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▶ **To cite this version:**

Julia Liguori, Ursula Trübswasser, Rebecca Pradeilles, Agnès Le Port, Edwige Landais, et al.. How do food safety concerns affect consumer behaviors and diets in low- and middle-income countries? A systematic review. Global Food Security, 2022, 32, 12 p. 10.1016/j.gfs.2021.100606 . hal-03511616

HAL Id: hal-03511616
https://hal.inrae.fr/hal-03511616

Submitted on 2 Jun 2022

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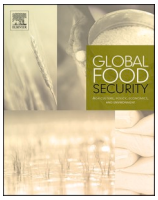
Global Food Security 32 (2022) 100606



Contents lists available at ScienceDirect

Global Food Security

journal homepage: www.elsevier.com/locate/gfs





How do food safety concerns affect consumer behaviors and diets in low- and middle-income countries? A systematic review

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ARTICLE INFO

Keywords:
Food safety
Low- and middle-income countries
Consumer behavior
Diets

ABSTRACT

Both food safety and dietary behaviors are major contributors to the global burden of disease, especially in rapidly urbanising environments. The impact that food safety concerns have on dietary behaviors in low- and middle-income countries (LMICs) is insufficiently documented. Therefore, we examined whether food safety concerns influence consumer behaviors/diets in LMICs. A systematic review identified 46 relevant studies from 20 LMICs for inclusion. A socio-ecological food environment framework was used to map food safety factors that influence consumer behaviors (food acquisition/purchase, eating out of home, food preparation/storage) and diets (consumption of nutrient rich/poor foods). Several studies (n = 11) reported that despite food safety concerns, consumers could not always ensure that they consumed safe food; barriers were affordability, accessibility and appeal. Key concerns included fear of pesticides, fertilizers, hygiene in/around food outlets, unhygienic vendor practices and household storage/preparation methods. These concerns may reduce consumption of animal sourced food and fresh fruit and vegetables; and increase consumption of starchy staples and processed/packaged foods. Policies such as upgrading urban market infrastructure to enhance food safety, accompanied by nutrition and hygiene education, could lead to increased accessibility, affordability and appeal of safe, nutrient-rich foods. Thus, reducing the appeal of packaged/processed food as a means to mitigate food safety risk; thereby contributing to preventing foodborne disease and multiple forms of malnutrition.

1. Introduction

Food safety (FS) concerns have increased as factors such as globalisation, urbanisation, increased disposable income and purchasing preferences continue to shift dietary patterns around the world. In low- and middle-income settings (LMICs), most foodborne diseases still stem from unsafe handling and preparation of fresh foods, such as animal sourced foods, fresh fruit and vegetables (FFV) (GP, 2016; Grace, 2015; Grace et al., 2010). In 2010, foodborne hazards accounted for 600 million cases of foodborne disease and were estimated to be responsible for 420, 000 deaths annually in LMICs (Havelaar et al., 2015). As such, foodborne diseases account for an additional 33 million Disability Adjusted Life Years (DALYs) (Havelaar et al., 2015).

Current literature suggests that FS concerns are occurring in every part of the food system; at production stages (unregulated use of pesticides, poor post-harvest handling), during processing (unregulated use of additives, contaminated water), during transportation, in the local food environment (unhygienic food outlets) or at the consumer level (unhygienic food preparation and storage practices) (Kang'ethe et al., 2020). Food is unsafe when it is exposed to any hazard that makes it harmful to health, including bacterial, viral, parasitic and/or chemical toxins (FAO/WHO, 2003). Evidence suggests that financial gain or

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https://doi.org/10.1016/j.gfs.2021.100606
Received 9 July 2021; Received in revised form 10 December 2021; Accepted 13 December 2021
Available online 31 December 2021
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convenience of food preparation outweigh the risk associated with consuming a product (Grace et al., 2010), while fear of poor food hygiene could outweigh concerns about the nutritional quality of food (Nago et al., 2012; Trubswasswer et al., 2020). The latter finding is worrisome as food safety and nutrition are potentially closely linked and concerns limiting the consumption of fresh FFV could make packaged (often ultra-processed) food, the perceived safer option (Grace and McDermott, 2015; Trubswasser et al., 2020). While homecooked food is considered the safer and healthier option in LMIC settings (Rao et al., 2007; Trubswasswer et al., 2020), eating out of home continues to increase especially in the urban context (Reardon et al., 2021). Street food has become increasingly popular as it is perceived as accessible, affordable, and convenient, but can carry great risk if food safety management is not in place (Abrahale et al., 2019; Asiegbu et al., 2016; Gupta et al., 2018; Hoffmann et al., 2019). These challenges are further compounded as food systems in many LMICs have limited regulatory, surveillance and control systems (Grace, 2015; Hoffmann et al., 2019; Reardon et al., 2009).

In addition to food safety challenges, food systems in LMICs are rapidly changing and have increasingly longer supply chains (Reardon et al., 2021). Cheap, ultra-processed foods and beverages are widely available and advertised, especially in urban areas (Baker et al., 2020; Dury et al., 2019), impacting the nutritional quality of diets and the double burden of malnutrition (Popkin et al., 2020). This nutrition transition takes place as busy urban lives and limited incomes shift many consumers towards relying on cheap and convenient street foods, which are often nutrient poor (high in fat, sugar and salt) and unhygienic (GP, 2016; Makinde et al., 2020). Furthermore, the livelihoods of small informal vendors, often women, could be jeopardised if small informal outlets are replaced with larger retail outlets (Kawarazuka et al., 2017; Wertheim-Heck et al., 2014, 2019). Food safety scares may lead to stringent municipal authorities' policy and regulations, which might be neither feasible nor affordable for small and/or informal vendors (FAO, 2016).

Despite evidence that LMICs carry the majority of the foodborne disease burden (Havelaar et al., 2015), most research on food safety has been conducted in high-income countries (Redmond and Griffith, 2003; Yeung and Morris, 2001; Young and Waddell, 2016). A recent evidence gap analysis of 1838 impact evaluations and 178 systematic reviews on the effects of food systems interventions on food security and nutrition outcomes in LMICs found only one study on food safety regulations (Moore et al., 2021). Food safety concerns in urban LMIC settings may differ from high-income settings, thus meriting further exploration. Evidence on the linkages between food safety concerns and consumer dietary behaviors in LMICs has not been previously synthesized. Based on this, we hypothesize that FS concerns could negatively impact consumer behavior and diet quality. Therefore, this review examined whether food safety concerns influence consumer behaviors/diets in LMICs (i.e., how unsafe FS exposures such as, hygiene, contamination and adulteration might influence consumer behavior and diets in LMICs) by synthesizing findings from quantitative, qualitative, and mixed-method studies. These findings will be key to design contextually appropriate policies that account for the identified drivers to contribute towards improving food safety and diets.

2. Conceptual framework linking exposures and outcomes

We used a framework to develop the coding structure for data extraction and guide analysis (Fig. 1). The focus of our research was consumer behaviors and diets within the wider food system (HLPE, 2017) and food safety concerns potentially influencing these behaviors. We reviewed existing frameworks and theories that conceptualized how different factors of food safety exposure might affect consumer behaviors and/or diets (FAO, 2016; GFSP, 2019; GP, 2016; HLPE, 2020; Osei-Kwasi et al., 2020). None of the individual frameworks captured food safety exposure and consumer dietary behaviors sufficiently. We therefore deconstructed the concepts of the different frameworks and fitted the food safety factors within the different levels of influence (individual/household, social, physical and macro) using a socio-ecological approach (Osei-Kwasi et al., 2020, 2021; Story et al., 2008). For example, factors at the different levels include: cultural norms and food regulations (macro), availability and accessibility of (un)safe/(un)hygienic food (physical), family food practices (social), and knowledge of the issue and prior experience of foodborne disease (individual). A list of factors and the respective levels of influence can be found in the framework in Fig. 1.

The outcomes of the food safety factors were categorized into dietary behaviors (DBs), comprised of consumer behaviors (acquisition/

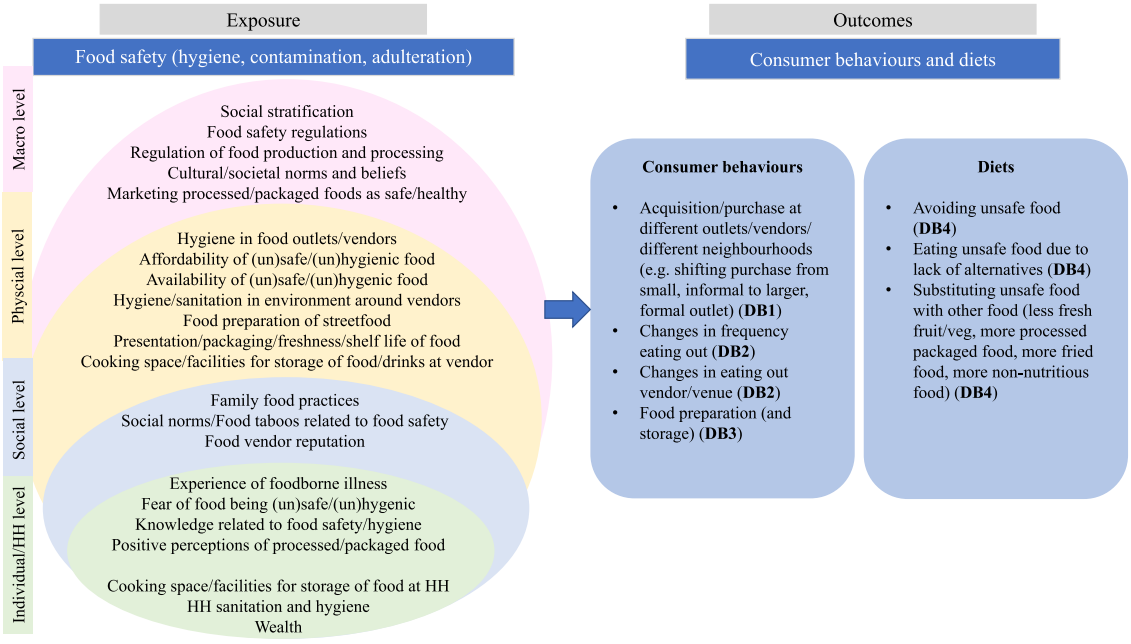


Fig. 1. Conceptual framework used to link the interactions between food safety exposures and consumer behaviors and diet outcomes.

preparation/storage/meal practices) and diets (quality/quantity) guided by food systems (HLPE, 2017) and food safety (FAO, 2016) frameworks. Under potential outcomes, we also accounted for possible changes in behavior or substitutions due to FS concerns. Changes in consumer behaviors could include shifting the purchase to different vendors (DB1), changing the frequency of eating out (DB2) or the way food is prepared or stored (DB3). In terms of diets, individuals could adapt their diets due to food safety concerns by avoiding unsafe food, by consuming less nutritious foods or more ultra-processed packaged food (DB 4).

3. Methods

3.1. Review typology

A systematic review was conducted to appraise and synthesize existing evidence, identify research gaps in the evidence base and make recommendations for future research (Grant and Booth, 2009). Following the PRISMA guidelines (Rethlefsen et al., 2021), the protocol was registered on the International prospective register of systematic review (available from PROSPERO 2020 CRD42020220617 https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=220617).

3.2. Inclusion and exclusion criteria

Qualitative, quantitative and mixed method study designs were considered for inclusion. Grey literature was also considered. Inclusion criteria for the review were study populations composed of males and females aged 10–18 years (adolescents) or 19–65 (adults) (if only part of the target group was covered, only attributable data to the selected target group was included). Studies had to be conducted in urban settings in countries classified as LMICs (using the World Bank definition of LMICs as of 2020) (World Bank Country and Lending Groups, 2020). Only studies that provided a clear link between FS exposure and a consumer behavior and/or dietary outcome were included. There was no restriction for date of publication. Among the excluded studies were: non-English publications, non-human or clinical populations, high income and rural-only settings and studies that investigated the association between food safety and consumers without a clear link with dietary behavior.

3.3. Information sources and search strategy

The search strategy was developed using the Population Exposure Context Outcome (PECO) model (Morgan et al., 2018) combining terms for Context (LMICs), Population (adolescent girls and boys, adult men and women aged 10–65 y), Exposure (food safety, food hygiene) and Outcome (consumer behavior and/or diets). Preliminary scoping searches were conducted to refine the search strategy, ensuring that relevant studies were identified with the search syntax. The final search syntax included text words and indexing terms specific for the different databases (e.g., MeSH for Pubmed). The search syntax was first developed for PubMed and then adapted to the additional database-specific search requirements. (Supplementary file 1: Search strategy).

A systematic search of PubMed, PsychInfo and Scopus was conducted on December 2, 2020. Google scholar was also searched for grey literature. Additional references were included from screening the references of included papers and their citations on Google scholar. An alert was created for new publications for all three databases. The search was updated on February 14, 2021 to include any recently published articles.

3.4. Screening

Complete references were imported and de-duplicated in Endnote X9.3.3. At the title, abstract and full text stage, JL and UT each screened all references with 20% double screened. Criteria for exclusion were recorded at every stage. In case of doubt, a reference was included in the next stage of reviewing. A third reviewer (ALP) independently screened 10% of excluded titles, abstracts and full texts.

3.5. Data extraction

Using a Google form, JL and UT extracted descriptive data including the first author; type of publication; year of publication; objectives; country where the study was conducted; study population (age, sample size, gender); research design; the type of dietary behavior; and the food safety dimensions (hygiene/contamination/adulteration at macro, physical, social or individual/household level) that the study assessed. The Google form extractions were converted into an excel file for further coding and analysis.

3.6. Quality appraisal

Each included study was critically appraised using a predefined list of criteria (n = 14 for quantitative studies, n = 10 for qualitative studies) (Kmet et al., 2004). As Cochrane guidance advises against the use of scores (Higgins and Green, 2006), the original Kmet quality assessment tool was modified by replacing the score for each criterion (0, 1, 2) with low quality/red (high risk of bias), medium quality/yellow, and high quality/green (low risk of bias).

Two authors (JL andUT) independently conducted quality appraisals of all included papers. ALP and EL checked 10% of the appraisals. Discrepancies in the rating were discussed until agreement was reached. Studies were not excluded based on the quality appraisal. (Supplementary file 2: Quality assessment).

3.7. Data synthesis

Analysis was first undertaken for every exposure and outcome individually. During this process, the conceptual framework (Fig. 1) was used to summarize themes related to influencing factors at the socio-ecological levels (macro, physical, social, individual/household level) and food acquisition and consumption behavior outcomes (Supplementary file 3: Framework for coding). Extractions were analyzed to develop a theory-based and data driven codebook to create the final list of DBs. The full data set was recoded to directly link the exposures with one behavioral outcome by JL, MH, RP and UT. During this stage, relevant quotes were identified for every link and short memos on findings and points for discussion were logged in a research diary. The results are presented in the following order for each identified level on influence of factors on dietary behavior: macro, physical, social and individual/household.

4. Results

In total, 46 studies met the inclusion criteria for this study (Fig. 2). Included studies were published between 2003 and 2021, with over half published after 2016 (n = 28). Twenty-two studies used qualitative methods (48%), 14 quantitative (30%) and the remaining 10 studies (22%) applied mixed methods.

4.1. Study characteristics

An overview of key study characteristics is given in Table 1. The included studies spanned 20 different LMICs (Fig. 3). Africa and the East Asia and Pacific region had the most publications (n = 6 respectively) followed by Latin America and the Caribbean (n = 4); South Asia (n = 2); Europe and Central Asia (n = 1); and Middle East and North Africa (n = 1). Twenty-three studies (50%) were conducted in upper-middle income countries, 20 studies (43%) in low-middle income countries, while only three studies (7%) were conducted in low-income countries. Nine

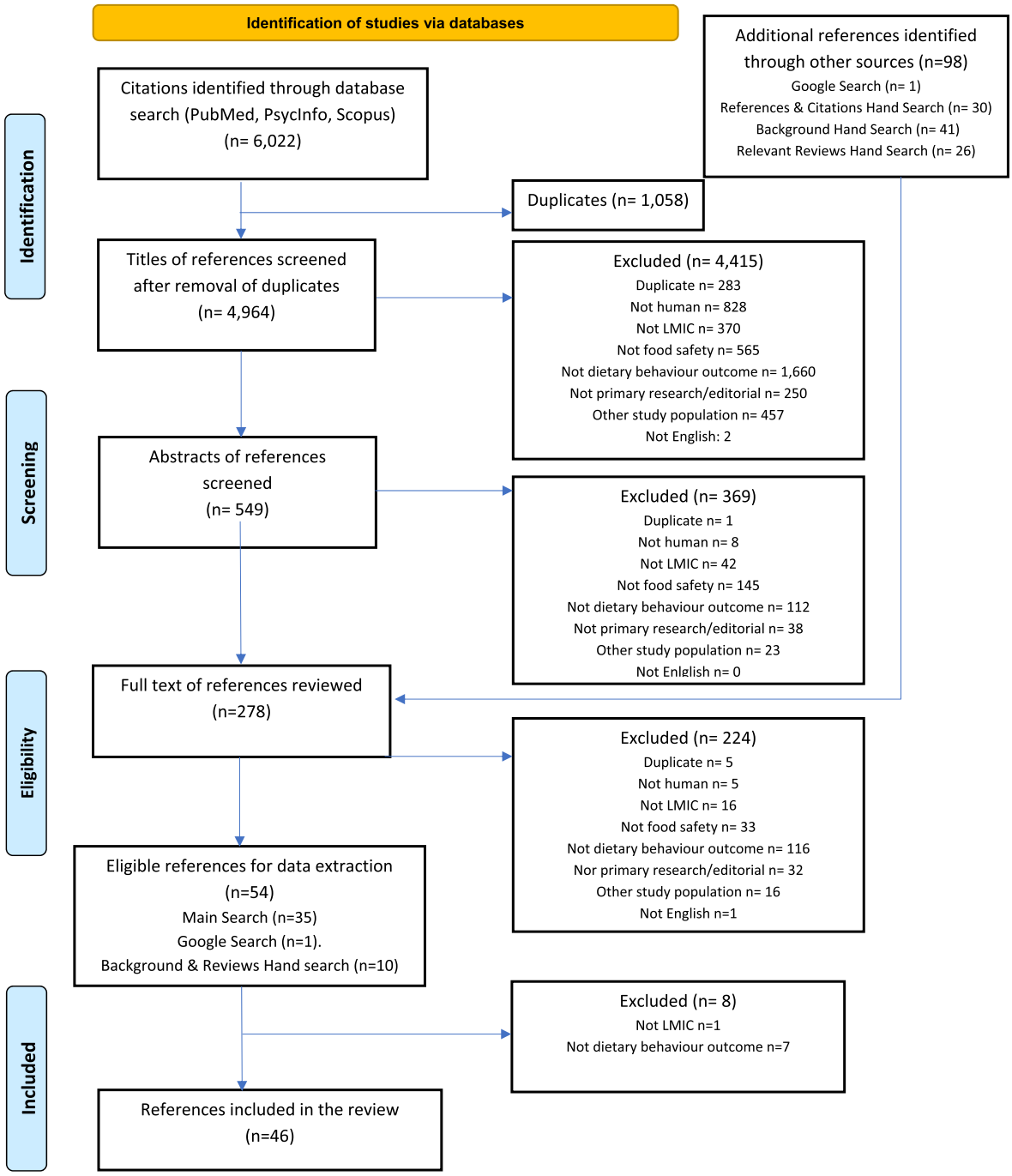


Fig. 2. PRISMA diagram showing the systematic screening process.

studies focused on adolescents (10–19 years), 20 on adults (18–65) and 11 had mixed age populations. The remaining six studies mentioned adults or adolescents in the text, but did not provide exact age, only age ranges.

4.2. Quality appraisal

The quality appraisal revealed that, out of the 29 qualitative studies, the majority of them (n = 25) failed to demonstrate reflexivity and/or to report verification procedures (n = 10) used to make the study more robust. Of the 24 quantitative studies, some failed to report/reported poorly on methods used for subject selection (n = 8), sample size (n = 8), estimate of variance (n = 10) and well-defined outcome measures (n = 12).

4.3. Food safety factors influencing what food consumers purchase (DB1)

Freshness and shelf life of FFV, and expiration dates on packaged goods determined which food was perceived as safe (Cheng et al., 2016; Zorba and Kaptan, 2011). FS knowledge, prior experience of FDB and fear that food was unsafe led consumers to smell or assess the foods' appearance before purchase (Ha et al., 2020; Kendall et al., 2019; Maitiniyazi and Canavari, 2021; Stanton, 2019). Vietnamese participants pointed out that those who had prior foodborne disease experience were less confident when selecting safe produce (Wertheim-Heck and Spaargaren, 2015). Consumers in China who purchased vegetables regularly, reported paying more attention to vegetable safety compared to less regular purchasers (Cheng et al., 2016). Some evidence suggested that limited FS knowledge restricted acquisition of safer foods: "*I can't*

Table 1
Key characteristics of all included studies (n = 46).

Author	Year	Country	Income quartile	Population	Number of participants	Gender	FS exposure/socio-ecological factor					DB outcome			
							Macro	Physical	Social	Household	Individual	DB1	DB2	DB3	DB4
Mixed Methods															
April-Lalonde et al.	2020	Ecuador	UM	Adults	2929	M & F	✔	✔				✔			
Bailey et al	2018	India	LM	Adults	38	F		✔				✔	✔		✔
Downs et al.	2018	Myanmar	LM	Adults	94	M & F					✔	✔			✔
Figuié	2003	Vietnam	LM	Not reported	210	M & F	✔	✔	✔		✔	✔		✔	
Figuié & Moustier	2009	Vietnam	LM	Adolescents & adults	110	M & F		✔				✔		✔	
Ha et al.	2020	Vietnam	LM	Adults	268	M & F		✔	✔	✔		✔	✔		
Lachat et al.	2011	Vietnam	LM	Adolescents	194	M & F					✔		✔		
Ramaroson Rakotosamimanana et al.	2014	Madagascar	L	Adults	1072	M & F		✔			✔	✔		✔	✔
Wertheim-Heck et al.	2015	Vietnam	LM	Not reported	2206	M & F		✔	✔	✔		✔		✔	✔
Wertheim-Heck et al.	2019	Vietnam	LM	Not reported	400	F		✔				✔			
Qualitative															
Adam et al.	2014	Ghana	LM	Adults	1106	M & F		✔					✔		
Bastami et al.	2019	Iran	UM	Adolescents & adults	42	M & F		✔							✔
Behrens et al.	2010	Brazil	UM	Adults	30	M & F		✔	✔			✔		✔	✔
Blum et al.	2019	Indonesia	UM	Not reported	Not reported	F		✔		✔					✔
Boatemaa et al.	2018	Ghana	LM	Adolescents & adults	30	M & F							✔	✔	
Correa et al.	2017	India and Canada	LM	Adolescents	73	M & F					✔		✔		
Hunter-Adams et al.	2019	South Africa	UM	Adults	78	M & F		✔							✔
Kendall et al.	2018	China	UM	Adults	42	M & F	✔	✔	✔	✔	✔	✔	✔	✔	✔
Li et al.	2018	China	UM	Adults	45	M & F		✔			✔		✔	✔	
Maitiniyazi & Canavari	2021	China	UM	Adults	61	M & F		✔			✔	✔			
Nago et al.	2012	Benin	LM	Adolescents	153	M & F		✔	✔		✔		✔	✔	✔
Pahlm et al.	2013	Nepal	LM	Adolescents	24	M & F					✔			✔	
Pham & Turner	2020	Vietnam	LM	Adults	43	M & F	✔	✔		✔	✔	✔			
Rheinlander et al.	2008	Ghana	LM	Adolescents & adults	67	M & F		✔	✔		✔		✔		
Sondari et al.	2019	Indonesia	UM	Adolescents	19	F					✔		✔		
Stanton	2019	Mexico	UM	Adults	20	M & F	✔	✔	✔	✔	✔	✔			✔
Trübswasser et al.	2020	Ethiopia	L	Adolescents	26	M & F		✔		✔	✔		✔	✔	✔
Veeck et al.	2014	China	UM	Adolescents	36	M & F		✔			✔	✔	✔		
Verstraeten et al.	2014	Ecuador	UM	Adolescents	144	M & F		✔							✔
Wertheim-Heck et al.	2014	Vietnam	LM	Not reported	176	M & F	✔	✔	✔			✔		✔	
Wertheim-Heck	015	Vietnam	LM	Adults	66	M & F		✔	✔	✔	✔	✔	✔		
Yiga et al.	2020	Uganda	L	Adults	81	F		✔						✔	✔
Quantitative															
Cheng et al.	2016	China	UM	Not reported	590	M & F		✔		✔	✔	✔			✔
Ergönul	2013	Turkey	UM	Adolescents & adults	600	M & F	✔	✔	✔		✔	✔			✔
Fatimah et al.	2011	Malaysia	UM	Adults	244	M & F		✔					✔		
Hiamey & Hiamey	2018	Ghana	LM	Not reported	315	M & F		✔			✔		✔		
Hu et al.	2017	China	UM	Not reported	4236	M & F		✔			✔		✔		
Knight et al.	2003	Jamaica	UM	Adults	110	M &F		✔		✔					✔
Lagerkvist et al.	2018	Ghana	LM	Adolescents & adults	332	M & F	✔	✔						✔	
Liu et al.	2014	China	UM	Adolescents & adults	1000	M & F		✔			✔		✔		

(*continued on next page*)

Table 1 (*continued*)

Author	Year	Country	Income quartile	Population	Number of participants	Gender	FS exposure/socio-ecological factor					DB outcome			
							Macro	Physical	Social	Household	Individual	DB1	DB2	DB3	DB4
Liu & Niyongira Nguyen et al.	2017 2018	China Vietnam	UM LM	Adults Adolescents & adults	1015 1740	M & F M & F		✓ ✓	✓	✓	✓		✓		✓
Phulkerd et al.	2020	Thailand	UM	Adolescents & adults	5634	M & F	✓				✓		✓	✓	
Sanlier & Seren Karakus	2016	Turkey	UM	Adolescents & adults	847	M & F		✓			✓		✓		
Valente et al.	2019	Brazil	UM	Adults	750	M & F	1	✓					✓		
Zorba & Kaptan	2011	Turkey	UM	Adolescents	2000	M & F		✓			✓	✓	✓		

*Footnote: L = low-income; LM = lower-middle income; UM = upper-middle income; FS = food safety; F = female; M = male; DB = dietary behaviour; DB1 = acquisition/purchase at different outlets/vendors/different neighbourhoods (e.g. shifting purchase from small, informal to larger, formal outlet); DB2 = changes in frequency eating out/vendor/venue; DB3 = food preparation (and storage); DB4 = avoiding unsafe food/eating unsafe food due to lack of alternatives/substituting unsafe food with other food (less fresh fruit/veg, more processed packaged food, more fried food, more non-nutritious food).

tell how safe food is when I buy it by myself. When I go out with my grandparents, they take care of this and ask me to figure out whether something is within the expiration date […] If I don't pay attention to expiration date, I may get sick. If I do this, I will at least have some protection" [Male, 15 years, China] (Veeck et al., 2014).

In Ecuador (April-Lalonde et al., 2020), purchasing of organic or certified foods was widespread, while in China (Cheng et al., 2016), purchase of organic foods was limited by price and availability. Study participants in China and Vietnam were motivated to grow their own vegetables to ensure their own access to safe vegetable (Ha et al., 2020; Kendall et al., 2019; Pham and Turner, 2020; Wertheim-Heck et al., 2015): *"In recent years, where have all the diseases, especially cancers, come from? Because of dirty food! We try our best to get clean food for our children's families and our grandchildren"* [Male, early 50s, Vietnam] (Pham and Turner, 2020).

4.4. Food safety factors influencing <u>where</u> (retailers) consumers purchase (DB1)

Consumers in Ecuador (April-Lalonde et al., 2020), Turkey (Ergönül, 2013) and Vietnam (Wertheim-Heck et al., 2014) reported shifting their points of purchase to small-scale producers, where they had less concerns about pesticide contamination. Different studies in Vietnam and Ethiopia suggested that traditional food outlets, such as markets or informal vendors, were considered to be less safe, but more accessible by consumers (Ha et al., 2020; Pham and Turner, 2020; Trubswasser et al., 2020; Wertheim-Heck et al., 2014, 2015, 2019): *"If they sold officially certified safe vegetables near here, then I would buy them frequently"* [Adult, Vietnam] (Wertheim-Heck et al., 2014). Three studies highlighted that trust was stronger for local produce, as consumers reported shifting their points of purchase to small-scale producers (April-Lalonde et al., 2020; Ergönül, 2013; Wertheim-Heck et al., 2014), including making the effort to travel to more rural areas to purchase safer food (animal sourced products and vegetables) (Ha et al., 2020; Wertheim-Heck and Spaargaren, 2015): *"One of my classmates sells organic vegetables or organic agricultural products […] All the animals in there are feed by coarse cereals. I went to her farms for one time. I totally trust that kind of farms*" [Female, adult, China] (Kendall et al., 2019).

Consumers assessed the cleanliness and tidiness of food outlets (April-Lalonde et al., 2020) along with food handlers' practices, food displays, packaging and climate controls, such as in-store refrigeration, before making a purchase at a food outlet (Knight et al., 2003). The supermarket was widely cited as a safe food outlet in several countries (Behrens et al., 2010; Cheng et al., 2016; Kendall et al., 2019; Knight et al., 2003; Maitiniyazi and Canavari, 2021; Wertheim-Heck et al., 2019): *"I come here [supermarket] every day, I worry about food safety, but here [supermarket] it is easy to find safe products"* [Adult, Vietnam] (Wertheim-Heck et al., 2015). Yet, the safe foods offered in the supermarket were also perceived as more expensive and less fresh (Wertheim-Heck et al., 2019). In China, participants purchased products at national and international supermarket chains, which were generally perceived as "trusted retailers" despite higher prices (Kendall, 2018). Concerns about FS were higher among Chinese consumers who spent more of their income on food and were able to afford to shop at supermarkets (Liu, 2017). Evidence from Vietnam reported that lower socio-economic (SES) consumers could not afford to shop at supermarkets: *"With my salary, I can't afford to shop at the supermarket. I know that vegetables are safe and guaranteed, but they cost twice as much as outside [at the markets]"* [Vietnam] (Figuié and Moustier, 2009). Poorer consumers were therefore dependent on traditional food vendors (Knight et al., 2003; Wertheim-Heck and Spaargaren, 2015; Wertheim-Heck et al., 2015).

Social ties, including advice from family and peers influenced acquisition of safe foods (Wertheim-Heck and Spaargaren, 2015). Building a rapport and gaining trust in a food vendor, especially in informal food outlets was mentioned in different countries as a mean of

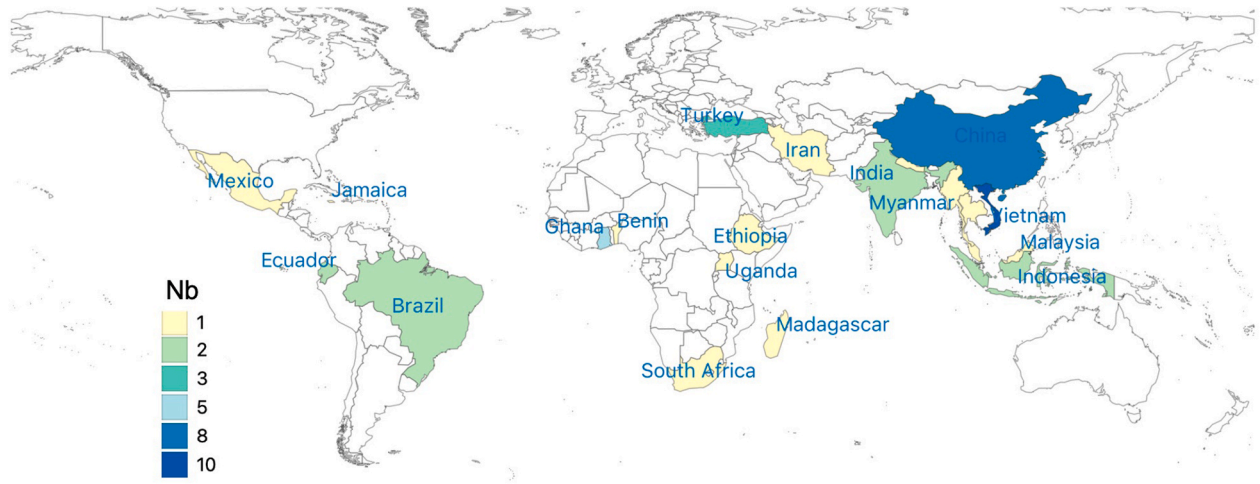


Fig. 3. Here Map showing density of food safety research-
*Footnote Nb = number of studies conducted in each country.

reducing risk and improving safety (Behrens et al., 2010; Figuié, 2003; Ha et al., 2020; Kendall et al., 2019; Pham and Turner, 2020; Stanton, 2019; Wertheim-Heck et al., 2014, 2015). One consumer highlighted this importance: *"Some months ago, I moved to this area. Before I had my regular vendor, but also here I searched for a good vendor and was lucky to find my new vendor. She advises me on what is safe and fresh to buy"* [Adult, Vietnam] (Wertheim-Heck et al., 2015). Purchasing animal sourced products from trusted butchers was also a strategy used to ensure food safety (Kendall, 2018; Zorba and Kaptan, 2011).

4.5. Food safety factors influencing eating out of home behaviors

In Asia, consumer concerns about food safety, including pesticides, chemicals and hormones in foods were also linked with eating out less often in (Kendall et al., 2019; Phulkerd et al., 2020): *"I feel nowadays many people have abused to use hormone and chemical* […] *so I am trying to only cook and eat at home"* [Male, China] (Kendall et al., 2019). Increased awareness about food safety risks and/or nutrition was also linked with eating out less often in Africa (Nago et al., 2012; Trubswasser et al., 2020) and Asia (Blum et al., 2019; Ha et al., 2020; Hiamey and Hiamey, 2018; Hu et al., 2017; Lachat et al., 2011; Liu and Niyongira, 2017; Phulkerd et al., 2020; Sondari et al., 2019).

Participants described additional food safety factors in their physical environment influenced their choice of food outlets. This link was observed in 14 studies across Africa (Adam et al., 2014; Boatemaa et al., 2018; Hiamey and Hiamey, 2018; Ramaroson Rakotosamimanana et al., 2014; Rheinlander et al., 2008), Asia (Fatimah et al., 2011; Hu et al., 2017; Li et al., 2018; Liu and Niyongira, 2017; Nguyen et al., 2018; Veeck et al., 2014; Zorba and Kaptan, 2011) and South America (Valente et al., 2019; Verstraeten et al., 2014). Food hygiene in outlets was of particular concern: *"[…] Sanitation includes but is not limited to a fresh smell in the restaurant, a clean-looking kitchen, and clean chairs and tables. You should routinely check whether there are hairs and other stuff in the food, and whether the food was washed"* [Male, 16 years, China] (Veeck et al., 2014).

Safety concerns extended to where food was prepared, cooked and sold. This illustrated that not only the hygiene of the immediate food setting matters, but also the environment surrounding the vendor was of importance. When Chinese consumers ate out of home, 48.5% reported buying food after assessing the hygiene of the vendor and of the surrounding premises (Liu and Niyongira, 2017). Participants in Ghana (Adam et al., 2014; Boatemaa et al., 2018; Rheinlander et al., 2008) also used FS awareness and prior experience of foodborne disease to assess the hygiene of a food outlet: "*there is rubbish at where she is cooking, that is how you would know that the food you will be buying is not good and it will bring you diseases so it's not good for you*" [Adult, Ghana] (Boatemaa et al., 2018). Participants in Ghana that were concerned about food outlet/vendor hygiene were also more likely to eat at restaurants as opposed to bush canteens [informal eateries] (Adam et al., 2014). Studies in Malaysia and Vietnam also reported on attention paid to the food environment's immediate hygiene, but observed that freshness, displays or food served led consumers to visit these locations more often (Fatimah et al., 2011; Nguyen et al., 2018).

Street food was generally distrusted and viewed as low quality when compared with home-cooked food: "*In fact the quality of food bought outside the homes can never be compared to food prepared at home. I only buy food from outside my home when and only when I fail to cook at home"* [Male, Ghana] (Rheinlander et al., 2008). In Turkey, only 2% of participants believed that food sold by street vendors are safe (Zorba and Kaptan, 2011). The vast majority (97.4%) of food truck consumers from a study in Brazil reported that hygiene at and around the food truck was important, stating that they (particularly men) would be willing to pay more to have safe, hygienic dishes (Valente et al., 2019). Factors like high prices and/or poor quality at school canteens have led students to shift their purchase to food outlets outside of the school (Veeck et al., 2014). Respondents also selected food outlets based on reputation or trust and not on observations of safe food handling practices (Rheinlander et al., 2008). Yet, other studies in China (Hu et al., 2017; Liu et al., 2014), Turkey (Sanlier and Seren Karakus, 2010; Zorba and Kaptan, 2011), Ghana (Rheinlander et al., 2008), India (Correa et al., 2017), Indonesia (Sondari et al., 2019) and South Africa (Hunter-Adams et al., 2019) found that consumers still take risks and continue purchasing from questionable street vendors. Affordability, preference and taste were important factors that drove consumers to maintain their eating out choices: "*We will have the road side vendors food, it's not safe having because it's open food and we don't know how they made it but it just tempts us"* [Female, adolescent, India] (Correa et al., 2017).

Indonesian mothers were reported to encourage family members to eat meals, especially breakfast, at home to reduce exposure to foodborne disease risk, as food vendors and their goods were perceived to be unhygienic (Blum et al., 2019). Parents in Madagascar distrusted small restaurants, also preferring meal preparation at home (Ramaroson Rakotosamimanana et al., 2014). Another study suggested that women were influenced by their husbands to eat out more often, despite their own food safety concerns: *"my husband likes food from outside, so I also started eating outside food"* [Female, 28 years, India] (Bailey et al., 2018).

4.6. Food safety factors influencing food preparation and storage behaviors

Participants reported that food safety during meal preparation was important to keep their families safe (Kendall et al., 2019; Knight et al., 2003; Pham and Turner, 2020; Wertheim-Heck and Spaargaren, 2015; Wertheim-Heck et al., 2015). Participants' actual or perceived knowledge of how foods are produced influenced food preparation and storage practices at home (Lagerkvist et al., 2018; Li et al., 2018; Nago et al., 2012; Wertheim-Heck et al., 2014; Wertheim-Heck and Spaargaren, 2015; Yiga et al., 2020).

Participants reported that cooking vegetables was time consuming and difficult, due to the preparation methods required to ensure safety, but pre-packaged vegetables from vendors were not prioritized as they were also deemed to be unhygienic (Yiga et al., 2020). One study in Vietnam demonstrated that social factors, such as an established relationship with vegetable vendors, could reduce time spent on food preparation at home: *"If the seller has already washed the vegetables, I even don't have to do that myself"* [Adult, Vietnam] (Wertheim-Heck et al., 2014). In Mexico (Stanton, 2019) and Vietnam (Wertheim-Heck et al., 2014), consumers reported that when they could not prepare food themselves, they looked for the most unprocessed item on the market to replace it to reduce risk.

The availability of water at home influenced the level of hygiene during food preparation in Ethiopia: *"If there's no water available when we prepare food, we might just peel the garlic and use it without washing it"* [Male, 17 years, Ethiopia] (Trubswasser et al., 2020). Using refrigeration, freezing and/or eating food soon after preparation were all cited as practices utilized to prevent safety risks within the home in Jamaica (Knight et al., 2003) and Vietnam (Wertheim-Heck and Spaargaren, 2015). Study participants in several countries described techniques used to clean fruit and vegetables to make them safer to eat. Washing hands before preparing food, washing produce before eating and using clean water for cooking was observed in Nepal (Pahlm et al., 2014) and detailed by a participant in Madagascar: *"When meals are served, the plates have been previously cleaned well, hands should be washed … that's cleanliness"* [Student, Madagascar] (Ramaroson Rakotosamimanana et al., 2014). Individuals in Vietnam were confident in their own food preparation practices, such as soaking and washing vegetables, and therefore believed that food prepared at home was generally safe (Figuié, 2003).

4.7. Food safety factors influencing the nutritional quality of diets-consumption of nutritious foods

Studies in Turkey (Ergönül, 2013), Myanmar (Downs et al., 2018), Uganda (Yiga et al., 2020) and Vietnam (Pham and Turner, 2020) reported that consumers are afraid to eat fresh fruit and vegetables due to fear of chemical fertilizers and pesticides used during production. One participant stated: "*the tomatoes, the cabbages, they grow up on pesticides, everything is sprayed with pesticides. Yes, even though we would like to eat them but when we think about the pesticides, we leave them"* [Female, Uganda] (Yiga et al., 2020). Therefore, home gardening was preferred among consumers, for example, it was reported to be associated with sufficient FFV intake in Thailand (Yiga et al., 2020). In a household survey in Vietnam, participants reported eating less vegetables due to food safety concerns (Wertheim-Heck et al., 2015). Yet, another study in Vietnam noted that fear of pesticides did not necessarily lead to a change in vegetable consumption, as participants believed in the high nutrient quality of vegetables (Figuié, 2003).

In Benin and Ethiopia, diet quality was influenced by the hygiene of the food outlet/vendor or food presentation, with unclean food outlets or environments acting as a barrier for fruit and vegetable consumption for adolescents (Nago et al., 2012; Trubswasser et al., 2020). A student described the influence family advice can have on dietary intake: "*if you want to eat mangoes or pineapple, daddy or mummy would tell you not to eat […] you will have diarrhea or something [another disease]. Otherwise, when I wake up and see a fruit, I eat it"* [Male, student, Benin] (Nago et al., 2012).

In addition to fruit and vegetables, the consumption of animal sourced foods was also influenced by food safety concerns. In Jamaica, 68% of survey participants reported discontinued purchase of meat, poultry and dairy products due to food safety concerns (Knight et al., 2003). In Turkey, consumers also mitigated perceived risk of chemicals (pesticides and hormones) by reducing their consumption of fish and poultry (Ergönül, 2013). Participants in China who had prior experience with food borne disease were also more likely to consume less animal sourced proteins (Liu and Niyongira, 2017).

4.8. Food safety factors influencing the nutritional quality of diets-consumption of ultra-processed packaged foods

Concerns about food adulteration, hygiene of food outlets/vendors, food presentation, perceived freshness of food and family safety concerns led study participants in Benin, Brazil, Ethiopia, Indonesia, Iran, Mexico and Turkey to prefer packaged foods (Bastami et al., 2019; Behrens et al., 2010; Blum et al., 2019; Ergönül, 2013; Nago et al., 2012; Stanton, 2019; Trubswasser et al., 2020). For example, in Iran, students bought pre-packaged foods because they did not want to worry about the hygiene of food sold by street vendors: *"a snack which is produced by dirty hands contains microbes and can cause illness […] Therefore, I prefer packed puffs and chips to traditional bread and cheese because they are safer"* [Female, student, Iran] (Bastami et al., 2019). Study participants from Ethiopia used food labels to decide if food was clean, which in turn increased their preference for packaged foods (Trubswasser et al., 2020). Mothers in Indonesia (Blum et al., 2019) and Mexico (Stanton, 2019) also bought more packaged snacks for their families to avoid unsafe products.

While many studies show a preference for packaged foods, some consumers within these studies, Mexico (Stanton, 2019) and Brazil (Behrens et al., 2010), expressed concerns about packaged food as potentially adulterated or expired, preferring to buy unprocessed food at wet markets: "*Packaged on January,* 19th. *I can't believe it! They say the product is fresh but the shelf-life could have been altered"* [Female, Brazil] *(Behrens* et al., *2010)*.

5. Discussion

This review aimed to synthesize evidence on how food safety might influence consumer behaviors and diets in LMICs. The studies included in this review reflect a growing interest for food safety research in LMICs in recent years. Evidence from our review suggests that food safety concerns, such as fears about contamination from pesticides from agricultural production, hygiene in and around food outlets, kinship networks with vendors and household level practices influence where consumers acquire, purchase or consume food.

5.1. Strengths and limitations

Our review followed a rigorous systematic review methodology (Rethlefsen et al., 2021), searching three databases to identify relevant peer-reviewed quantitative, qualitative and mixed methods studies. Constructing a novel analytical framework allowed us to fit food safety factors within the different levels of influence (macro, physical, social, individual/household levels) of a socio-ecological framework. This enabled us to review consumers' behaviors and diets, which often go unacknowledged. Our close look at the linkages between exposure and outcome, allowed a more nuanced understanding of the mechanisms through which food safety influences what people purchase or consume. The last noticeable strength of this study is the fact that we only considered studies that had data presenting a direct link between a food safety exposure and an outcome related to consumer behaviors or diets.

This approach however also means that 123 studies that discussed food safety in LMICs, but only reported on food safety factors without a dietary behavior outcome of interest, were not included. Finally limiting the language to English means that relevant literature in other languages were excluded.

5.2. Food safety findings and discussion

We found evidence that consumers change food acquisition patterns due to FS concerns. Although eating out of home is a common practice in LMICs, the review indicates that consumers may avoid or reduce eating out because of FS concerns. In contrast, home grown and home cooked food was regarded as safe and nutritious (even if this cannot be verified within the scope of the review). Despite their knowledge and concern, some consumers continue to eat out of home either due to lack of choice or preference for street food. In addition, easy access, low prices and convenience of street food can be more important or even outweigh consumers' concerns related to food safety.

FS practices in the home, such as hygienic preparation of vegetables and proper storage methods, are widely used as a way to ensure that food is safe to eat. However, time required to prepare food safely is often cited as a barrier (Rheinlander et al., 2008; Yiga et al., 2020). In addition, diet quality might decrease as a result of FS concerns, because consumers purchase and consume less perishable foods, such as fruit and vegetables. While packaged foods are not all nutritionally poor, several references were made to preferences for foods with ultra-processed ingredients.

Recent literature suggests that traditional consumers' mitigation strategies to decrease microbiological risk, such as boiling milk (Roesel and Grace, 2014) are no longer as efficient when consumers are presented with increased supplies of ultra-processed/packaged foods. Therefore, consumers must evaluate and manage food safety related risks, with little information or knowledge on the subject. Expressing their concerns over pesticide use in food production, consumers appeared to lack trust in the food system (Ha et al., 2020; Veeck et al., 2014). This could be due to consumers not trusting national regulations or ineffective risk communication strategies, designed to increase food safety understanding/minimize consumer risk, but failing to do so. In order to regain some control over their nutrition and health (Roesel and Grace, 2014), consumers mention forming friendships with vendors. Consumers often cited purchasing from trusted vendors as a way to mitigate these concerns (Behrens et al., 2010; Figuié, 2003; Ha et al., 2020; Kendall et al., 2019; Pham and Turner, 2020; Rheinlander et al., 2008; Stanton, 2019; Wertheim-Heck et al., 2014, 2015). As safe food items are purchased over an extended period, trusted vendors become a safeguard and are a more tangible way for consumers to reduce risk than trusting in national regulations within the food system.

As formal food outlets, such as supermarkets/formal markets often have private food safety checks and standards, consumers perceive food sold in these settings to be safer than those sold in informal settings (Reardon et al., 2009; Roesel and Grace, 2014). Despite this notion, there is a paucity of evidence on the quality of food safety in different outlets (Marshall et al., 2021). Some middle-class consumers in China and Vietnam distrust supermarkets guarantees, preferring to source food (often organic) directly from trusted farmers (Downs et al., 2018; Ha et al., 2020; Kendall et al., 2019; Wertheim-Heck and Spaargaren, 2015). These middle-class consumers order vegetables and animal sourced items online from rural areas to be delivered to their urban homes. This trend seems to be increasing among consumers in China due to the COVID-19 pandemic, opening further challenges to reassuring consumers and ensuring food safety supply chains (Zhang et al., 2020). However, low-income consumers face a different set of challenges, with supermarkets and online fruit or vegetable orders representing unaffordable and inaccessible alternatives. The 'supermarketisation' of urban areas and cities is often viewed as a way to guarantee a regulated food system. However, traditional markets, such as wet markets, often represent an important and preferred food outlet in LMICs (Béné et al., 2020; Chuvileva et al., 2020; Figuié and Moustier, 2009). Therefore, the needs and preferences of low-income consumers is important to avoid the negative effects on purchase, consumption and livelihoods. Especially as a lack of alternatives can lead poor consumers to buy what is available, despite FS concerns (Liu and Niyongira, 2017).

With the nutrition transition well underway in urban LMIC settings (Bailey et al., 2018; Baker et al., 2020; Rousham et al., 2020), the fear of poor hygiene, environmental sanitation, food contamination and adulteration of food are major concerns (Pradeilles et al., 2021) and could affect the already low consumption of fruit and vegetables in some LMICs (Bailey et al., 2018; Rousham et al., 2020). While healthy diets in LMICs are unaffordable to many (SOFI, 2020), the avoidance of fresh FFV due to FS concerns could potentially increase the already high consumption of ultra-processed foods and beverages, further disrupting progress towards current nutritional and sustainable development goals (SDGs) in LMICs (Baker et al., 2020; UNICEF et al., 2021).

5.3. Recommendations for future research

Several recommendations for research emerge from this analysis. These included increasing sample sizes to make findings more representative and generalizable (Behrens et al., 2010; Cheng et al., 2016; Ergönül, 2013; Figuié, 2003; Kendall et al., 2019; Maitiniyazi and Canavari, 2021; Pham and Turner, 2020; Stanton, 2019; Trubswasser et al., 2020; Veeck et al., 2014; Wertheim-Heck et al., 2019). Matching consumers' perceived safety risks with microbial or (bio)chemical tests to distinguish hazards from actual risks is also recommended (Figuié, 2003; Wertheim-Heck et al., 2019). This finding is supported by a study that showed that only 2% of the meat in Ibadan, Nigeria and 0% of tested milk samples in Assam state (India) met recommended standards (Grace et al., 2010). Further investigation of retail outlets and their typologies was also recommended in Vietnam, based on the need for participatory involvement (Wertheim-Heck et al., 2015, 2019). Furthermore, direct measures of the effects of food safety on consumer confidence, perceived risk and purchase intention (Fatimah et al., 2011) are needed. We also found that it was difficult to directly link influencing factors with outcomes, since many studies failed to fully assess consumer behaviors and even fewer studies collected data on actual diets. To identify opportunities for targeted and tailored future food safety interventions, data on individual behaviors and practices are needed.

Participatory inclusive risk analysis with good risk communication (Grace et al., 2010) on lived experiences (Neve et al., 2021) were also proposed by several studies in Vietnam. These studies discuss the need to listen to consumers' concerns and preferences to find retail outlets, perhaps 'hybrid structures' (Wertheim-Heck et al., 2014), that suit consumers best (Figuié, 2003; Figuié and Moustier, 2009; Wertheim-Heck et al., 2015, 2019; Wertheim-Heck and Spaargaren, 2015). Participatory approaches can guide researchers and policy makers to use a food systems approach to address all forms of malnutrition and food safety comprehensively. It was surprising that only four studies discussed the need to combine food safety into policies and practices that focus on nutrition, chronic disease and overweight and obesity (Bastami et al., 2019; Blum et al., 2019; Trubswasser et al., 2020; Wertheim-Heck et al., 2019). Overlooking this focus in food safety research on consumer behavior should be particularly salient for increasing overweight/-obesity polices and programming in LMICs (Béné et al., 2020; Shekar and Popkin, 2020).

5.4. Recommendations for policy action

The review allows us to identify a series of policy recommendations. Seven studies evoked the need to increase food safety education initiatives targeting the general population or specifically food vendors (Adam et al., 2014; Behrens et al., 2010; Correa et al., 2017; Knight et al., 2003; Liu and Niyongira, 2017; Rheinlander et al., 2008; Sanlier

and Seren Karakus, 2010). Improved regulations and/or the management or enforcement of current regulations was also frequently cited as a crucial area for change (Ha et al., 2020; Kendall et al., 2019; Nguyen et al., 2018; Sanlier and Seren Karakus, 2010; Trubswasser et al., 2020; Valente et al., 2019; Veeck et al., 2014). Certification, labelling and accreditation schemes were also suggested as a way to improve the quality of food (Downs et al., 2018; Lagerkvist et al., 2018; Maitiniyazi and Canavari, 2021). These recommendations have been further explored in a review in West Africa (Keraita and Drechsel, 2015), which concluded that regulatory measures, such as certification are not the most effective measure to improve food safety due to limited or overburdened institutional capacities (Grace, 2015; Wertheim-Heck et al., 2015; WHO, 2020). Improving and upgrading food safety in LMICs is important as most of the food system relies on the informal sector, which can have a significant impact on human and economic value.

6. Conclusion

Our findings confirm that food safety concerns influence consumer behaviors and diets. As these concerns are widespread in LMICs, they should be taken into account in food safety regulations. However, a focus on food safety and supermarket-only strategies, to reduce consumer unease about FS could distort the longer-term policy agenda away from other important issues. These trade-offs should be taken into consideration to create real solutions that ensure availability, nutritional adequacy and the safety of the food system, especially as the COVID-19 pandemic places a greater strain on food systems and dietary practices (Chuvileva et al., 2020; Fanzo, 2020). Taking the opportunity to combine these issues within the broader food system agenda, including overweight and obesity prevention or affordability of healthy foods is important. Failing to understand consumers' perceptions and behavior around these FS issues and missing the opportunity to, could further exacerbate the current unsustainability of food systems as we observe them in LMICs.

Funding

This review was supported by funding from CGIAR Research Program on Agriculture for Nutrition and Health (A4NH).

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.

Acknowledgments/Authors' contributions: MH, NB and RP defined the scope of the review. UT conducted the scoping searches to inform the review and protocol. All authors participated in the protocol writing. JL and UT conducted the search, screening, data extraction and quality assessment. JL conducted the analysis. MH and RP advised on the search, data extraction and analysis format. ALP/EL/ET served as reviewers for verifying quality appraisal, full text screening and/or data extraction. JL, UT, MH, RP wrote the first draft of the paper. All authors read and approved the final manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gfs.2021.100606.

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