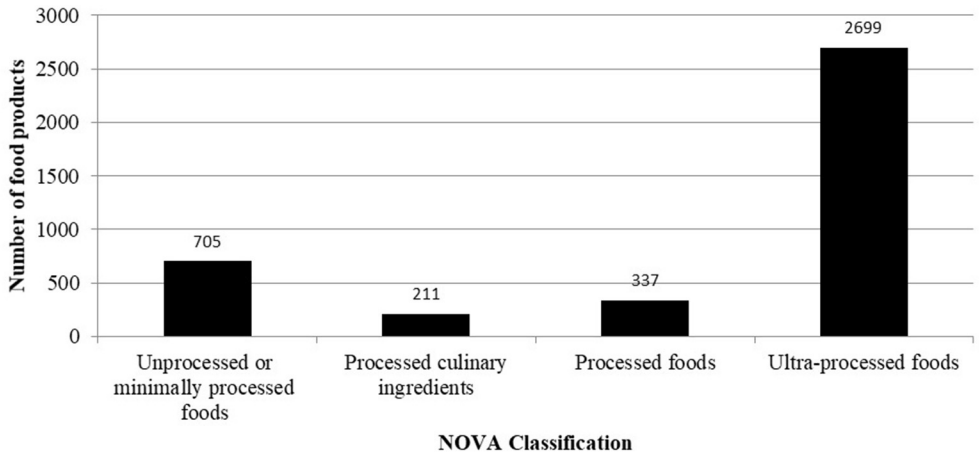

FIGURE 3
NOVA classification of unique food products in modern food outlets in all six study districts.

supermarkets/mini-marts in the wider food environment. For instance, it is likely the role of these food retail outlets in supplying customers in Ghana with fresh fruit and vegetables is quite low due to the significance and usage of other retailers such as greengrocers or open markets (23). Also, the relatively small sizes of the supermarkets found in Greater Accra compared to supermarket sizes found in other studies, for example in the USA (20, 31) could account for the unavailability of fruits and vegetables in the supermarkets. This is expected as mini-marts and smaller supermarkets would assign less shelf space to all products given their limited space.

While supermarkets/mini-marts provide access to healthier foods such as whole grain cereals, legumes, oilseeds and nuts, fresh milk, fresh yogurt, sugar-free milk and fresh fruit juice, a larger shelf area was devoted to unhealthy foods. For instance, the NOVA classification showed that 68% of the food products identified in all the supermarkets assessed were ultra-processed. In addition, a study conducted in Brazil, a middle-income country, showed that about 50% of ultra-processed foods were purchased from super/hypermarkets and mini-marts (32). This confirms the conclusion drawn from previous studies in Ghana that energy-dense, unhealthy foods are widely available (9, 16, 22, 28). And that, widespread availability of unhealthy food is therefore an issue of concern since a relatively high availability of such foods can influence preference and consumption of energy-dense, nutrient-poor foods. Relative availability of products

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TABLE 3 Ratio of healthy/unprocessed/minimally processed foods to unhealthy/ultra-processed foods by district.

District	Poverty profile	Unhealthy foods	Healthy foods	Ratio of unhealthy food: healthy food	Ultra-processed foods	Unprocessed/ minimally processed foods	Ratio of ultra-processed foods: Unprocessed foods
Accra Metro	Low	41,892	12,715	3.29	793	315	2.52
Ashiaman	Low	9,261	1,503	6.16	232	55	4.22
Ga South	High	15,003	2,241	6.70	354	61	5.80
La Nkwantanang	Low	100,259	18,627	5.38	625	150	4.17
Kpone katamanso	Low	18,168	7,071	2.57	252	38	6.63
Ningo Prampram	High	24,048	5,839	4.12	443	86	5.15
Overall (±SD),		34,772 (33,975)	7,999 (6,574)	4.70 (1.64)	450 (221)	118 (104)	4.75 (1.44)

is a major determinant of purchasing decisions and thus consumption (33).

Implications of findings

Our findings have implications for both researchers and policymakers. The widespread availability of ultra-processed foods (a proxy indicator of unhealthy foods) in the supermarkets/minimarts should be concerning to public health professionals. Governments, as well as the food industry, need to take actions. Policy makers seeking to improve health through dietary change, need to institute measures that improve relative availability of healthy, minimally processed foods within retail outlets. Such measures may include a mix of low-agency (fiscal policies, marketing restrictions) and high-agency (appropriate labeling) interventions.

Limitations

While this study has some strengths as discussed, there are a number of important limitations to be noted. First, we recorded a high non-response rate. Forty-one percentage of the managers of the modern retail outlets we approached declined to participate in the study—citing COVID-19 pandemic-related reasons. Relatedly, a few other retail outlets were not operating and could not be accessed. This limited the number of retail outlets assessed which could have led to a possible selection bias. It is possible that the retail outlet that denied us access had healthier food categories than unhealthy ones or vice versa. The current study's operational definition of supermarkets and mini-marts may not be comparable with that used in high income countries, and thus limits comparability. Indeed, given that the study was delimited to food retail outlets in the Greater Accra Region, we will discourage any attempt to do such extrapolations or generalizations. In addition, the retail outlets assessed used different display formats. For instance, some displayed vegetables on four smaller shelves placed on top of each other (where we measured the shelf length and breadth of all four shelves) and others placed the vegetables in one high bin (where we only measured 1 shelf length and breadth); the former might appear to have more vegetables than the latter, while actually the latter might have more if the quantity was measured. However, this was a rare occurrence. Finally, this analysis did not take into consideration food product price. Food product price has been highlighted as one of the strongest drivers of food acquisition and consumption, were not taken. Finally, while available evidence shows a very strong correlation between ultra-processed foods and high content of free/added sugars, sodium and saturated fatty acids, we note that calorie density and level of processing are not foolproof indicators of healthiness or lack thereof.

Conclusions

This study reveals widespread availability of unhealthy/ultra-processed foods in supermarkets/mini-marts in Greater Accra. For every 1 m^2 of shelf area for healthy foods, there was 5 m^2 of shelf area for unhealthy foods on average. For each unprocessed or minimally processed food product, there were 5 ultra-processed food products available in the supermarket/mini-mart on average. Relevant actors (the Food and Drugs Authority, Ministry of Food and Agriculture, Local Government, private sector, etc.) need to institute measures that

improve relative availability of healthy, minimally processed foods within supermarkets/mini-marts.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Ghana Health Service Ethics Review Committee (GHS-ERC 005/06/19) and the University of Ghana Ethics Review Committee for the Humanities (ECH 152/18-19).

Author contributions

AA and AL conceptualized the research question. AA performed the analysis and drafted the manuscript. GSA coordinated the data collection. WQ, AT, SV, and PA assisted in data collection. GSA, WQ, AT, RA, MH, CA, FZ, ML, KM, PA, DL, GA, DS, SV, and AL provided critical feedback, helped shape the research, analysis, and manuscript. AL supervised the work. All authors contributed to the manuscript and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Appendix

Appendix 1 The availability [measured by shelf area (m^2)] of the different food items in the retail outlets assessed in the six.

Districts	Accra Metro			Ashiaman			Ga South			La Nkwantanang			Kpone katamanso			Ningo Prampram			
Statistics	Mean	Std. Dev	Sum	Mean	Std. Dev	Sum	Mean	Std. Dev	Sum	Mean	Std. Dev	Sum	Mean	Std. Dev	Sum	Mean	Std. Dev	Sum	Total sum
Refined.grains_ refined.grain. products	1,129	1,172	15,799	702.5	291.5	4,215	435.0	229.0	3,915	1679.1	2310	36,941	1,139	2,208	6833.7	1,116	1043.2	11161.4	78865.1
Sugar_sweetened. beverages	761	623	10,650	549.0	181.1	3,294	392.4	207.2	3,532	1122.9	1662	24,703	610	1,046	3662.2	692	520.6	6923.5	52764.3
Alcoholic beverages	239	284	3,345	136.2	181.8	817	760.5	1,644.8	6,845	658.8	1066	14,494	52	69	312.4	198	273.9	1975.5	27788.5
Sweet foods	287	199	4,023	82.8	76.9	497	49.1	46.5	442	303.4	562	6,676	362	839	2173.9	156	97.8	1563.0	15374.4
Milk_dairy. products	196	146	2,744	85.4	79.9	513	65.7	60.2	591	267.9	644	5,894	411	936	2466.3	301	327.6	3014.8	15222.7
Water	159	193	2,227	103.4	103.0	620	131.5	82.3	1,184	264.8	530	5,826	110	244	657.9	148	120.6	1483.3	11997.6
Fats/Oil product	140	138	1,955	20.8	26.7	125	17.2	26.8	155	288.0	548	6,337	246	588	1474.7	97	68.9	972.4	11018.4
Processed Meat, fish and poultry	146	129	2,042	34.7	24.9	208	11.0	22.6	99	210.2	373	4,625	307	691	1843.2	88	55.1	875.6	9693.7
Salted snack	179	280	2,505	9.0	10.6	54	1.8	4.1	16	175.4	227	3,859	260	579	1561.9	32	24.8	322.6	8318.3
Legumes, oilseeds and nuts	175	229	2,448	34.5	66.5	207	13.3	24.6	120	59.3	84	1,304	239	563	1436.7	17	14.0	174.6	5690.4
Whole grain cereals	75	77	1,051	16.2	17.9	97	11.8	13.3	106	154.2	270	3,392	45	58	268.3	51	68.8	509.8	5423.3
Fresh.fruit_fresh.juice	98	85	1,373	9.7	15.1	58	0.0	0.0	0	69.4	150	1,527	343	738	2057.3	24	30.7	240.3	5255.9
Canned vegetables with added salt	75	84	1,056	8.5	20.7	51	0.0	0.0	0	119.3	330	2,624	51	101	306.1	25	53.0	254.4	4291.3
Other	278	377	3,897	0.0	0.0	0	0.0	0.0	0	0.0	0	0	0	0	0.0	0	0.0	0.0	3897.2
Unsweetened.beverages	164	168	2,301	0.0	0.0	0	0.0	0.0	0	0.0	0	0	0	0	0.0	0	0.0	0.0	2301.1
Fresh vegetables and unsalted canned vegetables	64	111	902	0.0	0.0	0	1.0	2.9	9	25.6	91	563	121	297	728.5	1	2.3	7.1	2208.9
Fresh_meat.fish. poultry_products	35	66	485	1.3	3.2	8	12.2	16.6	109	29.3	77	645	31	71	185.0	42	78.6	416.7	1848.7
Processed staples	37	45	517	0.0	0.0	0	0.0	0.0	0	0.0	0	0	0	0	0.0	0	0.0	0.0	516.9
Unprocessed staples	6	18	86	0.0	0.0	0	0.0	0.0	0	1.8	9	40	0	0	0.0	0	0.0	0.0	126.0

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Predictors of vitamin A rich food consumption among women living in households growing orange-fleshed sweetpotatoes in selected regions in Uganda

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Objective: Vitamin A deficiency (VAD) has serious public health consequences including morbidity and mortality for populations in low and middle-income countries (LMICs), especially for children under 5 years and pregnant women. LMICs are at greater risk of VAD, in part due to low levels of consumption of vitamin A-rich foods most of which are plant-based, such as orange-fleshed sweet potatoes (OFSP), with lower bioavailability than animal sources of the vitamin A. Food-based approaches such as biofortification of OFSP, including promoting the consumption of vitamin A-rich biofortified staple crops, has been shown to be potentially effective in improving the status of vitamin A and other micronutrients. This study examined vitamin A-rich food consumption and its predictors among women of reproductive age from OFSP-growing households in two regions of Uganda.

Methods: A cross-sectional survey was conducted among 617 OFSP growing households, focusing on women in the reproductive age group from the northern and eastern regions of Uganda. Households were not receiving any VAD-related intervention at the time of the survey. Quantitative data included vitamin A-rich food consumption, knowledge on vitamin A, and rich food sources dietary intake, using a 7-day food frequency questionnaire. Vitamin A consumption and risk of deficiency were estimated using the Hellen Keller International guide.

Results: The majority of women in this study were either pregnant (80%) or lactating (17%). More than 70% of the study population had a weighted vitamin A rich food consumption mean score of <6 days per week, indicating a high risk of VAD. Knowledge about vitamin A [b (SE) = −0.18 (0.50), $p < 0.001$] was significantly and inversely associated with vitamin A rich food consumption.

Conclusion: Components of food insecurity such as availability, affordability, utilization, and changing food preferences may contribute to the unexpected inverse relationship between knowledge and consumption of vitamin A rich foods. Scaling up biofortified food initiatives, including OFSP, can improve consumption of vitamin A rich foods with effective strategies to

comprehensively address consumption barriers such as lack of nutrition education, cooking skills, and storage facilities, as well as low production levels and perceived contamination of biofortified foods.

KEYWORDS

vitamin A, women, Uganda, food consumption, knowledge

Introduction

Micronutrient deficiencies, especially vitamin A, iron, folate, and iodine, are highly prevalent in low- and middle-income countries (LMIC) (1, 2). Micronutrients contribute to poor health (3), retarded growth, low productivity, growth impairment, and unexpected death (4–7). The burden of disease due to the health effects of micronutrient deficiencies has received increased attention in the last few decades (3). Women and children are at a higher risk of developing micronutrient deficiencies, with pronounced effects during preconception, pregnancy, and lactation (8, 9). These conditions are aggravated by low levels of household dietary diversity (4) and household food insecurity (10).

Vitamin A deficiency (VAD) is considered one of the most serious public health concerns in LMIC. Young children and pregnant women, especially in low-income, rural communities, are more susceptible to VAD. Vitamin A is an essential micronutrient for normal functioning of the visual system, growth, and development, as well as maintenance of epithelial cellular integrity, immune function, and reproduction (11). VAD, defined as serum retinol concentrations below 0.825 μmol/l (12), is estimated to affect two billion people globally (7, 13). The initial symptoms of VAD include impaired adaptation to the dark with serum retinol concentrations falling below 0.8 μmol/L (14). Xeropthalmia, an advanced condition of VAD that can lead to blindness, is a concern for pregnant women given greater vitamin A requirements during this period of the life course (7).

Globally, evidence supports dietary diversification for optimal nutrition and health (15, 16). Consumption of diverse diets is central to achieving and preserving nutrient adequacy throughout the life course (15, 16). Inadequate dietary quantity and quality result in deficiencies of essential nutrients, particularly during pregnancy and lactation (17). In China, inadequate consumption of fruits and vegetables was associated with low levels of serum vitamin A among lactating women (18). In Ethiopia, more than 70% of pregnant women had low dietary diversity scores and low consumption of animal sourced foods (19) and 60% of lactating women had inadequate consumption of vitamin A rich foods (20). Diets of healthy women of reproductive age in Indonesia were considered low in animal sourced foods and fruit and vegetable consumption, suggesting greater risk of nutrient deficiencies (21). Understanding barriers to consumption of vitamin-A rich foods is critical to food-based programming, especially in post conflict regions of the world which are prone to drought and other conditions that exacerbate food insecurity.

Despite the progress in addressing vitamin A deficiency in LMICs, including Uganda, it is still a persistent public health concern. In Uganda, the prevalence of VAD is 8.3 and 9.0% in the urban and rural areas, respectively (22). Higher prevalence rates have been reported in the following subregions of Uganda: Acholi (15.4%), Busoga (12.8%), and West Nile (11.2%) (22). High implementation costs of industrial food fortification and supplementation programs, and their limited reach in resource-poor rural communities, justify continued support of alternative food-based approaches such as diet diversification and the biofortification of daily staple crops, such as orange-fleshed sweet potatoes (OFSP), with vitamin A (23). Innovative food-based approaches have included production of beta-carotene rich OFSP as a preventive and therapeutic nutrition-specific intervention targeting livelihoods that can also potentially prevent and mitigate vitamin A deficiency (24).

More research is needed on dietary patterns related to consumption of vitamin A rich foods, including OFSP, among women during pregnancy and the postpartum period (25, 26). A better understanding of dietary patterns, including vitamin A rich food consumption such as intake of OFSP, can lead to improved interventions to prevent malnutrition and improve maternal and child health outcomes related to VAD and other micronutrient deficiencies. Examination of dietary patterns also has implications for dietary guidelines (27), which can subsequently lead to increased understanding of the mechanisms that facilitate higher consumption of vitamin A rich foods and improved vitamin A status among women. This study examined consumption patterns of vitamin A rich foods, including OFSP, and assessed the predictive capacity of knowledge of vitamin A rich foods, knowledge of OFSP, and misconceptions of OFSP on vitamin A rich food consumption among women from OFSP-growing households in two regions of Uganda.

Methods

Study design

This study examined baseline data collected in 2020 on dietary intake and livelihoods among 617 women residing in households growing OFSP from two regions in Uganda. Survey data was collected by the International Potato Center (CIP) as a baseline for their "Development and Delivery of Biofortified crops to scale (DDBIO)" project. Uganda is a landlocked country in East Africa with an estimated population of 43 million people (28). More than half (50.8 %) of the Ugandan population are women and nearly seven million are < 4 years of age (22). With 74% of the population residing in rural areas, the agricultural sector is the major economic backbone for the nation's population (29). The country is divided into four regions: central, western, eastern and northern, and these comprise of subregions of a number of districts. This study focused on data collected by CIP in 2020 in nine out of the twelve districts considered for the DDBIO project including Pader, Lamwo, Gulu, Kitgum, Agago, and Adjumani in the northern region and Busia, Tororo, and Karamoja in the eastern region of Uganda.

Study population

The study population comprised women who resided in households that grew sweet potatoes in the eastern and northern regions of Uganda. Districts within these regions were selected based on relatively higher prevalence of malnutrition as compared to other districts in the country, and limited efforts to improve nutritional status *via* food-based interventions. Baseline survey participants were recruited from the communities at the household level. Eligible participants were women in each of the households who were either pregnant or lactating, as well as adolescent girls. Women were ineligible to participate in the survey if they were sick or mentally unwell or had not stayed in the household in the past 3 months.

The sample size for this study was determined based on a priori sample size calculations. The statistical power needed to detect small, medium, and large effects was calculated for chi-square, *t*-tests, and regression analyses. Power analyses were conducted using G* power 3.1.9.7 software (30). Assuming a two-tailed test, 1- beta error probability of 0.8, and an alpha of 0.05, a sample size of 617 was determined to be sufficient to detect medium and larger sized effects for all tests, and to detect associations between selected independent variables and the outcome variable, vitamin A rich food consumption.

Data collection

Using a comprehensive semi-structured household-level survey, data included demographic characteristics, household food consumption, a 7-day food frequency questionnaire for vitamin A rich foods, knowledge about vitamin A, and other information. The survey tool was administered at the household level in local languages by trained research assistants.

Measures

HKI food frequency method

An adjusted Hellen Keller International (HKI) guide was used to collect data on vitamin A rich food consumption. The HKI Food Frequency Method, which has been validated against WHO standards to classify VAD (31) is based on a 7-day food frequency questionnaire consisting of 33 food items to capture vitamin A food intake. Participants were asked, "How many days, in the past seven days, did (a selected reference child/woman) eat (a specific food item)?" The HKI method assesses the extent to which communities and populations are at risk of VAD. If at least 70% of the communities surveyed (11 out of 15) are assessed as having a high prevalence of VAD, vitamin A deficiency is likely to be a public health problem in the entire area. VAD status is determined by either of two threshold values: $\leq$ 4 days per week for mean frequency of consumption of animal sources of vitamin A or $\leq$ 6 days per week for mean frequency of total consumption of animal and plant sources of vitamin A (weighted by the source), or a combination of these (31, 32). The vitamin A consumption frequency score was using the following formula:

Weighted total consumption days (Cw) = Total number of days animal sources of Vitamin A consumed (TVA) + Total number of days plant sources of Vitamin A consumed (TAP) divided by 6.

The weighted vitamin A consumption score (C) is equal to the total number of days the mother consumed vitamin A rich foods from animal sources plus the adjusted consumption from plant sources.

Women's knowledge of vitamin A

Interviewers asked open-ended questions on knowledge of vitamin A rich foods and knowledge of OFSP (see Supplementary material). For vitamin rich foods, interviewers recorded participant responses by checking off each answer from a list of possible responses; a write-in option allowed interviewers to record unlisted foods. A score of one was allocated for each correct response. We summed up the individual responses of the section items; summed responses were on a scale of 0–5, with 0 representing a woman not having heard about vitamin A or with no correct answer for the rest of

the items and five for a woman who has heard about vitamin A, knows two benefits of vitamin A and correctly identified two rich sources of vitamin A.

Women's knowledge of orange-fleshed sweet potatoes

Two scales were developed by running a series of exploratory factor analyses (i.e., principal axis factoring and direct oblimin rotation) to examine how many underlying factors explained women's knowledge of OFSP. Examination of the structural matrix allowed for the identification of items related to the underlying factors. Cut-off points of 0.32 were used for factor cross loading and 0.6 for a strong factor loading (33, 34). Items that had strong cross loadings or items that were shown to have factors that were not associated with knowledge, for example, responses to gender-related measures such as "sweet potato is a woman's crop and you can't grow sweet potatoes and be considered a man," were eliminated. Two factors were identified in this analysis: Factor one (misconceptions about sweet potatoes) with items: (1) Sweet potato is not good for children less than 2 years old, (2) Sweet potato is not good for pregnant women, and (3) Sweet potato is not good for lactating women; and factor two (the general benefits of sweet potatoes) with items: (1) Sweet potato leaves are good for human beings to consume and (2) Sweet potatoes that are orange inside are healthier than the ones that are white inside. The reliability test for the two scales yielded a mean of 2.46 (SD 1.07) with a Cronbach's alpha of 0.362 for the general health benefit item and a mean of 3.90 (SD 0.831) with a Cronbach's alpha of 0.662 for the misconceptions about OFSP, respectively. Participants' responses to the generated items/scales were considered for comparison with vitamin A consumption.

Individual dietary diversity score

Household dietary diversity represents the number of different food groups consumed by the household within a specified recall period (35). The individual dietary diversity score (IDDS) can also be calculated by summing the number of food groups consumed by the respondent over the recall period using the nine food groups recommended by FAO (36, 37) and with scores ranging from zero to nine. IDDS represents an indicator of the nutrition quality of an individual diet. Extracted from the list of 20 possible food items in the questionnaire, the nine food groups included: (1) cereals/grains and root tubers; (2) vitamin A rich fruit and vegetables; (3) fruit other than vitamin A rich fruit; (4) vegetables other than vitamin A rich vegetables; (5) legumes and nuts; (6) meat, poultry, and fish; (7) oils and fats; (8) diary; and (9) eggs. Other items such as tea, sugars, and beverages were not considered when calculating the IDDS for this study. Independent variables including age, education, employment, household food consumption, region, and number of household members were also examined.

Statistical analysis

Data were digitalised using CsPro during data collection and analyzed using SPSS version 26.0 (IBM Corp, 2019). Descriptive statistics and contingency tables were used to summarize household and participant characteristics and vitamin A rich food consumption. These were reported as proportions, percentages, means with corresponding standard deviations, and median values. The means and standard deviations for vitamin A consumption data for the women were computed from the weighted score, as well as separately for plant and animal sources of vitamin A. Exploratory factor analysis was conducted on knowledge items related to OFSP and summarized into two scales. For comparative statistics, bivariate correlations were conducted to examine associations between continuous independent variables and vitamin A rich food consumption. Multivariate linear regression tested the association between the outcome, vitamin A rich food consumption, and independent variables. Analysis of covariance was used to test associations between categorical variables. We considered a 95% confidence interval and statistical significance was set at $p < 0.05$.

Results

Mean age was 28.3 ±6.9 and 73.2% of all respondents were in the 20–34 age category. Most of the respondents were married (88.1%) and 78.2% had seven or less years of formal schooling. A majority of the women either pregnant (16.8%) or lactating (79.6%) at the time of data collection. Most households (66.5%) had between 5 and 9 members and were engaged in farming. Seventy-seven percent of the women consumed four or fewer food groups in the week preceding the survey (Table 1).

Knowledge of vitamin A and orange-fleshed sweet potatoes

The majority of participants (82%) had heard about vitamin A and were able to identify the health benefits of the vitamin (Table 2). Almost a quarter of the women (22.7%) could identify the role of vitamin A in the prevention of infection and diseases. One fourth (24.6%) of the participants identified dark leafy green vegetables as a source of vitamin A, while only 3.1% identified OFSP as a source of vitamin A (Table 2). The mean score of vitamin A knowledge among participants was 2.1 ± 1.8 (Table 3). Based on a three-item scale, close to one third of the participants (30.7%) had no information about vitamin A and

TABLE 1 Socio-demographic characteristics of households and women.

Variable	Categories	*N* (%)	Mean (SD)
Study sub-region	Eastern	216 (35)	
	Karamoja	137 (22.2)	
	Northern	19 (31.3)	
	West Nile	71 (11.5)	
Household size	1–4	127 (20.6)	6.6 (2.5)
	5–9	411 (66.5)	
	>9	80 (12.9)	
Sex of household head	Male	571 (94.4)	
	Female	34 (5.6)	
Relationship to household head	Household head	61 (10.5)	
	Spouse	494 (84.9)	
	Other	27 (4.7)	
Mother characteristics			
Age group (yrs)	15–19	44 (7.7)	28.3 (6.9)
	20–34	421 (73.2)	
	>35	110 (19.1)	
Marital status	Married with spouse	510 (88.1)	
	Married, spouse away	35 (6.0)	
	Divorced/separated	16 (2.8)	
	Widow	7 (1.2)	
	Never married	10 (1.7)	
Education	No formal education	138 (23.9)	4.99 (3.64)
(yrs of schooling)	1–7 years of schooling	321 (54.3)	
	>7 years of schooling	120 (20.8)	
Main Occupation	Farming (crops and livestock)	464 (80.3)	
	Household chores	62 (10.7)	
	Other	44 (8.3)	
Physiological state	Pregnant	97 (16.8)	
	Lactating	461 (79.6)	
	Non-pregnant, non-lactating	20 (3.5)	
Disability	Yes	22 (3.8)	
	No	557 (96.2)	
IDDS	≤ 4 food groups	443 (76.6)	3.4 (1.6)
	>4 food groups	135 (23.4)	

only 12% identified three sources and benefits of the vitamin (Table 3).

Two factors, which informed the development of two scales presented in this analysis, were derived from factor analysis of the knowledge items on OFSP included in the questionnaire. The first factor was awareness of the general health benefits of eating OFSP and the second factor was misconceptions about OFSP (Table 4). Based on the identified OFSP knowledge scales, 45% of the participants scored above the mean of 2.46 ± 1.07 (median 2.5) in the knowledge scale for the general health

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TABLE 2 Women's knowledge about vitamin A.

Questions about knowledge on vitamin A	Yes (*n*)	%
Heard about vitamin A	507	82
Health benefits for vitamin A		
Good for eye sight	69	11.2
Prevents infections/diseases	140	22.7
Important in blood production	10	1.6
Other benefits (i.e., healthy skin, appetite)	145	23.4
Source of information about vitamin A		
Health clinic	16	2.6
Media	27	4.4
Village health teams	26	4.2
School	17	2.8
Identified sources of Vitamin A		
Leafy green vegetables	152	24.6
Pumpkin/ripe mango/papaya	25	4.4
Orange-fleshed sweet potatoes	19	3.1
Eggs/Fish	132	21.4

TABLE 3 Vitamin A knowledge scores.

Score	Frequency (%)	Mean score
Score 0 (no information about vitamin A)	190 (30.7)	2.1 ± 1.8
Scored 1	69 (11.2)	
Scored 2	96 (15.5)	
Scored 3	91 (14.7)	
Scored 4	98 (15.9)	
Scored 5 (identified 3 sources and health benefits of vitamin A)	74 (12.0)	

benefits of OFSP and 61% scored below the mean score of 3.91 ± 0.82 (median 4) for misconceptions of OFSP (Table 5).

Vitamin A rich food consumption for women

Based on the Hellen Keller International (HKI) guide (32), plant sources had the highest mean consumption in days per week compared to animal sources of vitamin A (Table 6). Foods presented in Table 6 only reflect vitamin A rich foods that were consumed at least once in the past seven days (frequency). Other foods listed in the HKI guide were consumed less than once in the past 7 days in this sample. Dark green leafy vegetables were the most common source of vitamin A for the study population, with a mean consumption of 2.84 days per week. OFSP were consumed at least once in the previous week by approximately 38% of the study population. Carrots, ripe mango, passion fruit or other vitamin A rich fruits, butter, and vitamin A fortified margarine were not commonly consumed by this sample. When consumed, animal sourced foods had the lowest frequency of consumption (Table 6), including small dried fish which was captured under the "any fish" category. There was a statistically significant difference in the mean number of days per week of consumption of plant (4.5) vs. animal (1.5) sources of vitamin A (t, $df = -20.3, 616$ $p < 0.01$). Nearly all women (>95%) had ≤6 days per week for the mean frequency of total consumption of animal and plant sources of vitamin A (weighted score). Based on the HKI guide (32), a community is considered to be at high risk of VAD when the mean weighted score is <6 days per week or <4 days of consumption of animal food sources of vitamin A.

Predictors of vitamin A rich food consumption among women in Uganda

In the unadjusted regression model, knowledge of vitamin A (correlation coefficient −0.15, $p<0.01$) and knowledge of the benefits of OFSP (correlation coefficient 0.10, $p = 0.02$) were significantly associated with women's vitamin A rich food consumption while misconceptions about OFSP was not (Table 7). Given the inverse correlation between vitamin A knowledge and vitamin A rich food consumption observed in the unadjusted model, we examined the data separately for correlations between vitamin A knowledge and plant vs. animal sources of vitamin A. Vitamin A knowledge had a statistically significant inverse coefficient (correlation coefficient −0.16, $p < 0.01$) with vitamin A rich animal sources and a non-significant correlation with vitamin A rich plant sources (correlation coefficient 0.03, $p = 0.47$).

Multivariate linear regression analyses found that knowledge of vitamin A was significantly associated with women's vitamin A rich food consumption, after controlling for household size, education, age, and individual dietary diversity score, knowledge of OFSP, and misconceptions about OFSP [b (SE) = −0.18 (0.50), $p < 0.001$] (Table 7). Neither knowledge of OFSP nor misconceptions about OFSP were independent determinants of vitamin A food consumption (Table 7).

Discussion

Our findings contribute to the literature on predictors of vitamin A rich food consumption. Based on the Hellen Keller assessment guide (32), the study population was found to be at a high risk for vitamin A deficiency given that the consumption patterns of vitamin A rich foods for women were relatively low

TABLE 4 Items and scale information from the exploratory analysis of knowledge about orange-fleshed sweetpotatoes included in the questionnaire.

Item	Factor loading				
	1	2	1	2	3
General health benefits					
Sweet potato leaves are good for human beings to consume	0.014	**0.726**	−0.066	**0.681**	0.365
Sweet potatoes that are orange inside are healthier than ones that are white inside	−0.027	**0.767**	−0.031	**0.8**	−0.266
Misconceptions					
Sweet potatoes are not good for the child	**0.723**	−0.23	**0.744**	−0.251	0.043
Sweet potatoes are not good for pregnant women	**0.816**	0.1	**0.837**	0.091	−0.063
Sweet potatoes are not good for lactating women	**0.771**	0.021	**0.749**	−0.032	0.302
Too much sweet potato can cause stomach problems	0.331	−0.229	0.309	−0.275	0.318
Vitamin A is found in all types of sweet potatoes	0.178	0.098	0.071	−0.009	0.848
Eigenvalue	1.94	1.23	1.94	1.23	1.07
Percentage of variance	27.6	17.5	27.6	17.5	15.3

The table indicates the factor loadings of the different items, when 2 and 3 factors were selected respectively. The bolded data indicates the correct items that loaded on a particular factor.

TABLE 5 Participant scores on the scale dimensions derived from factor analysis of knowledge of orange-fleshed sweet potatoes (OFSP).

Scale component	Above mean *n* (%)	Below mean *n* (%)	Mean	Median
General health benefits of OFSP	242 (45)	296 (55)	2.46 (1.07)	2.50
Misconceptions about OFSP	217 (37.9)	355 (61.3)	3.91 (0.82)	4.0

TABLE 6 Vitamin A rich food group groups consumed at least once during the last week and meal frequency for women.

Food groups	*N* (%)	Mean frequency of consumption (days/wk)
Any dark green leafy vegetables	450 (78.3)	2.84
Carrots	6 (1)	2.83
Ripe mango	46 (8)	2.32
Pumpkin or orange squash	153 (26.6)	1.9
Ripe pawpaw, fresh or juice	118 (20.5)	2.27
Passion fruit (or other fruit rich in vitamin A)	29 (5)	3.13
Orange-fleshed sweet potato	218 (37.9)	2.25
Eggs with yolk	110 (19.1)	1.9
Any fish, fresh	210 (36.5)	2.42
Liver from any animal	47 (8.2)	1.27
Butter	17 (3)	2.1
Vitamin A fortified margarine	8 (1.4)	2.25

TABLE 7 Estimated correlation coefficient and unstandardized (b) coefficient for association between independent variables and vitamin A rich food consumption for women.

	Unadjusted model	Full Model Model 1
Variable	***r* (coefficient)**	**B (SE)**
Household size	0.52	−0.04 (0.04)
Education	0.05	0.05 (0.03)
Age	0.06	−0.008(0.01)
Knowledge of vitamin A	−0.15**	−0.18 (0.50)§
General Knowledge of benefits of orange-fleshed sweetpotatoes	0.10*	0.18 (0.09)
Misconception about orange-fleshed sweetpotatoes	0.65	0.20 (0.11)
Individual dietary diversity score	0.07	0.78(0.11)

*Significant at $p < 0.05$, **significant at $p < 0.01$, §significant at $p < 0.001$.

with a mean weighted score below the threshold of adequate consumption. This is compounded by findings that suggest generally low knowledge about vitamin A was observed in this sample where a significant proportion of women were either pregnant or lactating at the time of data collection. These stages of the life course have higher vitamin A requirements and low intakes during these stages are associated with adverse health consequences (38). Recommendations are based on the expected secretion of retinol into human breast milk which is dependent

on the mothers' vitamin A status, with the expectation that infants would also benefit (39). Breast milk is a fundamental source of vitamin A, especially in the first 6 months of life (40). Given the critical role of vitamin A in infant health and development, it is essential that women of reproductive age get adequate vitamin A and other micronutrients (41).

The targeted regions are post conflict areas of Uganda that experience greater food and nutrition insecurity due to food shortages and disrupted economic activities. In Uganda, like in many other developing countries, large scale programs are needed to make a significant impact on high rates of malnutrition, including VAD. However, there has been limited experience and success in scaling up programs (42). Based on the weighted consumption score, which found that nearly all women consumed low amounts of both animal and plant sources of vitamin A, the surveyed communities are considered to be at a high risk for VAD. Plant foods were the most frequent sources of vitamin A compared to animal sources of vitamin A which influences vitamin A status due to bioavailability of carotenoids (43).

The vitamin A rich food consumption patterns of the participating communities were not uniquely different and accentuated the reliance on plant source diets in limited resource settings in Sub Saharan Africa. Animal source foods are associated with higher serum retinol levels (44), however, are less affordable for low income populations (45). Previous studies corroborate our findings, suggesting that individuals from resource-constrained settings have limited access to foods containing preformed vitamin A from animal-based food sources and they do not commonly consume available foods containing beta-carotene due to poverty or lack of information on the importance of the food sources (46).

Nutrition education has the potential to increase knowledge of nutrition benefits among at-risk communities to improve consumption of carotenoids, including of OFSP, mangoes, papaya and dark leafy green vegetables and diversification to include animal sources of vitamin A (47). However, we observed a significant and inverse association between knowledge of vitamin A and vitamin A rich food consumption, after adjusting for covariates. This suggests that despite gains in nutrition knowledge, other barriers may play a role in the levels of consumption of vitamin A rich foods in these regions of Uganda. Some consumption barriers could include lack of access of vitamin A rich foods due to seasonal variation, especially among small holder subsistence farmers who are commonly stricken by poverty (48).

Seasonal variation in food supply can be addressed by growth of drought-resistant and dry season crops, such as tubers, which can alleviate food insecurity, although they may not necessarily be the best sources of vitamin A (49). Leafy green vegetables and OFSP were the commonly consumed sources of vitamin A in this population. Being seasonal crops, this translates into reduced consumption during out of season periods. Seasonality needs to be considered for consistent vitamin A intake across the year. Having the potential to purchase or grow other sources in the market during off seasons is a strategy to be considered in program interventions. Education and peer mentoring on home-based gardens for alternative vitamin A sources during periods of food insecurity, especially in the dry season, could prove to be instrumental in mitigating malnutrition (50, 51).

Vitamin A rich plant foods could also be readily available in the community but likely underutilized. In these situations, existing cultural practices that prohibit pregnant and lactating women from consuming potentially good sources of vitamin A may pose another barrier to consumption that may need to be abated (52, 53). Targeted nutrition education can be incorporated in food-based programs to increase community knowledge on ways to improve health outcomes, including bioavailability and absorption of vitamin A from plant sources (42, 54). Education can include preparation methods that allow the addition of fat to increase bioavailability of vitamin A which is fat soluble and can be stored in the body (55). An intervention study, with nutrition education, conducted among adolescent girls in Sri Lanka resulted in a highly significant ($P < 0.001$) increase in knowledge and consumption of local vitamin A rich foods (56). The percentage of adolescent girls with low serum retinol concentrations (<20 microg/dL) decreased from 17 to 4.8% as a result of the intervention (56).

Similar to this study, low dietary diversity was highly prevalent among pregnant women ($N = 104$) in the Damot Sore district of Southern Ethiopia (57). Another studies in Ethiopia reported that one quarter of households had low dietary diversity (58) or low to medium dietary diversity (20). In contrast, a study among 624 lactating mothers attending an immunization clinic in Gondar town, Ethiopia, determined that women had adequate vitamin A consumption with a greater proportion of women consuming more than five food groups (20). Nutrition knowledge was also found to be higher among women attending an immunization clinic in Gondar town, Ethiopia (20).The difference in vitamin A rich food intake in these Ethiopian communities might be explained by the women in Gondar having access to health care, experiencing greater food security, and residing in a semi-urban area of the country.

We found that knowledge of vitamin A was a statistically significant predictor of vitamin A rich consumption after adjusting for covariates. Similarly, knowledge was a predictor of vitamin A rich food consumption in a Nepali study (59). However, no statistically significant association was found between knowledge of vitamin A and vitamin A rich food consumption among lactating women in two regions of Tanzania (60). While age, education, household size, and individual dietary diversity were not predictors of vitamin A rich food consumption in this study, other studies suggest otherwise (21, 60, 61). Having a college degree, family size, and being from a higher economic class were identified as factors

associated with vitamin A consumption in an Ethiopian study (20). Given that the study was conducted in an urban setting, it is possible women who attended the clinic in this town setting were more educated, knowledgeable, and economically well off (20) compared to women in our study who lived in post-conflict areas and relied on farming income. A study conducted in northern Benin where 34% of women were identified as being at a greater risk of VAD, found that maternal education, maternal farming activity, maternal health status, low food diversity, lack of fruit and vegetable consumption, low protein food consumption, and high infection rates were associated with the vitamin A status (61). In a study of 569 lactating mothers in Tanzania, the prevalence of VAD was 88.5% and was associated with place of residence (60). Sixty-eight percent of the lactating mothers in this Tanzanian study lacked knowledge about vitamin A and fortified oil, however they had a positive attitude toward the consumption of vitamin A rich foods (60). These findings suggest benefits of nutrition education, specifically on vitamin A and its health benefits, in low-resourced communities (60).

Our study contributes to scientific knowledge on predictors of vitamin A rich food consumption in low resource rural settings with subsistence farming activity. The results of this study will inform the International Potato Center's (CIP) implementation and scaling up of initiatives related to OFSP in selected post conflict regions in Uganda; adjustments to the initiative that improve nutrition education and remove consumption barriers can promote program effectiveness related to improved vitamin A rich food consumption within these communities.

By the time this paper was written, scaling up the program for the delivery of biofortified OFSP had begun to improve accessibility which may have translated into higher consumption among participating communities.

CIP is partnering with humanitarian agencies such as the World Food Programme (WFP) to make OFSP available for improving nutrition and livelihoods of vulnerable populations. This project is built on the premise that the proven nutrition and livelihood benefits of OFSP can be delivered efficiently through existing large-scale humanitarian programs, especially because these transition into market-based approaches that engage local and national agri-food systems to respond to and reduce the need for humanitarian food aid. Sweet potatoes and specifically OFSP, is new in the farming and food systems of the targeted regions. The intervention with the introduction of OFSP in these drought-prone post conflict regions has shown that the crop is an important part of the local diet and food system, where roots and leaves are both consumed as part of a healthy diet. The results of this study provide the CIP with important lessons on barriers to consumption, opportunities to improve uptake, and ultimately on strategies for scaling up of OFSP to improve the nutritional status, livelihoods, and food security status of these vulnerable populations.

Limitations

Limitations include the lack of serum level data for assessment of vitamin A status of our participants. Although vitamin A consumption was computed from the Hellen Keller International guide which has been validated against acceptable standards, it is still possible underestimation of vitamin A consumption may have occurred based on the vulnerable population of women and the local environment. In addition, responses to the questionnaire could have been prone to both recall and social desirability bias. Finally, food practices/patterns could be unique to the post conflict situation of the rural areas of Uganda. Results may not be generalizable to populations in other regions or urban areas of Uganda.

Conclusion

We found that the study population was considered to be at high risk for VAD. Knowledge of vitamin A rich foods was an inverse and significant predictor of vitamin A rich food consumption among women, suggesting other barriers to uptake of these foods. Components of food insecurity such as availability, affordability, utilization, and changing food preferences may contribute to the unexpected inverse relationship between knowledge and consumption of Vitamin A rich foods. Scaling up biofortified food initiatives, including OFSP, can improve consumption of vitamin A rich foods with effective strategies to comprehensively address consumption barriers such as lack of nutrition education, cooking skills, and storage facilities, as well as low production levels and perceived contamination of biofortified foods. The results of the study suggest that food-based interventions addressing vitamin A rich food consumption through scaling up of biofortified foods, such as orange-fleshed sweet potatoes, consider opportunities to address the broad range of consumption barriers that persist despite gains in nutrition knowledge.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The study involving human participants was reviewed and approved by the Makerere University School of Health Sciences Institutional Review Board and received a waiver from the University of Massachusetts Amherst subject protection committee. Written informed consent from the participants' legal guardian/next of kin was not required to participate in

this study in accordance with the national legislation and the institutional requirements.

Author contributions

JN and LC drafted the manuscript. JN, LC, LS, FG, NK, and SH contributed to the conception of the study. FG, NK, and SH collected the data and were responsible for data preparation. LC, LS, EM, and FG reviewed the manuscript and critically revised it for important content. SH assisted with additional research resources. All authors read and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.880166/full#supplementary-material

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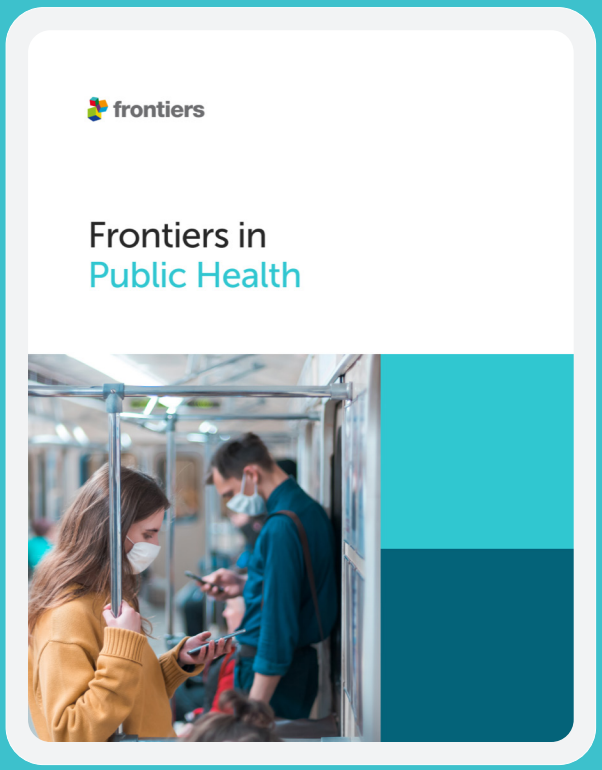

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