Journal of Agriculture and Food Research 14 (2023) 100728

Contents lists available at ScienceDirect

Journal of Agriculture and Food Research

journal homepage: www.sciencedirect.com/journal/journal-of-agriculture-and-food-research

Urban households' food safety knowledge and behaviour: Choice of food markets and cooking practices

Makafui I. Dzudzor [a,*], Nicolas Gerber [b]

[a] Centre for Development Research (ZEF), University of Bonn, Genscherallee 3, D-53113, Bonn, Germany
[b] Institute for Food and Resource Economics (ILR), University of Bonn, Nussallee 19, D-53115, Bonn, Germany

ARTICLE INFO

Keywords:
Food safety
Food market
Urban households
Knowledge
Cooking behavior

ABSTRACT

Food safety is a public health issue and a shared responsibility of everyone. Traditional food markets can be high-risk locations for the spread of foodborne diseases, especially in developing countries. The focus has been to improve institutional food handlers' food safety knowledge and behaviour. However, the household is the last barrier to preventing the transmission of foodborne diseases. Households' knowledge and proper behaviour towards food safety in the home can improve their protection against foodborne diseases. Using household data from the NOURICITY project on urban households in Ghana, the study sought to answer the primary research questions, including; the main factors that influence urban households' choice of food markets and the effect of household food safety knowledge and wealth status on food safety cooking practices/behaviour. Structural Equation Modelling (SEM) was applied to address these questions. The study results show that convenience (proximity and availability of all products at one location) is the primary consideration for choosing a food market, not food safety. Only 18% of respondents considered food safety one of their topmost priorities in choosing a market. In addition, although households are food safety knowledgeable and have a positive attitude towards food safety, neither food safety knowledge nor attitude has a statistically significant effect on food safety cooking practices/behaviour. However, household wealth status positively affects food safety cooking practices/behaviour. We conclude that households' food safety cooking behaviour may improve when in addition to appropriate food safety knowledge, households are economically better off.

1. Introduction

Food safety is fundamental to food and nutrition security and health [1]. Unsafe food has the potential to create a vicious cycle of food and nutrition insecurity, malnutrition and poor health [1]. Food safety issues can affect everybody and are of concern at every stage of the food system [2,3]. Food safety is the assurance that food prepared or consumed by an individual for an intended purpose will not cause harm or adverse health effects [4]. Unsafe foods can result from various microbial and chemical contaminants [2,5–7]. Food safety is a collective and shared responsibility of all stakeholders [1,8]. The consequences of unsafe food are enormous, especially in developing countries. Foodborne diseases caused by food contaminants cause productivity loss of about US$ 95.2 billion annually in low- and middle-income countries. Sub-Saharan Africa accounts for about US$16.7 billion of this total productivity loss [9]. Moreover, children bear the brunt of foodborne diseases. Children under five years account for about 40% of the global burden of foodborne diseases, primarily found in low- and middle-income countries [10].

The importance of food safety as a public health and socioeconomic issue must be considered, especially in developing countries like Ghana. For example, institutional catering (restaurants, food vendors, "chop bars", and schools) are a significant source of food safety concerns in Ghana [11]. For example, the Ghanaian Food and Drugs Authority (FDA) shut down restaurants and local food outlets because consumers experienced symptoms of foodborne diseases, and investigations revealed poor sanitation, poor food handling practices and heavy microbial load (pathogens) in the food sold by these eateries [12,13]. Furthermore, urban households are exposed to high risks of foodborne disease transmission because most urban households rely on traditional open-air markets to meet their food consumption needs: traditional open-air markets are prone to unsanitary and unhygienic conditions, which are fertile grounds for the spread of foodborne pathogens [14–16].

The home is the final barrier to preventing and transmitting

* Corresponding author.
E-mail address: mdzudzor@uni-bonn.de (M.I. Dzudzor).

https://doi.org/10.1016/j.jafr.2023.100728
Received 26 February 2023; Received in revised form 6 July 2023; Accepted 3 August 2023
Available online 6 August 2023

foodborne diseases [17] but can also be an avenue for the spread of food pathogens and foodborne diseases [18]. Therefore, proper food handling in the home is critical to preventing foodborne diseases [19], and food handlers are essential in implementing safe and hygienic cooking practices in the home [20]. However, home food handlers still grapple with their role in ensuring food safety at home [20]. Moreover, food safety concerns like chemical contamination of food are generally beyond the capacity and ability of the home food handler to address. Notwithstanding some of these hidden food safety hazards confronting households, proper personal hygiene and household water, sanitation and hygiene (WASH) behaviour can prevent many foodborne diseases [21]. So, households are urged to eat healthier and safer home-cooked meals instead of food away from home [22,23]. Inherent in this statement is that the food handler in the home is knowledgeable in food safety and healthy food preparation and has the tools and the environment to act according to their knowledge.

However, the literature on food-related knowledge translating into appropriate food behaviour change is mixed [17,24–26]. Campbell et al. [27] showed that maternal knowledge of food safety and healthy diets in the home environment influences children's food behaviour. Tabbakh and Freeland-Graves [28] showed a positive relationship between a mother's nutritional knowledge and the diet of her adolescent child. Men's nutritional knowledge can also improve the nutritional status of households [29,30]. However, knowledge does not necessarily translate into appropriate behaviour [24,31,32]. For example, a food handler with proper food safety knowledge only sometimes translates this knowledge into appropriate food safety practices [33]. Nevertheless, the lack of food safety knowledge is a significant barrier to food safety practices [34]. Therefore, the effect of food safety and nutrition knowledge on behaviour is a necessary but insufficient factor in positive food safety and nutrition behavioural change [35].

Reviewing the existing literature on household food safety behaviour shows a paucity of empirical evidence on food safety knowledge, attitude, and practice (KAP) in Ghanaian urban homes. The focus has been on institutional food handlers like restaurants, food outlets, and food sellers and vendors [36,37]. Thus, this paper aims to explore the knowledge level of household food handlers on safe foods; and the effect of food safety and nutrition knowledge in determining households' food purchases and food safety cooking behaviour. We hypothesise that households with the appropriate food safety knowledge will always practice food safety cooking behaviour. The study answers the questions: What are the main factors that influence urban households' choice of a food market; does food safety knowledge affect cooking behaviour, and what is the moderating effect of household wealth status on food safety behaviour? Our study is unique because, to the best of our knowledge, there is currently a need to study Ghanaian urban household food safety knowledge and cooking practices using the methods applied in this study.

2. Material and methods

2.1. Conceptual framework

Different theories and models explain behaviour and behaviour change [38–41]. These theories have shaped our understanding of the factors influencing behaviour change [40]. For example, according to Ajzen's [41] theory of planned behaviour, behavioural intention is the immediate predictor of actual behaviour change. A person's intention is the individual's effort to undertake a behaviour. Also, behavioural intention is influenced by an individual's attitude, subjective norm, and perceived behavioural control. These factors are further shaped by the normative beliefs, motivation and evaluation of outcomes by the individual [41].

Additionally, internal (knowledge, skill and individual abilities and characteristics) and external (resources, money, time, equipment and legal barriers) factors can interfere with the actualisation of behaviour [42]. Therefore, for example, households will have a firm intention to purchase food from a hygienic food environment and practice food safety cooking practices at home when they have a positive attitude towards that behaviour, how much social pressures they feel to perform that behaviour (subjective norms) and the belief that they can practice these behaviours comfortably. Therefore, according to Ajzen [42], knowledge (correct factual information) does not directly influence actual behaviour, but rather knowledge influences beliefs which intend influences attitude, subjective norm and perceived behavioural control. However, from the social cognitive theory by Bandura [40], knowledge creates a precondition for change. A person with appropriate knowledge and essential skills is positioned to successfully perform a behaviour because of a high self-efficacy (confidence) in his or her ability [40]. Therefore, knowledge is just one factor that influences behaviour [35,43]. However, it is a critical factor in the formation of behaviour. Other factors (moderators) affect the strength of the relationship, whiles others (mediators) explain the mechanisms through which knowledge and behaviour are related [44,45].

We present the conceptual framework in Fig. 1. Knowledge can either directly affect food behaviour or indirectly affect food behaviour through the food attitude of the household [46]. Internal and external factors in our study, like the food handler's personal and household characteristics, source of information (government and private sources), and educational level, influence their knowledge. Subsequently, the relevant acquired food knowledge may indirectly influence food behaviour through the attitude of household members towards food safety and healthy diets. The household with appropriate knowledge and skills will then have to overcome barriers like the cost of foodstuffs, kitchen space, cooking utensils and fuels to perform food safety cooking practices and prepare healthy meals.

We analyse the relationship between food safety knowledge, food safety cooking behaviour, and source of food purchases in urban areas. We assume that households with the requisite food safety knowledge will purchase food from markets or places that meet their food safety standards. Also, the household has the requisite cooking tools and cooking area to translate the food safety cooking knowledge into appropriate cooking behaviour. However, the lack of cooking tools and the cooking area may prevent households from observing appropriate cooking behaviour.

2.2. Study area

The study area is Ghana, located in West Africa: the study sites are located in three cities in Ghana-Accra, Kumasi and Tamale, in the southern, middle and northern parts of Ghana, respectively (Fig. 2). According to Ghana's 2010 Population and Housing Census (PHC), these cities are the biggest in the southern, middle and northern parts of Ghana based on the population size of the cities. They have large food markets integral to the county's food system. The three study sites provide a national picture of the urban food system investigated from different geographic and socioeconomic perspectives. We provide further details on these unique cities surveyed in this study.

2.2.1. Accra metropolis

The Accra Metropolitan Assembly (AMA) is in southern Ghana. According to the 2010 PHC, the metropolis makes up about 42% of the total population of the Greater Accra Region. The entire metropolis is urban. However, there are variations in the socioeconomic status of the people. There are about 450,748 households in the metropolis. About 47% of the population are migrants. The informal private sector is the largest employer, with about 48% of the inhabitants self-employed. The city is the economic hub of the country; and has some of the largest food markets, namely Makola and Agbogbloshie markets. The AMA has three sub-metros: Ablekuma South, Ashiedu Keteke and Okaikoi South [47].

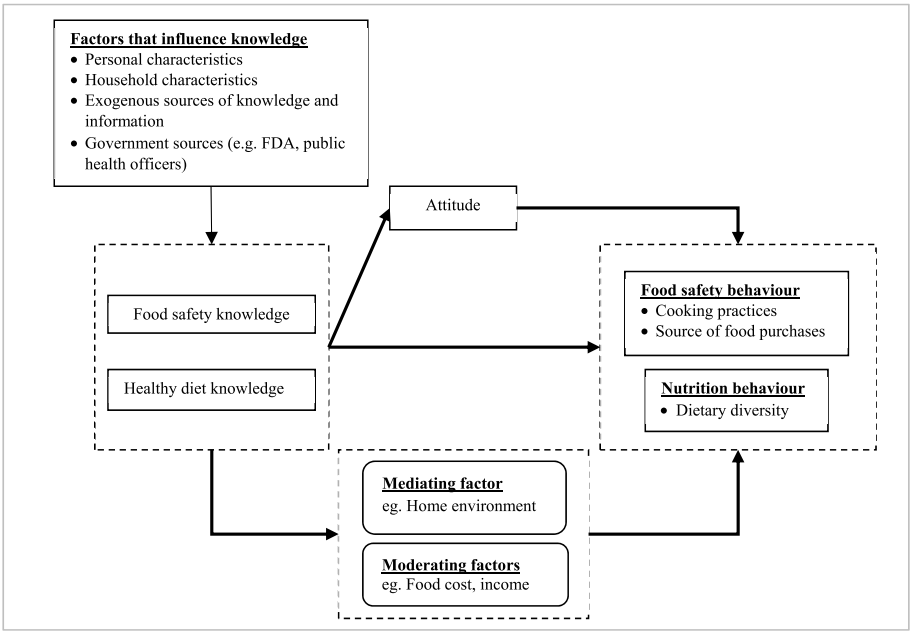

Fig. 1. Conceptual framework of the effect of food safety and nutrition knowledge on behaviour.

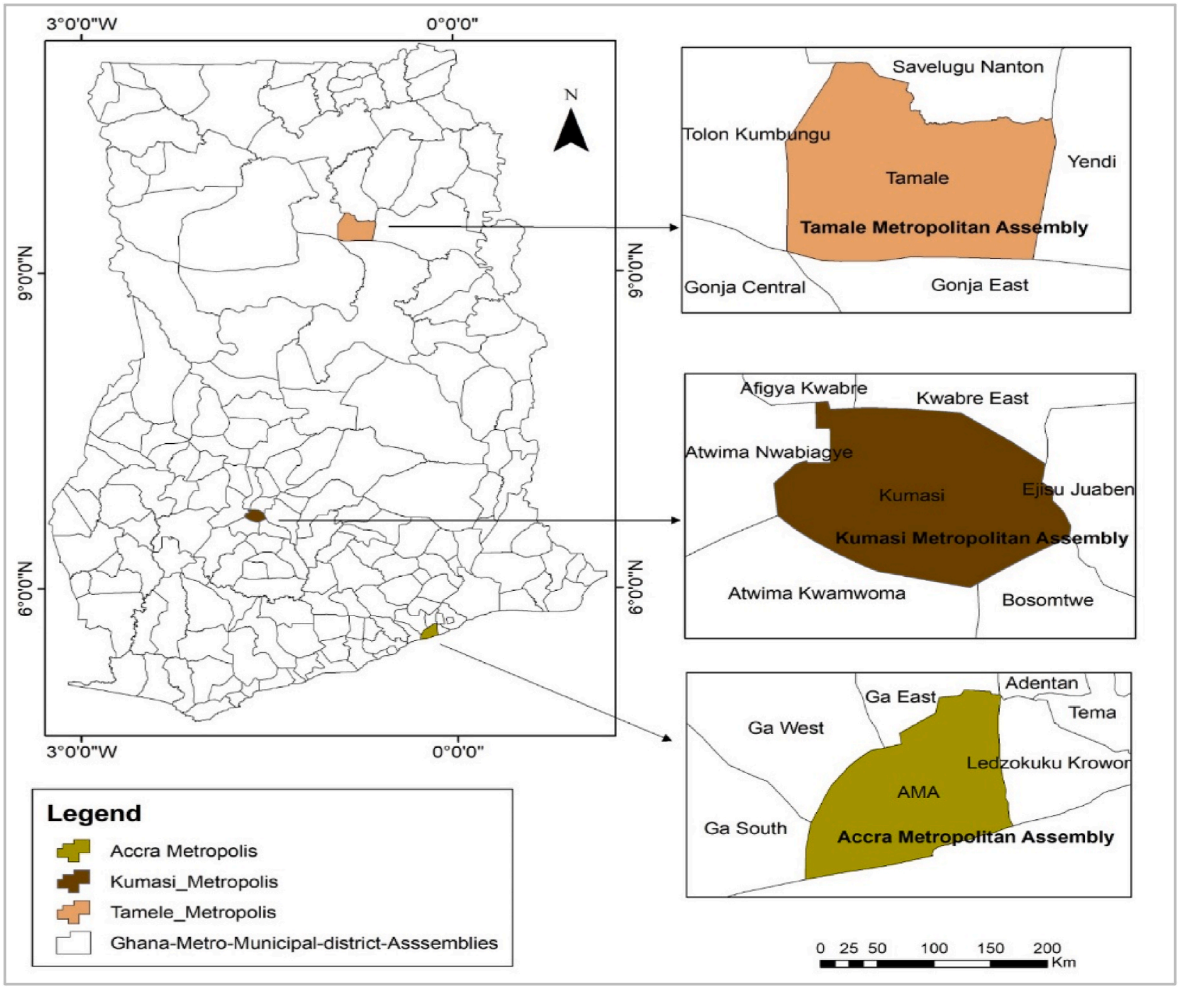

Fig. 2. A map of Ghana showing the study sites.

2.2.2. Kumasi metropolis

The Kumasi Metropolitan Assembly (KMA) is in the middle of Ghana. According to the 2010 PHC, the metropolis makes up about 36% of the total population of the Ashanti Region and has about 440,283 households. The city is a vibrant commercial centre. Strategically positioned to link the north and the south of the country. The Kejetia central market is the largest open-space food market in West Africa, and the food section is one of the largest in Ghana. The city's food system and the rural food system of neighbouring districts are closely linked. Food prices in the city are lower compared to other cities in the country [47].

2.2.3. Tamale metropolis

The Tamale Metropolitan Assembly (TaMA) is in northern Ghana. According to the 2010 PHC, it accommodates about 9.4% of the Northern Region's population. About 80% of the metropolis is urban. The total number of households in the city is 219,971. The metropolis is the centre of economic activity in the Northern Region and other regions in northern Ghana. This city is unique because of its geographical location and the socio-cultural and economic status of the people. Food systems in the metropolis are linked to other national and international food systems and the rural food system. The nature and type of food consumed vary from those eaten in the middle and southern parts of the country [47].

2.3. Survey data and sampling design

2.3.1. Survey data and questionnaire

The data used in this study is part of the more extensive data collected under the NOURICITY project in Ghana. The NOURICITY project is a European Union Horizon 2020 research and innovation program-funded project. The NOURICITY project studied the urban food systems in Ghana, South Africa and Uganda. The project ran from 2018 to 2022. We conducted different research activities in Ghana, including stakeholder workshops, market and household surveys, and microbial food analysis. We used in this paper the first of four rounds of household survey data collected under the NOURICITY project. We collected the first round of household data in November–December 2019. The study relied on the first round of the household survey because; we did not introduce any interventions between survey rounds targeted at changing the households' food safety knowledge, attitude and practices (KAP), which are the key variables of interest in this study.

We administered a structured questionnaire to sampled households. We trained data collectors in administering the questionnaires. As part of the training, we trained the data collectors in administering the questionnaire in the local language. Technical and key terms were agreed upon during the training to ensure consistent communication with the respondents. After the training, we pre-tested the questionnaire to ensure all questions were phrased concisely and appropriately to capture the needed information. The comments and feedback from the pre-testing were discussed and appropriately incorporated into the final version of the questionnaire.

The questionnaire administered to households had sections on the household roaster and demographics, food purchasing behaviour, food safety and nutrition KAP, food security indicators, the health status of household members, household income and expenditure module, access to public amenities and housing characteristics. We based the section of the questionnaire on food safety and nutrition KAP on the "World Health Organisation's (WHO) five keys to safer food" [19]. The WHO's five keys to safer food is a manual used to evaluate food handlers' knowledge, attitude and behaviour towards their cooking practices. The core themes of the five keys to safer food are: keep clean; separate raw and cooked; cook thoroughly; keep food at safe temperatures; and use safe water and raw materials. These five themes comprise eleven "true", "false", and "don't know" questions that assess food safety knowledge. In addition, there are ten "agree", "not sure", and "disagree" statements that tested food safety attitudes. Finally, there are ten "always", "most times", "sometimes", "not often", and "never" statements that assessed food safety self-reported behaviour [19].

2.3.2. Household survey sampling design

The NOURICITY project used a multistage sampling technique in the sampling of households. A three-stage sampling procedure was applied. The first stage was purposive, and the subsequent two stages were randomisations. In the first stage, we selected the three largest cities in the south, middle and north of Ghana based on the 2010 Population and Housing Census (PHC). The choice of these study sites was because; of the presence of major food markets, level of development and urbanisation, food socialisation behaviour, socioeconomic characteristics and agroecological characteristics. The three study sites provide a national picture of the urban food system in large and main cities in Ghana. The consideration is to have a geographically evenly distributed sample. The second stage of sampling was randomisation at the level of the Enumeration Area (EA). The EAs are the lowest geographical units demarcated by the Ghana Statistical Service (GSS) for national population census purposes. The Ghana Statistical Service (GSS) performed the randomisation at the EA level. Based on our budget and geographical representation, the GSS randomly selected the total number of EAs we requested in the various study sites based on the 2010 PHC.

The third stage of randomisation was at the household level within each EA. Within each EA, data collectors did random walks to the households. They started from the EA base, the major landmark within the EA, and moved in four opposite directions to sample the households. Where the houses are densely populated, we sampled after every 10th house. In Accra and Tamale, we sampled 18 households from each EA, whiles in Kumasi, we sampled 12 households each. The total sample collected was 672 households from 44 EAs. However, after data cleaning and management, 609 responses had complete data for analysis. Table 1 presents the distribution of households sampled.

3. Data analysis and empirical strategy

3.1. Measurement of key variables

Food safety cooking behaviour is the primary outcome variable of interest. Food safety cooking behaviour is computed using respondents' responses to 10 statements on their food safety behaviour contained in the WHO's "five keys to safer foods" [19]. Respondents indicate whether they "always", "most times", "sometimes", "not often", and "never" practice the stated behaviours. So, household food safety behaviour was computed as the sum of all the "always" responses per household. The higher the aggregated number, the better the implementation of appropriate food safety cooking behaviour of the household according to WHO standards.

The explanatory variables used in this study include; household knowledge and attitude towards food safety, household nutrition knowledge, source of food safety information, household wealth index, and household characteristics. Food safety and nutrition knowledge are computed based on the summation of correct answers to standard WHO

Table 1
Number of households sampled.

Region	City	Sub-metro/ district	Number of EAs sampled	Number of households sampled	Completed number of household interviews
Greater Accra	Accra	Ashiedu-keteke	12	216	175
Ashanti	Kumasi	Manhyia & Subin	20	240	218
Northern	Tamale	Tamale	12	216	216
			44	**672**	**609**

Source: NOURICITY project survey, 2020

questions on household food safety and nutrition. Using principal component analysis (PCA), households' wealth index (a proxy for income) is computed based on households' assets.

3.2. Estimation strategy

We applied Structural Equation Models (SEM) to address the questions on the effect of household food safety knowledge and attitude on food cooking practices/behaviour. Food safety knowledge, attitude and behaviour (KAP) are treated as latent variables [48]. Therefore, to measure the latent variables, a set of indicators that best explain various components of the latent variables are measured. In addition, the complex interactions between knowledge, attitude and behaviour make them interdependent and bidirectional. SEM is appropriate to address these peculiarities. A system of equations is required to establish the relationship between food safety knowledge and food cooking behaviour [49]. A measurement model of the relationship between each indicator and knowledge, attitude and behaviour was built. We then combined the measurement models of these latent variables to establish their relationship while controlling for measurement errors in the observable indicators [49].

The indicators of each latent variable (knowledge, attitude and behaviour) are the observable attributes that constitute knowledge and the respondent's responses to a set of questions showing their attitude towards food safety (positive or not). The respondent's behaviour is based on self-reported confirmation of their activities before, during and after food preparation and where the household purchases food for cooking. The indicator variables (Xs) of each latent variable used in the study are in Table 9. The complex interaction of the various variables and their bidirectional nature leads to endogeneity and measurement error challenges. In our conceptual framework, we assume that multiple factors measure multiple variables, and the factors can be correlated and have feedback loops. This results in non-recursive models [50]. Moderators are also incorporated into the knowledge-behaviour models to analyse the pathways through which knowledge-behaviour models interact.

We performed three activities to build the SEM for our study: exploratory factor analysis (EFA), confirmatory factor analysis (CFA), and run SEM. We used STATA 15.1 to perform all the analyses. The EFA extracted the items/questions used to construct the latent variables of food safety knowledge, food safety attitude, food safety cooking practices/behaviour and healthy diet knowledge. The extracted factors are based on eigenvalues greater than (>) 1 using the principal factor method (pf), the communality values greater than (>) 3 and factor loadings of scale items greater than (>) 0.4. In addition, we conducted the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, Bartlett's test of sphericity and Cronbach alpha test to test the appropriateness of the items used to reflect the latent variables [51–53].

After conducting the EFA to select the appropriate items, we performed a CFA to confirm the relationship among the variables of interest based on the study's conceptual framework. After this, we ran the SEM model to find the model that best fits the theory and data of the study. After running a SEM model, we performed a goodness of fit test based on some indices to determine the appropriateness of the model for its intended purpose. The recommended cut-off levels for the goodness of fit indices [54–56] include; the Root Mean Squared Error of Approximation (RMSEA) and Standardised Root Mean Squared Residual (SRMR) values less than (<) 0.08 and Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) greater than (>) 0.9. Models that meet these thresholds are close fit models and suitable for their intended purpose.

As presented in Fig. 3, the study extends this basic model to include all the outcome variables of interest and the moderating indicators. The study specifies three models to explain the relationship between food safety knowledge, attitude, healthy diet knowledge, and food safety cooking behaviour.

4. Results and discussion

4.1. Household demographic and socioeconomic characteristics of respondents

Table 2 presents summary statistics of all households that completed the household survey (N=609). About 52% of households are male-headed. Accra (38.9%) and Kumasi (38.1%) have a relatively lower number of male-headed households. The average age of a household head is 47 years, with Accra (44 years) having the average youngest household head compared to 51 years for household heads in Tamale. Unmarried (single) household heads constitute a relatively significant component of the sampled households in Accra and Kumasi. About 19 and 21% of household heads are unmarried in Accra and Kumasi. Out of this number, a disproportionate number are female. In Accra and Kumasi, 88 and 82% of unmarried household heads are female.

The average household size is 3.9. Tamale has the highest number of household members, 5.0, compared to 3.4 and 3.3 for Accra and Kumasi, respectively. The average Household Dietary Diversity Score (HDDS) is 7.05. Dietary diversity across cities is similar; the observed differences are not statistically significant. However, we observe statistically significant differences among households' food expenditure per capita. Households in Accra (GHS 254.69) and Tamale (GHS78.07) spend the highest and lowest on food per capita, respectively. The average household is in the middle wealth index (3.06). On average, households in Kumasi (3.4) have a higher wealth index than households in Tamale

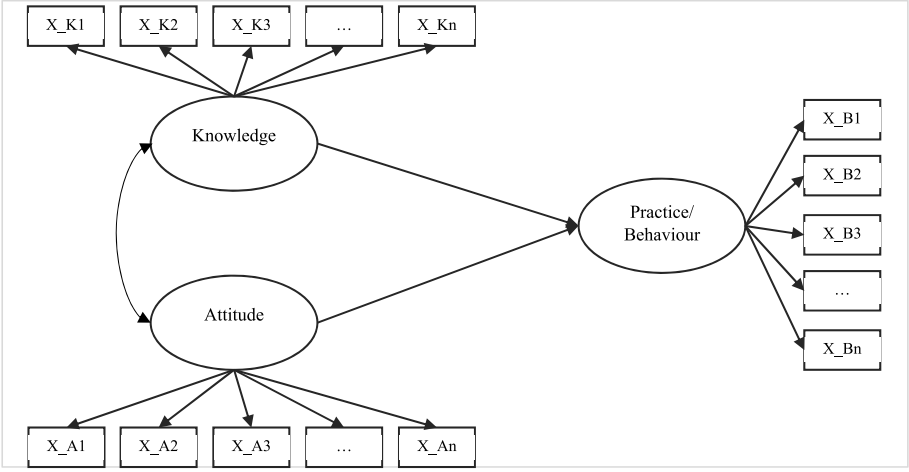

Fig. 3. Basic model of food safety knowledge, attitude and practice.

Table 2
Household demographic and socioeconomic characteristics.

Variable	Accra	Kumasi	Tamale	Total	*P-value*
Household head characteristics					
Male headed households (%)	38.86	38.07	84.26	52.08	0.0000***
Age (mean)	44.191	45.873	51.174	47.270	0.0000***
Education (%)					0.000***
None	7.43	13.76	41.67	21.84	
Primary	15.43	9.63	1.85	8.54	
Secondary	72.00	68.35	36.11	57.96	
Tertiary	5.14	8.26	20.37	11.66	
Read &write in English (%)	69.14	63.30	50.00	60.26	0.0003***
Marital status of household head (%)					0.000***
Single	18.86	20.64	3.24	13.96	
Monogamous	45.71	50.92	76.39	58.46	
Polygamous	0.00	0.00	10.19	3.61	
Divorced	13.14	6.88	2.31	7.06	
Widowed	16.00	14.68	6.94	12.32	
Separated	5.14	6.42	0.93	4.11	
Cohabitation	1.14	0.46	0.00	0.49	
N	*(175)*	*(218)*	*(216)*	*(609)*	
Gender of unmarried household head (female=1)	87.88	82.22	85.71	84.71	0.7943
N	*(33)*	*(45)*	*(7)*	*(85)*	
Other household characteristics					
Household size (mean)	3.377	3.335	4.968	3.926	0.0000***
Household Dietary Diversity Score (HDDS)	7.091	7.151	6.907	7.048	0.5174
Household food expenditure per capita (GHS)	254.685	209.006	78.071	175.692	0.0000***
Mean household wealth index (1=lowest; 5=highest)	2.783	3.358	2.995	3.064	0.0002***
Employment status of household head (%)	89.14	82.11	82.87	84.40	0.1203
Mean percent of household members employed	51.314	47.448	41.224	46.351	0.0017***
Households living in compound houses (%)	73.14	60.55	69.91	67.49	0.0191**
N	*(175)*	*(218)*	*(216)*	*(609)*	

+ANOVA conducted across study sites. *** p<0.01, ** p<0.05, * p<0.1.

(3.0) and Accra (2.8). Compound houses are the most common type of dwelling for households. About 67% of the total sample live in compound houses. The average percent of household members employed is less than 50%.

In summary, household characteristics vary across cities except for HDDS, employment status of household heads and the proportion of unmarried female household heads. Further, households in Tamale have the most male-headed households, oldest household heads, largest household sizes, and lowest number of single (unmarried) household heads. The above household characteristics are mainly in tandem with the latest round of the nationally representative survey of the Ghana Living Standards Survey 7 (GLSS 7), conducted in 2017. According to the GLSS 7 report [57], the national average household size is 3.8, with urban areas having an average household size of 3.5. The national mean age of a household head is 44.2 years, and about 45.6 years in Accra. In addition, nationally, about 57.3% of households live in compound houses, and 37.2% of households in urban areas live in rented dwellings [57].

4.2. Source of food purchases and food safety concerns by urban households

The source of food purchases is an essential component of a household's food decision-making. From Table 3, convenience is the principal reason for the choice of market for food purchases among sampled households. Convenience in terms of proximity to the market and the availability of all products at one location. About 66 and 58% of households considered the distance to the market and availability of all products at one location among their top three considerations when choosing the market to purchase food items. Table 4 shows that out of the options provided, 50 and 19% of households selected distance to the market and availability of all products at one location, respectively as their main reason for choice of market. The results show that transaction cost considerations are of high importance to households. Households in urban areas adopt time-saving mechanisms to deal with the growing opportunity cost of time. They cut back on time allocated to domestic activities, including food preparation and shopping, and channel the time saved into other economic activities. They optimise their interactions with the food environment by choosing accessibility (short distance to market) and convenience (brevity of time) [58].

Tables 3 and 4 also show that food safety concerns were low among the considerations of respondents. Many households need to be made aware of the primary state institution in charge of championing food safety. Less than 50% of households are aware of the Food and Drugs Authority (FDA), the primary state institution to champion food safety issues in Ghana. Further, only 18% of households considered food safety among their top three considerations for the choice of market (Table 3). Only 2% of households had food safety concerns as their topmost consideration in selecting a food market (Table 4). The relatively lower consideration for food safety in the choice of market is not necessarily a lack of care for safe food. The social construct around food and cooking in Ghana may explain this observation. Consumers who have had positive previous experiences with a retailer and have developed a trustworthy relationship may continue to purchase food items from that retailer, irrespective of the current food safety status of the retailer [36]. Consumers may continue to patronise a particular food retailer provided there are no immediate adverse effects from consuming food from that source.

Open-air markets are still the main markets patronised by households in cities. The main market in the city/community, which are open-air markets, remains the preferred choice for food purchases. In Table 5, about 59 and 31% of households sourced food items from the community's main and satellite markets, respectively. This finding is consistent with Hannah et al. [59], who found that open-air markets are the preferred option for urban households in eighteen cities in Kenya and Zambia because open-air markets meet households' expectations

Table 3
Choice of food market and awareness of FDA.

	Accra	Kumasi	Tamale	Total	*P-value*
% of households' who consider …. as 1 of their top 3 considerations for choice of market					
Convenience (short distance to market)	70.86	67.43	60.19	65.85	0.0716*
Convenience (all products at one place)	58.86	54.59	60.65	57.96	0.4252
Safety standards/good quality products	15.43	15.14	22.22	17.73	0.0992*
% of households aware of Food and drugs authority (FDA)	49.71	54.59	26.39	43.32	0.0000***
% of households that have received any form of education from FDA	15.43	26.61	9.72	17.41	0.0000***
N	175	218	216	609	

+ANOVA conducted across study sites. *** p<0.01, ** p<0.05, * p<0.1.

Table 4
Households' main reason for choice of market for purchase of food items.

Main reason for choice of type of market for shopping	N	%
Overall sample		
Convenience (short distance from my house)	303	49.75
Convenience (all products at one place)	115	18.88
Lower price of products	103	16.91
The products are fresh	44	7.22
Can buy in bulk	19	3.12
Safety standards/quality of product	14	2.30
Others (social construct, buy product on credit, culture/tradition)	11	1.82
Total	**609**	**100.00**
Accra		
Convenience (short distance from my house)	93	53.14
Lower price of products	29	16.57
Convenience (all products at one place)	27	15.43
The products are fresh	14	8.00
Safety standards/quality of product	7	4.00
Social construct	3	1.72
Others (buy in bulk, culture/tradition)	2	1.14
Total	**175**	**100.00**
Kumasi		
Convenience (short distance from my house)	115	52.75
Lower price of products	41	18.81
Convenience (all products at one place)	34	15.60
The products are fresh	17	7.80
Can buy in bulk	7	3.21
Safety standards/quality of product	3	1.37
Others (culture/tradition)	1	0.46
Total	**218**	**100.00**
Tamale		
Convenience (short distance from my house)	95	43.98
Convenience (all products at one place)	54	25.00
Lower price of products	33	15.28
The products are fresh	13	6.02
Can buy in bulk	11	5.09
Safety standards/quality of product	4	1.85
Others (buy products on credit, culture/tradition, social construct)	6	2.78
Total	**216**	**100.00**

Table 5
Where households mostly purchase food items.

Where respondents mostly purchase food items	N	%
Overall		
Main market in the city/community	361	59.28
Daily market (satellite market)	186	30.54
Periodic markets	34	5.58
Sidewalk	20	3.28
Supermarkets	6	0.99
Others	2	0.33
Total	609	100
Accra		
Main market in the city/community	93	53.14
Daily market (satellite market)	68	38.86
Periodic markets	8	4.57
Sidewalk	6	3.43
Total	175	100
Kumasi		
Main market in the city/community	111	50.92
Daily market (satellite market)	84	38.53
Periodic markets	10	4.59
Sidewalk	9	4.13
Supermarkets	4	1.83
Total	218	100
Tamale		
Main market in the city/community	157	72.69
Daily market (satellite market)	34	15.74
Periodic markets	16	7.41
Supermarkets	5	2.31
Sidewalk	2	0.93
Others	2	0.93
Total	216	100

regarding dietary preference, convenience, accessibility and prices of foodstuffs.

On the other hand, our findings show that about 1% of households sourced their food items from supermarkets. Supermarket shopping for food products, especially fresh fruits and vegetables, and some local food commodities still need to be higher among respondents in urban areas. Despite the growth in the supermarket sector in Ghana [60], we may attribute households' very low patronage of supermarkets to the uniqueness of the study areas, which are close to major traditional open-air markets. In places where open-air markets and supermarkets are nearby, consumers patronise open-air markets because of lower prices, fresher products and convenience [59,61]. In addition, unlike open-air markets, supermarkets are associated with food safety because of the implementation of quality and safety standards throughout the supply chain [62]. However, supermarkets sell more processed foods from the start of operations than fresh fruits and vegetables [63], especially local and indigenous varieties. So major traditional markets, compared to supermarkets, are more convenient (proximity and all products at one location) for households to get their domestic fresh fruits and vegetables and processed food items from other retail shops in the market.

4.3. Household food safety knowledge and information

The results presented in Table 6 show that households' average score on food safety knowledge is 60.9%. Households in Tamale (61.5%) had the highest score on food safety knowledge. However, differences in food safety knowledge across study sites are not statistically significant. Food handlers performed better on some questions than others (Table A1). Over 90% of respondents know it is essential to wash hands before handling food, cooked food should be kept very hot before serving and wash fruit and vegetables before use. Although 83% of food handlers know that raw food needs to be stored separately from cooked food, only 17% of them know that it is a false statement that the same cutting board can be used for raw and cooked foods provided it looks clean. Although over 96% of food handlers know it is essential to wash fruit and vegetables before use, only 20% of them know that safe water cannot be identified by how it looks. Also, only 21% of food handlers know that cooked meat cannot be left at room temperature overnight to cool before refrigerating.

Regarding food handlers' attitudes, about 75.5% of households had a positive attitude towards or agreed with the food safety guidelines presented to them (Table 6). However, food handlers have different attitudes towards safe food handling activities and general hygiene (Table A2). Over 90% of food handlers have a positive attitude towards keeping kitchen surfaces clean to reduce the risk of illness and inspecting food for freshness and wholesomeness. However, only 31% of food handlers have a positive attitude towards meat thermometers as useful kitchen gadgets for ensuring food is cooked thoroughly.

Regarding food handlers cooking practices, only 53% of households

Table 6
Food safety knowledge, attitude and self-reported behaviour.

Food safety knowledge, attitude and behaviour	Accra	Kumasi	Tamale	Total	P-value
Average accurate percentage score	61.14	60.13	61.53	60.92	0.5020
% of positive attitude towards food safety guidelines	73.0	78.2	75.0	75.5	0.0144**
% of practiced food safety behaviour always	47.14	55.64	55.05	53.00	0.0045***
Healthy diets knowledge (mean)	16.97	17.94	18.75	17.95	0.0000***
N	175	218	216	609	

+ANOVA conducted across study sites. *** p<0.01, ** p<0.05, * p<0.1.

practised all the safety guidelines provided "always" (Table 6). Food handlers practised more activities than others (Table A3). Most maintain general hygienic conditions in their cooking spaces: they constantly wash their hands before and during food preparation (78.8%) and wash fruit and vegetables with safe water before eating (79.2%). The least practised safe food handling activities are thawing frozen food in the refrigerator or other cool place (31.2%), using separate utensils and cutting boards when preparing raw and cooked food (36.1%) and storing any left-over food in a cool place within 2 hours after cooking (36.3%). Based on the WHO's five keys to a healthy diet [64], respondents also scored an average of 18 out of 20 on their knowledge of healthy diets. Respondents in Accra had the lowest average mark of 17 out of 20. Regarding healthy diet knowledge (Table A4), food handlers knew about the potentially harmful effects of consuming high amounts of fats, oils, sugar and salts.

The results clearly show that households are knowledgeable about food safety and healthy diets and have a positive attitude towards food safety. However, fewer households practice food safety cooking activities always. These findings are consistent with the results of Makhunga et al. [65]. Using the WHO's five keys to safer food, the authors found that food handlers in the eThekwini District in South Africa had good knowledge, positive attitude and acceptable behaviour towards safe food handling. However, unlike our findings, household food handlers in Bangladesh showed insufficient food safety knowledge and handling practices [66]. Also, Langiano et al. [18] observed that respondents in Cassino, Italy had insufficient food safety knowledge on the transmission of foodborne diseases and pathogens.

The home environment is the primary source of food safety information. Many household food handlers acquired food safety information from their mothers/guardian and relatives (Table 7). Mother/guardian and other relatives account for about 63% of responses as a source of food safety information. The home is still an important place for food socialisation. The home can serve as a platform to introduce food safety conversations that can improve knowledge and behaviours. Our finding on the source of food safety information is similar to that of Marklinder et al. [67]. The authors found that among sampled university students in Sweden, a majority (45%) of them had their food safety knowledge from family and friends.

4.4. SEM analysis

4.4.1. Exploratory factor analysis

We performed exploratory factor analysis (EFA) to identify the items that affect the structure of the latent variables (food safety knowledge, attitude and behaviour). Tables 8 and 9 present the sampling adequacy and reliability and the factor loadings of the items used in the EFA, respectively. The number of items (indicators) used to estimate the latent variables are 4 and 6 for food safety knowledge and attitude, and 8 and 12 for food safety cooking practice/behaviour and healthy diet knowledge, respectively. In Table 8, the KMO values are 0.54, 0.70, 0.79 and 0.74 for food safety knowledge, attitude, and behaviour, and healthy diet knowledge, respectively. The corresponding Cronbach's alpha values are 0.35, 0.62, 0.77 and 0.73, respectively. The overall KMO and Cronbach alpha values for the 30 items are 0.80 each. The KMO and Cronbach's alpha values are all within recommended levels for all the latent variables [51–53] except the Cronbach alpha value of 0.35 for food safety knowledge. In Table 9, the factor loadings of the items presented are above 0.4. For each latent variable, the average factor loading is above 0.5, indicating that convergent validity is present [68]. Thus, the items extracted from the EFA to the CFA to construct the model are appropriate.

Table 7
Sources of information on food safety.

Source of food safety information	% of responses
Mother/guardian	42.15
Other relatives	21.46
Friends	13.48
School	9.36
Media (mainstream/social)	7.21
Others (public health officer, social grouping, search internet, etc.)	6.34
Total	**100.00**

Table 8
Sampling adequacy (KMO) and internal consistency (Cronbach alpha).

Latent variables	Kaiser-Meyer-Olkin (KMO)	Bartlett's test of sphericity (p-value)	Cronbach's alpha	No. of questions/ items
Food safety knowledge	0.537	0.000	0.3534	4
Food safety attitude	0.696	0.000	0.6202	6
Food safety behaviour	0.789	0.000	0.7732	8
Nutrition knowledge	0.735	0.000	0.7277	12
Total[a]	0.799	0.000	0.8037	30

[a] All items (questions/statements) used to compute all latent variables.

4.4.2. Confirmatory factor analysis

After running the SEM model, we performed a goodness of fit test to determine the appropriateness of the model for its intended purpose. Our models' goodness of fit summary statistics shows acceptable results based on recommended cut-off levels [54–56]. The Root Mean Squared Error of Approximation (RMSEA) and Standardized Root Mean Squared Residual (SRMR) values are within recommended levels of less than 0.08 (Table 10). Specifically, RMSEA values are 0.08 and 0.05 for models 1 and 2, respectively. The SRMR values are 0.06 and 0.07 for models 1 and 2, respectively. The Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) are very close to the recommended levels of greater than (>) 0.9. Our models have CFIs values of 0.8 and 0.9 and TLI values of 0.8 each for models 1 and 2, respectively. Thus, the models are satisfactory for the data, and with RMSEA and SRMR values within acceptable limits, with caution, the models can be used for their intended purpose.

Table 11 shows the estimated standardised results of the models and their goodness of fit statistics. In model 1, we estimated the relationship among food safety KAP. The results indicate that food safety knowledge ($\beta1=0.595$, $p>0.05$) and attitude ($\beta1=0.220$, $p>0.05$) positively affect food safety cooking practices/behaviour. However, the effect is not statistically significant. In addition, food safety knowledge and attitude are positively correlated ($\beta1=0.902$, $p<0.05$), and this association is statistically significant. These findings are similar in part to Soon et al. [17], who found that the effect of food safety knowledge on food safety practices was negative and statistically not significant among consumers in Malaysia, but attitude had a positive and significant effect. Further, Akabanda et al. [37], showed that the food safety knowledge of food handlers in Ghana needed to correspond with their food safety practices. Mihalache et al. [68], observed the contrary. The authors observed that food safety knowledge and shopping attitude had a positive and statistically significant effect on kitchen practices among consumers in Romania [68].

In model 2, we include healthy diet knowledge in the food safety KAP model (model 1). The results show that food safety knowledge ($\beta1=0.648$, $p>0.05$), healthy diet knowledge ($\beta1=-0.311$, $p>0.05$) and food safety attitude ($\beta1=0.307$, $p>0.05$), do not have a statistically significant effect on households' food safety cooking practice/behaviour. However, a statistically significant positive correlation existed between food safety knowledge, attitude and healthy diet knowledge (Table 10).

In model 3, we include the household wealth status in the model as a moderating factor of knowledge and attitude on cooking practices/behaviour. Within the household, income is a significant moderator in

Table 9
EFA with factor loadings of items used in SEM.

Indicators (Xs)		Factor loading
Knowledge		
X_K1	Raw food needs to be stored separately from cooked food.	0.6092
X_K2	Proper cooking includes meat cooked to 40 °C.	0.4777
X_K3	Cooked meat can be left at room temperature overnight to cool before refrigerating.	0.6632
X_K4	Refrigerating food only slows bacterial growth.	0.5778
Attitude		
X_A1	Frequent hand-washing during food preparation is worth the extra time.	0.4961
X_A2	Keeping raw and cooked food separate helps to prevent illness.	0.7022
X_A3	Using different knives and cutting boards for raw and cooked foods is worth the extra effort.	0.4940
X_A4	Meat thermometers are useful for ensuring food is cooked thoroughly.	0.5682
X_A5	Thawing food in a cool place is safer.	0.5443
X_A6	I think it is unsafe to leave cooked food out of the refrigerator for more than 2 h.	0.5246
Self-reported behaviour		
X_B1	I wash my hands before and during food preparation.	0.6834
X_B2	I use separate utensils and cutting-boards when preparing raw and cooked food.	0.7131
X_B3	I separate raw and cooked food during storage.	0.7617
X_B4	I check that meats are cooked thoroughly by ensuring that the juices are clear or by using a thermometer.	0.5697
X_B5	I thaw frozen food in the refrigerator or other cool place.	0.5051
X_B6	After I have cooked a meal, I store any leftovers in a cool place within 2 h.	0.7574
X_B7	I check and throw away food beyond its expiry date.	0.6838
X_B8	I wash fruit and vegetables with safe water before eating them.	0.4592
Knowledge of Healthy diets		
1	It is better to use unsaturated vegetable oils (eg. Olive, soy, sunflower or corn oil) rather than animal fats or oils high in saturated fats (eg. Butter, ghee, lard, coconut and palm oil)	0.8264
2	White meat (eg. Poultry) and fish are better than red meat because they are lower in fat	0.7524
3	Eat only limited amounts of processed meats because these are high in fat and salt	0.4360
4	People who eat too much saturated fat and *trans*-fat are at higher risk of heart disease and stroke	0.6309
5	Choose fresh fruits instead of sweet snacks such as cookies, cakes and chocolate	0.6210
6	People who eat too much salt have a greater risk of high blood pressure which can increase their risk of heart disease and stroke	0.6071
7	People who eat too much sugar have a greater risk of becoming overweight or obese, and an increased risk of tooth decay.	0.7976
8	From birth to 6 months of age, feed babies exclusively with breast milk (i.e. give them no other food or drink), and feed them "on demand" (i.e. as often as they want, day and night)	0.8236
9	At 6 months of age, introduce a variety of safe and nutritious foods to complement breastfeeding, and continue to breastfeed until babies are 2 years of age or beyond	0.5784
10	Exclusively breastfed babies have better resistance against common childhood illnesses such as diarrhoea, respiratory infections and ear infections.	0.6035
11	Eat a wide variety of vegetables and fruits	0.7963
12	Avoid overcooking vegetables and fruit because this can lead to the loss of important vitamins	0.4526

the food environment. Compliance with appropriate food safety measures has cost implications for the household. The appropriate cooking space, cooking utensils and kitchen tools, safe water and foodstuff to cook; constrain the household's choice to practice appropriate food safety behaviour.

Table 10
Results of the paths of food safety knowledge, attitude and behaviour.

Pathway	Model 1		Model 2	
	Std. estimate	p-value	Std. estimate	p-value
Food safety Knowledge → Food safety behaviour	0.595	0.257	0.648	0.143
Food safety Attitude → Food safety behaviour	0.220	0.671	0.307	0.383
Knowledge of healthy diet → Food safety behaviour			−0.311	0.105
Food safety Knowledge ↔ Food safety Attitude	0.902	0.000	0.607	0.000
Food safety Knowledge ↔ Healthy diet knowledge			0.148	0.000
Healthy diet knowledge ↔ Food safety Attitude			0.310	0.000
Goodness of fit statistics				
RMSEA	0.075		0.054	
SRMR	0.060		0.066	
CFI	0.825		0.851	
TLI	0.782		0.825	
Observations	595		595	

Table 11
Household wealth status as a moderating factor in household food safety KAP model.

Pathway	Model 3	
	Std. estimate	p-value
Food safety Knowledge → Food safety behaviour	0.745	0.122
Food safety Attitude → Food safety behaviour	0.204	0.591
Knowledge of healthy diet → Food safety behaviour	−0.368	0.086
Knowledge of healthy diet → HDDS	0.039	0.459
Household wealth status → Food safety behavior	0.131	0.004
Household wealth status → Food expenditure per capita	0.069	0.095
Household wealth status → HDDS	−0.286	0.868
Food expenditure per capita → HDDS	−0.126	0.001
Food safety Knowledge ↔ Food safety Attitude	0.832	0.000
Food safety Knowledge ↔ Healthy diet knowledge	0.621	0.000
Healthy diet knowledge ↔ Food safety Attitude	0.319	0.000
Goodness of fit statistics		
RMSEA	0.052	
SRMR	0.065	
CFI	0.840	
TLI	0.813	
Observations	595	

The goodness of fit summary statistics (Table 11) shows that model 3 is fit for purpose. The RMSEA and SRMR values are 0.05 and 0.07, respectively. The CFI and TLI values are each 0.8. The results show that food safety knowledge ($\beta1=0.745$, $p>0.05$) and attitude ($\beta1=0.204$, $p>0.05$) have a positive but statistically insignificant effect on food safety cooking practices/behaviour. Household food handlers can pay more attention to food safety cooking practices than currently. They are knowledgeable about food safety and have a positive attitude toward food safety guidelines (Table 6). The absence of a statistically significant effect of knowledge and attitude on food safety cooking behaviour (models 1–3) may be due to the perceived consequence of food handlers' food safety cooking practices/behaviour not resulting in any immediate adverse impact on their health that will cause them to change their food safety cooking practices/behaviour. The perceived consequence of a practice/behaviour will influence the level of compliance [35]. Also, other mediating factors like income influences the practice of appropriate food safety cooking behaviour.

Household wealth status ($\beta1=0.131$, $p<0.05$) has a positive and statistically significant effect on households' food safety cooking

practices/behaviour. A unit change in household wealth status leads to a 0.13 unit increase in practising appropriate food safety cooking behaviour: this implies that as a household's wealth status improves, households practise more appropriate food safety cooking behaviour. Furthermore, with improved wealth, households are more likely to have access to cleaner cooking areas and improved water and sanitation facilities [69,70], which are critical to food safety. On the other hand, poorer households are more likely to use solid fuels like wood, animal dung and charcoal which adversely affects their health [70] and compromise the hygiene of the cooking area. In addition, poorer households cannot practice appropriate WASH behaviours, including hand washing with soap [71,72], and therefore, the household food environment is compromised.

A counterintuitive result is healthy diet knowledge's statistically significant negative effect ($\beta1=-0.368$, $p<0.05$) on food safety cooking behaviour. Food safety and healthy nutrition are complementary concepts but practically can sometimes be incompatible because food safety encompasses food handling, preparation and storage, and healthy nutrition addresses the nutritional quality of food [73]. So, for example, food cooked at high temperature and longer to kill harmful food pathogens risk destroying the nutrient value of the food [74,75]. Also, the knowledge of the toxic effect of *trans*-fatty acids in food is optional to practice personal hygiene (e.g. washing hands before and during food preparation) when cooking. Therefore, food safety knowledge and nutrition knowledge may differ. Therefore, our finding may arise because some nutrition knowledge may be outside the skills required to practice appropriate food safety cooking behaviour. The model also shows that the correlation between food safety and nutrition knowledge, attitude and behaviour remains positive and statistically significant (Table 11).

Other pathways (model 3) were significant in the household food safety consideration. Household wealth status positively affects household food expenditure per capita ($\beta1=0.069$, $p<0.05$), but household wealth status has a negative and statistically insignificant effect on HDDS ($\beta1=-0.286$, $p>0.05$). Food expenditure per capita also has a negative and statistically significant effect on HDDS ($\beta1=-0.126$, $p<0.05$). These observations may be attributed to increasing-income households likely shifting to consuming other processed and ultra-processed foods high in fats, sugars and salts, but not necessarily more diversified foods [76,77]. Consumption of unhealthy ultra-processed foods is a public health concern. However, concurrently, improved incomes and convenience-induced motives drive the consumption of processed and ultra-processed foods in the long run [78]. For example, in developing countries, households may spend on relatively costly processed foods when their income increase, reducing the consumption of more diversified, relatively cheaper local alternatives. In Ghana, households may reduce the consumption of cooked beans with red palm oil, gari and fried plantain ("red-red") and increase their consumption of fried rice (oily rice with ready-made spices and seasoning). The former is a more balanced meal than the latter.

5. Conclusion

The study answers the primary research questions of the urban households' choice of food markets and the effect of household food safety knowledge on food safety cooking practices/behaviour of urban households. The study relied on household data from three Ghanaian cities (Accra, Kumasi and Tamale).

We conclude that many urban households must prioritise food safety when choosing food markets. Only 18% of respondents considered food safety one of their top three considerations for the choice of market. Convenience (68.6% of sampled households) in terms of proximity to the market and availability of all products at one location was the primary consideration for urban households for their choice of food markets. Economic considerations of reducing their transaction cost (e.g. transportation cost, time spent on food shopping) underline households' choice of market. Open-air markets remain the preferred food market for households. Supermarket shopping for food products, especially fresh fruits and vegetables and some local food commodities, could be higher among respondents in the study areas.

We also confirm that although households are knowledgeable and have a positive attitude towards food safety, neither food safety knowledge nor attitude has a statistically significant effect on food safety cooking practices/behaviour. However, household wealth status positively affects food safety cooking behaviour (model 3), indicating that households' food safety cooking behaviour improves when in addition to appropriate food safety knowledge, households are economically better off.

The demands on urban dwellers from the labour market, especially those in big cities like our study areas, have altered urban life and households' cooking practices and eating behaviour. The home is the last point to ensure food safety. Food safety advocacy, training and public education by state institutions are critical to ensuring food safety for all. We recommend accompanying public education drives and other interventions in promoting food safety knowledge with programs and strategies to reduce the associated cost of practising food safety measures in the home, especially for the urban poor.

Ethics statement

The study obtained ethical clearance from the Centre for Development Research's (ZEF) Ethics Committee and the University of Ghana Ethics Committee. All respondents consented to the in-person interviews, and their responses remained anonymous.

Author contributions

NG conceptualised the NOURICITY project. MD and NG contributed to the study design, designed the questionnaire and critically reviewed the manuscript. MD collected and analysed the data and wrote the first draft of the manuscript. All authors contributed to the article and approved the final submitted version.

Funding

The European Union's Horizon 2020 research and innovation program under grant agreement No. 727715 provided funding for the NOURICITY project. In addition, the Open Access Publication Fund of the University of Bonn supported the open-access publication of this paper.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors will make the data supporting this article's conclusions available upon request and subject to the conditions of the NOURICITY project.

Acknowledgements

We would like to thank our partners at the Institute of Statistical, Social and Economic Research (ISSER), University of Ghana for their immense support during the implementation of the project in Ghana. We would also like to thank the participants for agreeing to be part of this study.

Appendix

Table A.1
Households' knowledge of safe food handling

Construct	Items	Correct answers (%)			
		Accra	Kumasi	Tamale	Total
Keep clean					
	It is important to wash hands before handling food	98.86	100.00	99.07	99.34
	Wiping cloths can spread microorganisms	77.14	83.03	88.43	83.25
Separate raw and cooked					
	The same cutting board can be used for raw and cooked foods provided it looks clean	23.43	19.72	8.80	16.91
	Raw food needs to be stored separately from cooked food	75.43	83.03	89.81	83.25
Cook thoroughly					
	Cooked foods do not need to be thoroughly reheated	42.29	38.53	11.11	29.89
	Proper cooking includes meat cooked to 40 °C	51.43	42.20	58.80	50.74
Keep food at safe temperatures					
	Cooked meat can be left at room temperature overnight to cool before refrigerating	26.86	21.10	15.28	20.69
	Cooked food should be kept very hot before serving	90.29	87.16	95.37	90.97
	Refrigerating food only slows bacterial growth	73.14	77.52	83.33	78.33
Use safe water and raw materials					
	Safe water can be identified by the way it looks	20.00	13.76	27.31	20.36
	Wash fruit and vegetables	93.71	95.41	99.54	96.39
Total respondents		175	218	216	609

Table A.2
Households' food safety attitude

Construct	Items	Positive attitude (%)			
		Accra	Kumasi	Tamale	Total
Keep clean					
	Frequent hand-washing during food preparation is worth the extra time	85.14	83.49	83.80	84.07
	Keeping kitchen surfaces clean reduces the risk of illness	93.71	96.33	96.76	95.73
Separate raw and cooked					
	Keeping raw and cooked food separate helps to prevent illness	82.86	87.16	93.06	88.01
	Using different knives and cutting boards for raw and cooked foods is worth the extra effort	52.57	61.01	68.52	61.25
Cook thoroughly					
	Meat thermometers are useful for ensuring food is cooked thoroughly	22.29	28.44	40.28	30.87
	Soups and stews should always be boiled to ensure safety	93.71	94.95	94.44	94.42
Keep food at safe temperatures					
	Thawing food in a cool place is safer	62.86	69.27	55.09	62.40
	I think it is unsafe to leave cooked food out of the refrigerator for more than 2 h	51.43	72.94	43.98	56.49
Use safe water and raw materials					
	Inspecting food for freshness and wholesomeness is valuable	94.86	94.95	94.44	94.75
	I think it is important to throw away foods that have reached their expiry date	93.71	95.41	79.17	89.16
Total respondents		175	218	216	609

Table A.3
Self-reported food safety cooking behaviour

Construct	Items	Practice always (%)			
		Accra	Kumasi	Tamale	Total
Keep clean					
	I wash my hands before and during food preparation	73.14	81.19	81.02	78.82
	I clean surfaces and equipment used for food preparation before re-using on other food	54.29	66.97	65.74	62.89
Separate raw and cooked					
	I use separate utensils and cutting-boards when preparing raw and cooked food	30.86	43.12	33.33	36.12
	I separate raw and cooked food during storage	39.43	50.00	53.70	48.28
Cook thoroughly					
	I check that meats are cooked thoroughly by ensuring that the juices are clear or by using a thermometer	35.43	39.91	44.91	40.39
	I reheat cooked food until it is piping hot throughout	45.14	47.25	45.83	46.14
Keep food at safe temperatures					
	I thaw frozen food in the refrigerator or other cool place	25.71	36.70	30.09	31.20
	After I have cooked a meal I store any left-overs in a cool place within 2 h	30.29	42.66	34.72	36.29
Use safe water and raw materials					
	I check and throw away food beyond its expiry date	67.43	76.15	67.59	70.61

(*continued on next page*)

Table A.3 (*continued*)

Construct	Items	Practice always (%)			
		Accra	Kumasi	Tamale	Total
	I wash fruit and vegetables with safe water before eating them	69.71	72.48	93.52	79.15
Total respondents		175	218	216	609

Table A.4
Households' healthy diet knowledge

	Items	Correct answers (%)			
		Accra	Kumasi	Tamale	Total
Eat moderate amounts of fats and oils					
1	It's better to use unsaturated vegetable oils (eg. Olive, soy, sunflower or corn oil) rather than animal fats or oils high in saturated fats (eg. Butter, ghee, lard, coconut and palm oil)	76.57	88.99	97.22	88.34
2	White meat (eg. Poultry) and fish are better than red meat because they are lower in fat	79.43	81.19	93.06	84.89
3	Eat only limited amounts of processed meats because these are high in fat and salt	84.00	91.74	91.20	89.33
4	People who eat too much saturated fat and *trans*-fat are at higher risk of heart disease and stroke	74.29	87.61	91.67	85.22
Eat less salt and sugars					
5	When cooking and preparing foods, limit the amount of salt and high-sodium condiments (eg. Soy sauce, fish sauce, cubes)	91.43	94.95	97.22	94.75
6	Avoid foods (eg snacks) that are high in salt and sugars	88.00	94.50	94.44	92.61
7	Limit intake of soft drinks or soda and other drinks that are high in sugars (eg. Fruit juice, cordials and syrups, flavoured milks and yogurt drinks)	93.71	95.41	92.13	93.76
8	Choose fresh fruits instead of sweet snacks such as cookies, cakes and chocolate	87.43	88.99	92.13	89.66
9	People who eat too much salt have a greater risk of high blood pressure which can increase their risk of heart disease and stroke	81.71	88.07	94.91	88.67
10	People who eat too much sugar have a greater risk of becoming overweight or obese, and an increased risk of tooth decay.	77.71	84.40	90.74	84.73
Breastfeed babies and young children					
11	From birth to 6 months of age, feed babies exclusively with breast milk (i.e. give them no other food or drink), and feed them "on demand" (i.e. as often as they want, day and night)	88.57	89.91	99.54	92.94
12	At 6 months of age, introduce a variety of safe and nutritious foods to complement breastfeeding, and continue to breastfeed until babies are 2 years of age or beyond	89.71	93.12	99.07	94.25
13	Do not add salt or sugars to foods for babies and young children	69.14	77.06	85.65	77.83
14	Exclusively breastfed babies have better resistance against common childhood illnesses such as diarrhoea, respiratory infections and ear infections.	90.86	88.99	87.04	88.83
Eat a variety of foods					
15	It is better to eat a combination of different foods, including staple foods, legumes, vegetables, fruits and food from animal sources than just focusing on a particular food	92.57	97.25	96.30	95.57
16	Eating a healthy, balanced diet is especially important for young children's growth and development	92.57	94.50	98.15	95.24
17	Eating a variety of whole (ie unprocessed) and fresh foods every day helps children and adults to obtain the right amounts of essential nutrients.	93.71	95.87	94.44	94.75
Eat plenty of vegetables and fruits					
18	Eat a wide variety of vegetables and fruits	92.00	95.87	98.15	95.57
19	For snacks, choose raw vegetables and fresh fruit, rather than foods that are high in sugars, fats or salt	83.43	85.78	91.20	87.03
20	Avoid overcooking vegetables and fruit because this can lead to the loss of important vitamins	70.86	79.82	91.20	81.28
	Total respondents	175	218	216	609

References

[1] World Health Organization, WHO Global Strategy for Food Safety 2022-2030: towards Stronger Food Safety Systems and Global Cooperation, World Health Organization, Geneva, 2022, 2022. Licence: CC BY-NC-SA 3.0 IGO.

[2] Z. Gizaw, Public health risks related to food safety issues in the food market: a systematic literature review, Environ. Health Prev. Med. 24 (1) (2019) 1–21.

[3] HLPE, Nutrition and Food Systems. A Report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on, World Food Security, Rome, 2017.

[4] Codex Alimentarius, General Principles of Food Hygiene, CXC 1-1969, Food and Agriculture Organization of the United Nations, Rome, 2020 (FAO)/World Health Organization (WHO) Codex Alimentarius; 2020, https://www.fao.org/fao-who-codexalimentarius/sh-proxy/en/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FStandards%252FCXC%2B1-1969%252FCXC_001e.pdf.

[5] A. Thakali, J.D. MacRae, A review of chemical and microbial contamination in food: what are the threats to a circular food system? Environ. Res. 194 (2021), 110635.

[6] I.A. Rather, W.Y. Koh, W.K. Paek, J. Lim, The sources of chemical contaminants in food and their health implications, Front. Pharmacol. 8 (2017) 830.

[7] World Health Organization, *Food Safety* (No. EM/RC46/6), 1999.

[8] FAO & WHO, A Guide to World Food Safety Day 2021. Safe Food Now for a Healthy Tomorrow, 2021. Rome, https://www.fao.org/3/cb3404en/cb3404en.pdf.

[9] S. Jaffee, S. Henson, L. Unnevehr, D. Grace, E. Cassou, The Safe Food Imperative: Accelerating Progress in Low-And Middle-Income Countries, World Bank Publications, 2018.

[10] WHO, WHO Estimates of the Global Burden of Foodborne Diseases: Foodborne Disease Burden Epidemiology Reference Group 2007-2015, World Health Organization, 2015. https://apps.who.int/iris/bitstream/handle/10665/199350/9789241565165_eng.pdf?sequence=1.

[11] P.F. Ababio, P. Lovatt, A review on food safety and food hygiene studies in Ghana, Food Control 47 (2015) 92–97.

[12] Food and Drugs Authority (FDA), January 27, FDA Conducts Investigations into Foodborne Disease Outbreak in Oyibi, Accra, 2023. http://www.fdaghana.gov.gh/img/press/FDA%20CONDUCTS%20INVESTIGATIONS%20INTO%20FOOD%20BORNE%20DISEASE%20OUTBREAK%20IN%20OYIBI-ACCRA.pdf. (Accessed 10 February 2023).

[13] F.D.A.(June 13, Public Notice. Update: Marwako Food Poisoning Incident, FDA, Accra-Ghana, 2022. http://www.fdaghana.gov.gh/img/press/MAR_11-01.pdf. (Accessed 10 February 2023).

[14] WHO, WHO Global Strategy for Food Safety. Reducing Public Health Risks Associated with the Sale of Live Wild Animals of Mammalian Species in Traditional Food Markets-Infection Prevention and Control, 2022. EB 150/26, January 2022, https://apps.who.int/gb/ebwha/pdf_files/EB150/B150_26-en.pdf. (Accessed 9 April 2023).

[15] WHO, A Guide to Healthy Food Markets, World Health Organization, Geneva, 2006, 2006, http://apps.who.int/iris/bitstream/handle/10665/43393/9241593938_eng.pdf. (Accessed 9 April 2023).
[16] International Food Policy Research Institute (IFPRI), Global Food Policy Report, International Food Policy Research Institute, Washington, DC, 2017, https://doi.org/10.2499/9780896292529, 2017.
[17] J.M. Soon, I.R.A. Wahab, R.H. Hamdan, M.H. Jamaludin, Structural equation modelling of food safety knowledge, attitude and practices among consumers in Malaysia, PLoS One 15 (7) (2020), e0235870.
[18] E. Langiano, M. Ferrara, L. Lanni, V. Viscardi, A.M. Abbatecola, E. De Vito, Food safety at home: knowledge and practices of consumers, J. Public Health 20 (2012) 47–57.
[19] WHO, Five Keys to Safer Food Manual, 2006. https://www.who.int/foodsafety/publications/consumer/manual_keys.pdf. (Accessed 10 October 2019).
[20] M. Jevšnik, V. Hlebec, P. Raspor, Consumers' awareness of food safety from shopping to eating, Food Control 19 (8) (2008) 737–745.
[21] S. Brockett, M.K. Wolfe, A. Hamot, G.D. Appiah, E.D. Mintz, D. Lantagne, Associations among water, sanitation, and hygiene, and food exposures and typhoid fever in case–control studies: a systematic review and meta-analysis, Am. J. Trop. Med. Hyg. 103 (3) (2020) 1020–1031.
[22] L.P. Smith, S.W. Ng, B.M. Popkin, Trends in US home food preparation and consumption: analysis of national nutrition surveys and time use studies from 1965–1966 to 2007–2008, Nutr. J. 12 (1) (2013) 1–10.
[23] K. Glanz, J.J. Metcalfe, S.C. Folta, A. Brown, B. Fiese, Diet and health benefits associated with in-home eating and sharing meals at home: a systematic review, Int. J. Environ. Res. Publ. Health 18 (4) (2021) 1577.
[24] I. Spronk, C. Kullen, C. Burdon, H. O'Connor, Relationship between nutrition knowledge and dietary intake, Br. J. Nutr. 111 (10) (2014) 1713–1726.
[25] K. Asakura, H. Todoriki, S. Sasaki, Relationship between nutrition knowledge and dietary intake among primary school children in Japan: combined effect of children's and their guardians' knowledge, J. Epidemiol. 27 (10) (2017) 483–491.
[26] T. De Vriendt, C. Matthys, W. Verbeke, I. Pynaert, S. De Henauw, Determinants of nutrition knowledge in young and middle-aged Belgian women and the association with their dietary behaviour, Appetite 52 (3) (2009) 788–792.
[27] K.J. Campbell, G. Abbott, A.C. Spence, D.A. Crawford, S.A. McNaughton, K. Ball, Home food availability mediates associations between mothers' nutrition knowledge and child diet, Appetite 71 (2013) 1–6.
[28] T. Tabbakh, J.H. Freeland-Graves, The home environment: a mediator of nutrition knowledge and diet quality in adolescents, Appetite 105 (2016) 46–52.
[29] R. Ambikapathi, S. Passarelli, I. Madzorera, et al., Men's nutrition knowledge is important for women's and children's nutrition in Ethiopia, Matern. Child Nutr. 17 (2021), e13062, https://doi.org/10.1111/mcn.13062, 2021.
[30] J. Ochieng, V. Afari-Sefa, P.J. Lukumay, T. Dubois, Determinants of dietary diversity and the potential role of men in improving household nutrition in Tanzania, PLoS One 12 (12) (2017), e0189022.
[31] D.S. Kenkel, Health behavior, health knowledge, and schooling, J. Polit. Econ. 99 (2) (1991) 287–305.
[32] A. McCluskey, M. Lovarini, Providing education on evidence-based practice improved knowledge but did not change behaviour: a before and after study, BMC Med. Educ. 5 (1) (2005) 1–12.
[33] W.H. Ko, The relationship among food safety knowledge, attitudes and self-reported HACCP practices in restaurant employees, Food Control 29 (1) (2013) 192–197.
[34] R. Meysenburg, J.A. Albrecht, R. Litchfield, P.K. Ritter-Gooder, Food safety knowledge, practices and beliefs of primary food preparers in families with young children. A mixed methods study, Appetite 73 (2014) 121–131.
[35] A. Worsley, Nutrition knowledge and food consumption: can nutrition knowledge change food behaviour? Asia Pac. J. Clin. Nutr. 11 (2002) S579–S585.
[36] T. Rheinländer, M. Olsen, J.A. Bakang, H. Takyi, F. Konradsen, H. Samuelsen, Keeping up appearances: perceptions of street food safety in urban Kumasi, Ghana, J. Urban Health 85 (2008) 952–964.
[37] F. Akabanda, E.H. Hlortsi, J. Owusu-Kwarteng, Food safety knowledge, attitudes and practices of institutional food-handlers in Ghana, BMC Publ. Health 17 (1) (2017) 1–9.
[38] M. Gorton, D. Barjolle, Theories of food choice, in: Food Consumer Science, Springer, Dordrecht, 2013, pp. 15–26.
[39] S. Michie, M. Johnston, C. Abraham, R. Lawton, D. Parker, A. Walker, Making psychological theory useful for implementing evidence based practice: a consensus approach, BMJ Qual. Saf. 14 (1) (2005) 26–33.
[40] A. Bandura, Health promotion by social cognitive means, Health Educ. Behav. 31 (2) (2004) 143–164.
[41] I. Ajzen, The theory of planned behavior, Organ. Behav. Hum. Decis. Process. 50 (2) (1991) 179–211.
[42] I. Ajzen, The theory of planned behavior: frequently asked questions, Human Behavior and Emerging Technologies 2 (4) (2020) 314–324.
[43] J. Sobal, C.A. Bisogni, Constructing food choice decisions, Ann. Behav. Med. 38 (suppl_1) (2009) s37–s46.
[44] S. Bamberg, G. Möser, Twenty years after Hines, Hungerford, and Tomera: a new meta-analysis of psycho-social determinants of pro-environmental behaviour, J. Environ. Psychol. 27 (1) (2007) 14–25.
[45] J.L. Meinhold, A.J. Malkus, Adolescent environmental behaviors: can knowledge, attitudes, and self-efficacy make a difference? Environ. Behav. 37 (4) (2005) 511–532.
[46] C. Liu, C. Liu, D. Wang, X. Zhang, Knowledge, attitudes and intentions to prescribe antibiotics: a structural equation modeling study of primary care institutions in Hubei, China, Int. J. Environ. Res. Publ. Health 16 (13) (2019) 2385.
[47] Ghana Statistical Service [GSS] (2013), Population and Housing Census. National Analytical Report, 2010.
[48] M. Tolvanen, S. Lahti, J. Miettunen, H. Hausen, Relationship between oral health-related knowledge, attitudes and behavior among 15–16-year-old adolescents—a structural equation modeling approach, Acta Odontol. Scand. 70 (2) (2012) 169–176.
[49] K.A. Bollen, M.D. Noble, Structural equation models and the quantification of behavior, Proc. Natl. Acad. Sci. USA 108 (Supplement 3) (2011) 15639–15646.
[50] R.B. Kline, Principles and Practice of Structural Equation Modeling, Guilford publications, 2011.
[51] J.F. Hair, J.J. Risher, M. Sarstedt, C.M. Ringle, When to Use and How to Report the Results of PLS-SEM. *European Business Review*, 2019.
[52] J.F. Hair, R.E. Anderson, B.J. Babin, W.C. Black, Multivariate Data Analysis: A Global Perspective, vol. 7, 2010.
[53] J.A. Gliem, R.R. Gliem, Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for Likert-type scales, in: Midwest Research-To-Practice Conference in Adult, Continuing, and Community Education, 2003.
[54] T.A. Brown, Confirmatory Factor Analysis for Applied Research, Guilford publications, 2015.
[55] C.Y. Yu, Evaluating Cutoff Criteria of Model Fit Indices for Latent Variable Models with Binary and Continuous Outcomes, University of California, Los Angeles, 2002.
[56] L.T. Hu, P.M. Bentler, Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives, Struct. Equ. Model.: A Multidiscip. J. 6 (1) (1999) 1–55.
[57] Ghana Statistical Service (GSS), Ghana living standards survey (GLSS) 7-main report, June, 2019, in: Ghana Statistical Service, 2019 (Accra).
[58] C. Turner, S. Kalamatianou, A. Drewnowski, B. Kulkarni, S. Kinra, S. Kadiyala, Food environment research in low-and middle-income countries: a systematic scoping review, Adv. Nutr. 11 (2) (2020) 387–397.
[59] C. Hannah, J. Davies, R. Green, A. Zimmer, P. Anderson, J. Battersby, T.P. Evans, Persistence of open-air markets in the food systems of Africa's secondary cities, Cities 124 (2022), 103608.
[60] K.S. Andam, D. Tschirley, S.B. Asante, R.M. Al-Hassan, X. Diao, The transformation of urban food systems in Ghana: findings from inventories of processed products, Outlook Agric. 47 (3) (2018) 233–243.
[61] S. Wertheim-Heck, J.E. Raneri, P. Oosterveer, Food safety and nutrition for low-income urbanites: exploring a social justice dilemma in consumption policy, Environ. Urbanization 31 (2) (2019) 397–420.
[62] T. Reardon, S. Henson, A. Gulati, Links between supermarkets and food prices, diet diversity and food safety in developing countries, Trade, food, diet and health: perspectives and policy options (2010) 111–130.
[63] E.J.O. Rao, M. Qaim, Supermarket growth and rural welfare: evidence from Kenya, in: Organised Retailing and Agri-Business: Implications of New Supply Chains on the Indian Farm Economy, Springer India, New Delhi, 2015, pp. 81–97.
[64] WHO, Five keys to a healthy diet (n.d), https://apps.who.int/nutrition/topics/5keys_healthydiet/en/index.html. (Accessed 10 October 2019).
[65] S.E. Makhunga, M. Macherera, K. Hlongwana, Food handlers' knowledge, attitudes and self-reported practices regarding safe food handling in charitable food assistance programmes in the eThekwini District, South Africa: cross-sectional study, BMJ Open 13 (4) (2023), e065357.
[66] M.N. Islam, N. Roy, M.B. Amin, F.K. Madilo, K. Karmakar, E. Hossain, N.J. Airin, Food safety knowledge and handling practices among household food handlers in Bangladesh: a cross-sectional study, Food Control 147 (2023), 109578.
[67] I. Marklinder, R. Ahlgren, A. Blücher, S.M.E. Börjesson, F. Hellkvist, M. Moazzami, M.L. Danielsson-Tham, Food safety knowledge, sources thereof and self-reported behaviour among university students in Sweden, Food Control 113 (2020), 107130.
[68] O.A. Mihalache, L. Dumitraşcu, A.I. Nicolau, D. Borda, Food safety knowledge, food shopping attitude and safety kitchen practices among Romanian consumers: a structural modelling approach, Food Control 120 (2021), 107545.
[69] E.A. Adams, G.O. Boateng, J.A. Amoyaw, Socioeconomic and demographic predictors of potable water and sanitation access in Ghana, Soc. Indicat. Res. 126 (2016) 673–687.
[70] B. Behera, A. Ali, Patterns and determinants of household use of fuels for cooking: empirical evidence from sub-Saharan Africa, Energy 117 (2016) 93–104.
[71] World Health Organization (WHO) & United Nations Children's Fund (UNICEF), Progress on Household Drinking Water, Sanitation and Hygiene 2000–2020: Five Years into the SDGs, WHO, Geneva, 2021, 2021.
[72] N. Gaffan, A. Kpozèhouen, C. Dégbey, Y. Glèlè Ahanhanzo, R. Glèlè Kakaï, R. Salamon, Household access to basic drinking water, sanitation and hygiene facilities: secondary analysis of data from the demographic and health survey V, 2017–2018, BMC Publ. Health 22 (1) (2022) 1–16.
[73] H. Walls, P. Baker, E. Chirwa, B. Hawkins, Food security, food safety & healthy nutrition: are they compatible? Global Food Secur. 21 (2019) 69–71.
[74] S. Coe, A. Spiro, Cooking at home to retain nutritional quality and minimise nutrient losses: a focus on vegetables, potatoes and pulses, Nutr. Bull. 47 (4) (2022) 538–562.
[75] S. Prabhu, D.M. Barrett, Effects of storage condition and domestic cooking on the quality and nutrient content of African leafy vegetables (Cassia tora and Corchorus tridens), J. Sci. Food Agric. 89 (10) (2009) 1709–1721.

[76] J. Kearney, Food consumption trends and drivers, Phil. Trans. Biol. Sci. 365 (1554) (2010) 2793–2807.
[77] C.A. Monteiro, R.B. Levy, R.M. Claro, I.R.R. de Castro, G. Cannon, Increasing consumption of ultra-processed foods and likely impact on human health: evidence from Brazil, Publ. Health Nutr. 14 (1) (2010) 5–13.
[78] T. Reardon, D. Tschirley, L.S.O. Liverpool-Tasie, T. Awokuse, J. Fanzo, B. Minten, B.M. Popkin, The processed food revolution in African food systems and the double burden of malnutrition, Global Food Secur. 28 (2021), 100466.