

## Perspectives on food safety across traditional market supply chains in Nigeria



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### ABSTRACT

Food supply chains play a key role in ensuring food safety, as actions anywhere along the chain can impact the safety of food when it arrives at markets and in homes. However, pre-retail food supply chains are often understudied and receive limited policy attention; most work on food safety focuses on the retail or consumer level. This study helps fill these gaps by examining perceptions and actions related to food safety among the supply-chain actors who provide food to traditional markets in Birnin Kebbi, a mid-sized secondary city in northern Nigeria. Data were collected through extended in-depth interviews with producers, processors, transporters, storage providers, and wholesalers of six food commodities (including legumes, grains, vegetables, and animal-source foods). With some diversity depending on the commodity, the study found supply chain actors share similar motivations and challenges. All supply chains were dominated by men, and children were found to play a non-negligible role in supporting supply chain activities (e.g., loading vehicles). Interviewees generally had a limited conception of food safety hazards and little worry about the food they sold/handled being unsafe and were confident that they could detect food safety/quality issues through simple (mostly visual) signs. Interviewees generally reported that their clients had little concern about food safety or interest in discussing it. Worries related to price fluctuations and limited perception of their responsibility emerged as barriers to supply chain actors' adopting food safety practices. These barriers seemed highest for transport providers, who stood out as being less well organized into associations; less vested in and knowledgeable about particular commodities; and feeling particularly little responsibility for food quality/safety. The importance of repeat relationships of trust to maintain their livelihoods, strong social norms, and rapid uptake of an emerging safe-storage technology were all identified as factors potentially facilitating improved food safety. The results are discussed in the context of the literature to consider potential approaches and inroads for improving food safety along the supply chain in Nigeria, with potential lessons for LMICs more broadly.

### 1. Introduction

Foodborne disease is a major public health problem stemming from the food system. It is responsible for an estimated 600 million illnesses and 420,000 premature deaths annually, as well as major economic costs, particularly in sub-Saharan Africa (Havelaar et al., 2015; Jaffee et al., 2018). Contaminants that can make food unsafe include foodborne pathogens (viruses, bacteria, protozoa), natural or synthetic

chemical contaminants, or other adulterants. For instance, animal-source foods are often vulnerable to contamination by pathogenic bacteria such as *Salmonella* or pathogenic *Escherichia coli* (Persad & LeJeune, 2015; Rhoades et al., 2009; Rouger et al., 2017; Thomas et al., 2020). Fresh vegetables can also become contaminated with pathogenic microorganisms (e.g., via animal manure or irrigation water) or with pesticide residues and other chemicals (Wadamori et al., 2017). Grain and pulses can become contaminated by microorganisms, can be

*Abbreviations:* GLV, green leafy vegetables; LMIC, low- and middle-income countries; PICS, Purdue Improved Crop Storage bags; SCA, supply chain actor

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susceptible to mycotoxin contamination (Neme & Mohammed, 2017), and can harbor pesticide residues (Anzene et al., n.d.; Sonchieu et al., 2010).

Nigeria, as a transitioning lower-middle-income country with considerable urbanization, is among the countries for which food safety concerns are at their most critical due to rapid economic, demographic, and dietary change but limited food safety management capacities (Jaffee et al., 2018). In Nigerian markets/abattoirs, studies have found pathogenic bacteria and toxins (such as those described above) in 15–60 % of raw vegetables, 14–22 % of beef, 2–10 % of dairy products, and 100 % of smoked fish (Grace et al., 2018).

The food supply chain or value chain refers to all activities that bring food products to consumers, including primary production, processing, storage, distribution, and wholesale and retail (Gómez et al., 2011), and food contamination found at the retail level could be introduced at any stage of the supply chain. Improving food safety thus requires working across a whole supply chain to ensure food is kept safe as it moves from farm to fork (Aworh, 2021; Chamhuri & Batt, 2013; Ortega & Tschirley, 2017). Doing so requires understanding (and potentially influencing) the motivations, attitudes, beliefs, and practices that shape the food safety-related decisions of those working in supply chains.

However, very little work on food safety in Nigeria, as well as in other low- and middle-income countries (LMICs), focuses on the supply chain as a whole. Most such work examines global supply chains serving high-income countries or specific supply chains within those countries (e.g., Attenborough & Matthews, 2000; Hernández-Rubio et al., 2018; Machado Nardi et al., 2020; Nanyunja et al., 2016), or on individual supply chain segments. An exception to this is Wineman and Liverpool-Tasie (2022), which surveyed a broad set of stakeholders, including but not limited to supply chain actors, to understand their perceptions of the most pressing challenges faced by small businesses in fish and vegetable supply chains in Nigeria. That study found a clear prioritization of food affordability as opposed to food safety and noted that a lack of knowledge was considered a key barrier to improving food safety, but it did not examine supply chain actors' perceptions related to food safety in detail. Among studies of particular supply chain segments in Nigeria and other LMICs, most focus is either on primary production (e.g., Arif et al., 2017; Johnson et al., 2018; Udomkun et al., 2018) or on the final step in the supply chain: retail vendors and food service providers. In particular, studies on ready-to-eat food vendors' practices are extensive (e.g., Adesokan et al., 2015; Aluh & Aluh, 2017; Aluko et al., 2014; Oladoyinbo et al., 2015). In contrast, the 'midchain' portion—i.e., the wholesale, transport, storage, and processing segments—is often understudied and receives limited policy attention in general (AGRA, 2019; Reardon, 2015), or in research in Nigeria.

Moreover, existing research on food safety issues within supply chains tends to rely on quantitative surveys (e.g., 'knowledge, attitude and practice (KAP)' surveys, used extensively in Nigeria (Nordhagen, 2022) and other LMICs (Wallace et al., 2022)) or chemical or microbial analysis (e.g., Liverpool-Tasie et al., 2019), not qualitative methods. However, qualitative methods can be well suited to understand the motivations, beliefs, and attitudes of food chain actors. Some notable exceptions include a small qualitative study examining vendors of grilled meat skewers in Abuja, which sought to uncover the roots of respondents' food safety conceptions and motivations, noting connections to their religious or cultural background (Iwar, 2017), and three studies on meat sellers in Ibadan, which noted the importance of gender roles and fatalistic attitudes in shaping food safety practices as well as challenges with implementing improvements (Grace, Dipeolu, et al., 2012; Grace, Olowoye, et al., 2012; Grace et al., 2019). These exceptions aside, there remain large gaps when it comes to understanding supply chain actors' perceptions of food safety, the salience of food safety as a concern, or cultural and socioeconomic issues that might influence food safety-related behaviors.

This study helps fill these gaps by examining perceptions and actions related to food safety among the supply-chain actors who provide food to traditional markets in Nigeria. The study focuses on the supply chains supplying Birnin Kebbi, a mid-sized secondary city in northern Nigeria. Secondary cities are generally underrepresented in the literature on food systems despite being key drivers of urbanization and local economic growth (Resnick et al., 2019). The study examines two interrelated questions: How do supply-chain actors (SCA) understand and recognize issues related to food safety? What actions do they take related to food safety? To understand entry points for strengthening food safety, it also asks: What are SCAs' challenges, motivations, and relationships within the supply chain? The results are discussed in the context of the literature to consider potential inroads for improving food safety in Nigeria and to draw insights that could be applied to LMIC supply chains more broadly.

## 2. Methods

The study, implemented as part of the USAID Feed the Future-funded EatSafe program, focused on SCAs who supplied at least one of three main markets in Birnin Kebbi, the capital of Kebbi State in northwestern Nigeria (population 360,000, 2016 est.). The supply chain roles considered were primary producers (farmers), transporters, storage providers, wholesalers, and processors, with a focus on wholesale and processing due to the high potential for contamination, proximity to retail, and gaps in prior research. Sampling was undertaken to cover a range of SCAs and commodities. The focus commodities were chosen to cover diverse varieties (grains, legumes, vegetables, and animal-source foods) and in alignment with stakeholder priorities.

Thirty-four SCAs were interviewed; while this is a small sample by the standards of quantitative surveys, it is typical for a qualitative study, which usually aims for 'data saturation' (i.e., capturing most views on a topic within a population) as opposed to statistical representativity (Pelto, 2013). To be included, SCAs needed to be over age 18; regularly play a role in supplying at least one focus food to at least one target market, including through wholesale, transport, warehousing, processing, or production; speak English or Hausa; and be able and willing to give informed consent. The study aimed to interview both female and male SCAs, but there were few women involved at certain supply chain stages (e.g., transport, wholesale) and for certain commodities (e.g., beef). Men are thus more heavily represented.

SCAs were recruited through snowball sampling beginning with vendors at the three markets who were randomly selected for interview for a prior study (Nordhagen et al. 2022a; 2022b). The field data collection team contacted 10 vendors, randomly chosen from the prior study's interviewees, and covering all six focus foods and asked these vendors to refer them to actors within their supply chain. In total, the vendors referred 35 SCAs; these SCAs were then asked to refer other SCAs within their supply chain, resulting in an additional 10 referrals. Of the 45 potential respondents, 10 refused to participate, all due to time constraints, and five were found to be ineligible. Of the 30 eligible and willing SCAs, five were excluded at random because the relevant sampling quota for their food/role was already filled. To recruit the remaining interviewees, in line with the needed food-role quotas, market management officials were asked to refer potential respondents. Ten referrals were received, and respondents were selected randomly from this list within each food-role category. The final sample was as in Tables 1 and 2; all quotas for supply-chain activity were met, but two foods (green leafy vegetables (GLV) and maize) had only three respondents, not the four or more originally sought.

Data collection, conducted in September–October 2021, consisted of detailed, in-person semi-structured interviews in Hausa. All interviewers were local to the region, fluent in local languages, had extensive interviewing experience, and completed a week-long training. Interviews typically lasted 90 min to 2 h and covered a range of topics related to the actor's role, their challenges and motivations, and how

**Table 1**  
Study sample, by SCA type and commodity.

Supply chain actor	Food						Total
	GLV	Beef	Fish	Maize	Rice (local)	Cowpea	
Primary producers (farmers)	2	0	0	1	2	1	6
Transporters	0	1	2	0	2	0	5
Storage	0	1*	1	1	1	0	4
Wholesaler	0	2	3	0	2	4	11
Pre-Retail Processor	1	2*	2	1	2	0	9
<b>Total</b>	<b>3</b>	<b>5</b>	<b>8</b>	<b>3</b>	<b>9</b>	<b>6</b>	

\*Indicates one respondent with multiple roles.

they perceived food safety issues within the supply chain. The interviews used detailed interview guides, which included various optional prompts for follow-up. These were designed based on those used in prior qualitative studies of food safety in Nigeria (Nordhagen et al., 2022a, 2022b), drawing on the ‘focused ethnographic study’ technique developed for use in qualitative studies of public health topics by Pelto and co-authors (Cove & Pelto, 1993; Pelto & Armar-Klemesu, 2011, 2015).

All interviews were audio recorded, then transcribed verbatim into English. Demographic data were entered via tablets. All participants provided signed informed consent, and the study was reviewed and approved by the National Health Research Ethics Committee of Nigeria, Approval Number NHREC/01/01/2007-20/08/2021.

Demographic data were analyzed using Stata SE15, and transcripts were analyzed using ATLAS.ti. Text data from the transcripts were subjected to analysis involving multiple passes following the six-phase framework of Braun and Clarke (2006): 1) familiarization with the data, 2) generating initial codes, 3) searching for themes (Spradley, 1979), 4) reviewing themes, 5) defining themes, and 6) reporting themes. Through this process, the analysis was driven by the data itself (not pre-existing hypothesis), drawing on the grounded theory approach (Corbin & Strauss, 2008). However, to improve the ability to draw wider conclusions and compare to existing research, we also used prior studies (Nordhagen et al., 2022a, 2022b) to develop the starting codebook; this was added to (and subtracted from) iteratively during analysis, based on the insights emerging from the data. Quotations illustrative of either shared opinions or particularly interesting divergences from those are included throughout the text; aside from small corrections to grammar

and punctuation, these are presented verbatim from the English transcriptions. Each is associated with an anonymous respondent code.

### 3. Results

Respondents’ demographic characteristics are summarized in Table 1. Compared to vendors in the markets they serve (Nordhagen et al., 2022a), SCAs were similar in gender breakdown, age, ethnicity, and religion but were more educated.

#### 3.1. Structure of the studied supply chains

Scenes from various nodes of the GLV supply chain, as an example, are illustrated in Fig. 1. The studied supply chains varied in length and number of intermediaries. The shortest, simplest supply chain was that for GLV, wherein farmers often sold directly to retailers (and sometimes consumers), with no pre-retail processing and only some use of wholesalers. In contrast, the (domestic) rice supply chain was the most complex, often passing through multiple wholesalers and undergoing multiple steps of processing (i.e., de-husking, polishing, parboiling). The maize supply chain was similar in structure to that for rice (with shelling and milling as processing stages), while the cowpea supply chain was somewhat simpler, but with limited processing. Both animal-source foods, beef and fish, had relatively simple supply chains, with fish being sold (usually live) by fish farmers or fishermen to wholesalers, who sold to retailers, with only a small amount being processed (i.e., smoked or dried) before sale. The beef supply chain was similar, though from the trader cattle passed through an abattoir before meat was sent to retailers.

**Table 2**  
Respondent demographic characteristics.

<b>Respondent characteristics</b>	
Percent male	88 %
Average age (range)	43 (19–58)
Ethnicity	Hausa (94 %), Zuru (6 %)
Religion	Muslim (100 %)
Pct. completing primary school	71.5 %
Pct. completing secondary school	44.1 %
Pct. completing tertiary school	5.9 %
Avg. years in role (range)	19.6 (3–40)
Respondent is the household’s principal income earner	77.8 %
Respondent has another income source	41.2 %
Other income sources	Farming or livestock (7 of 34); vending (4), other (5)
Avg. number of household residents (range)	12.2 (2–30)
Ownership of ICT	Radio (65 %), TV (53 %), mobile phone (100 %)
Pct. Living in Poverty at 1.90 PPP/person/day	10.3 % (at 1.90 PPP/person/day); 33.8 % (at 3.10 PPP/person/day)
<b>Business characteristics</b>	
Focus foods supported	Fish (24 %), GLV (9 %), beef (15 %), cowpea (18 %), maize (26 %), rice (24 %)
Supports additional non-focus foods	50 % (primarily other grains and legumes)
Pct. with employees	76 %
Average num. of employees (range)	5.76 (0–40)
<b>N</b>	<b>34</b>

Note: likelihood of living in poverty is calculated using the Poverty Probability Index (PPI), using a threshold of 1.90 or 3.20 PPP (purchasing power parity) per person, per day (IPA, 2020).



**Fig. 1.** Images illustrating supply chain nodes in traditional markets in Kebbi State. (A) Transporters conveying vegetables to a wholesale market. (B) Wholesalers receiving a shipment of GLV at a wholesale market. (C) Retail vendors procuring fresh produce from a wholesale market.

Nearly all studied foods originated in Kebbi or neighboring states, though cattle were also brought from Niger.<sup>2</sup> The mid-chain roles of aggregation, wholesaling, and storage were more significant for grains and legumes than fish, meat, or vegetables. Of all foods examined, only maize had a considerable non-food market (for feed and beer-making), which was not examined here. Transportation providers could appear at numerous supply chain steps; while some transport was provided by another SCA (e.g., wholesalers), most food was transported by third-party transporters (i.e., hired trucks). Cold storage was very rarely reported as part of any of the studied supply chains: for example, only one of three beef processors had access to a working refrigerator. Casual laborers were integrated into supply chains at many stages, particularly for loading/unloading goods before/after transport. In most cases, SCAs rarely interacted with end consumers.

Fig. 2 shows a simplified description of the fish supply chain; similar diagrams for other commodities' supply chains are included in [Supplementary materials](#).

### 3.2. SCAs' challenges and motivations

Across all supply chains and roles, similar challenges emerged: price fluctuations or increases (the most-cited issue), insecurity/banditry, non-repayment of credit, lack of credit/capital, bribery from government officials (e.g., at road security checkpoints), customs expenses and hassles, limited transport, and insufficient customers. Transporters also cited high fuel prices, poor road quality, and frequent repairs due to poor roads. Additional challenges noted within the beef supply chain were scarcity and animal mortality; those in the fish supply chain also noted fish dying as a common challenge. Grain wholesalers and processors named product loss during storage or processing.

*Banditry has caused scarcity and increases in prices for cows; what we [once bought at] ... 100,000 [Naira], we buy it at 700,000, and the one of 700,000, you must buy it at above a million. Before with a million you can buy four cattle, but now it's a different game altogether! – 3309, 55-year-old male beef wholesaler*

Most respondents had entered their line of work due to it being in the family, having friends already working in it, or not having other options; few had sought the work out deliberately. As one fish wholesaler put it, “I don't know any other business that I can do” (3331). Motivations to work in the role were mainly related to simply earning a living: making an income and feeding one's family. A few SCAs did note, however, gaining satisfaction from providing others with food at reasonable prices or through their relationships with supply chain colleagues.

Across all commodities and roles, SCAs cited similar key qualities for success: honesty, patience, perseverance or determination, and relating well with people or being friendly/accommodating. Being knowledgeable about the particular commodity and having capital were also named as important—as was faith in God. For transporters, punctuality, well-maintained vehicles, and speed were all named as important. Religion (in this case, Islam) was commonly noted across interviews as a motivator and determinant of success.

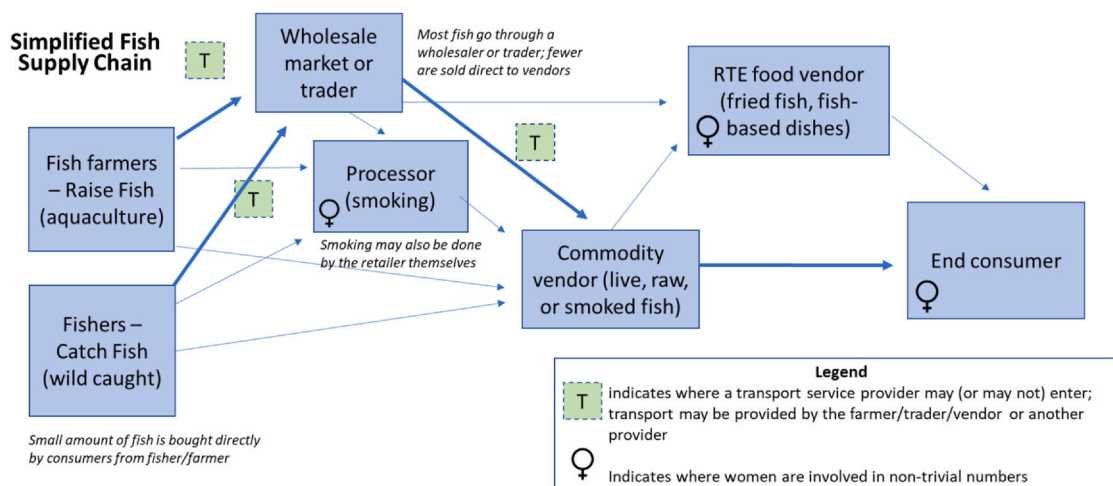
### 3.3. Relations within the supply chain

It was common to have repeat customers throughout the supply chain, and trust and a strong reputation were important in maintaining clients. Strongly related to repeat, trusted relations was credit provision: this was important across the supply chain for both attracting customers and maintaining links with suppliers. Retailers often purchased from wholesalers or processors but did not pay until they had sold the product. Credit was also a cause of challenges for many, due to non-repayment and feeling obligated to provide credit regardless.

In general, there was considerable collaboration cited among SCAs within each supply chain – both across different segments in the chain and among actors within each segment. This included discussing shared concerns, sharing resources, providing loans, or referring customers.

*My colleagues in the driving job, we have a good relationship between us. Myself, if I have plenty of jobs, I call maybe one of them to come and assist me, and then when we are done, we then know how we will share the money so that everybody will get something from it. Same goes for them; when work is too much for them, they do call me, too, to come and assist them. – 3314, 39-year-old male fish transporter*

<sup>2</sup> Rice is also imported from outside Nigeria, usually Asia, but this study focused only on locally produced rice.



**Fig. 2.** Simplified depiction of the fish supply chain into Birnin Kebbi. Arrow weights indicate more or less significant flows with heavier and lighter weights, respectively. RTE – ready-to-eat.

One emergent result across several supply chains was the concept of setting a fair price (with little mark-up beyond the purchase price), summed up as: “If you get it cheap, sell cheap; if you get it expensive, sell expensive” (3325, a 52-year-old male beef processor). Adding too much markup was seen as a way to lose client trust and as being “un-fair.” Several respondents mentioned that setting a fair or common price was a regular topic of conversation among SCAs.

An emergent result from the analysis was that children (mainly boys) play a role in all six supply chains. Though no questions were asked about children’s roles specifically, half of respondents mentioned them. Children were noted as helping prepare meat in the market, fetching goods from the processor/wholesaler, delivering goods to customers, loading/unloading goods, helping with sales, packing goods, shopping for their household, and selling ready-to-eat foods.

The Kebbi region is primarily Hausa Muslim and fairly religiously conservative. In line with this, all supply chains studied were highly gendered: women played a role in preparing and selling ready-to-eat foods and in processing certain foods (e.g., smoking fish, parboiling rice). Otherwise, women’s supply chain roles were minor, particularly in transportation, trading, and wholesale. The main explanations given for this limited role were tradition or culture, but various aspects of character or capacity (e.g., the work being hard or requiring travel) were also mentioned; restrictions were particularly tight for married women.

*[There are fewer women selling beans] because they don't know about the business of beans, they think it's hard... because of the difficulty involved, because this our trade, you have to fasten your belt, you have to go to the bush. - 3310, a 41-year-old male cowpea wholesaler*

Across supply chains, most respondents belonged to a formal or informal professional association specific to their commodity or supply chain role. The exceptions to this were for those processing and selling ready-to-eat foods (largely women), who generally belonged to no association and reported little collaboration with others in their role. Beef processors were the most strongly and specifically organized, through a national butchers’ association. The main advantages seen of such associations were conflict resolution, legally protecting members in disputes, sanctioning misbehavior, sharing information, collective problem-solving, government advocacy, protection from harassment by inspectors, and credit access. A few interviewees noted that, while they belonged to associations, membership offered them few benefits. Only two respondents (both fish wholesalers) noted the association helps ensure food safety and quality.

In all supply chains, transporters stood out from other SCAs in several ways. They were hired service providers and typically had little

expertise or interest in particular foods. They were not well integrated with other actors within the supply chain; when they belonged to associations, these typically included diverse transport providers, such as bus and taxi drivers. They had less agency than, for example, wholesalers, as they did not have much choice in their clients or the types of products they transported and did not own those products. They did not interact with end consumers and thus did not express being particularly responsive to their concerns. While some engaged in repeat interactions with the same customers, this was less common than for other SCAs. They reported few demands being placed on them by their clients, other than to deliver on time. Overall, they saw themselves as playing isolated roles, with limited interactions with those beyond their direct suppliers and clients and limited interest in any broader supply chain actions.

*I don't really select them [my clients]... There are no real questions asked between us [my clients and I], just that if they know where we will go to bring fish, they just let me know, and then we go... - 3314, a 39-year-old male fish transporter*

### 3.4. Perceptions of food safety

Interviewed SCAs generally saw food safety as narrowly related to specific traits of the commodities they sold. For fish, safety and quality were seen in one way: the fish being alive and appearing healthy. Meat safety, similarly, was seen as being related to the health of the animal and the time since slaughter. For GLV, safety was seen as freshness and a lack of insect damage; for cowpea, it was a lack of weevil infestation and chemicals used to prevent such contamination. Rice and maize were seen as having limited safety issues, primarily related to being insufficiently dried, stored too long, or containing stones. Across all commodities, respondents did not generally make a clear distinction between food safety issues and broader food quality issues.

In line with these conceptions, SCAs generally had specific signs and heuristics they used to assess safety/quality. For example, a lively, moving fish was considered a safe fish; safe meat could be identified by being shiny, fresh looking, and having a red color while “bad” meat would be yellowish or black in color; and “good” leafy greens would have strong green leaves and no apparent insect damage. SCAs generally expressed confidence that, by using these signs, they were well able to detect the “good” products. In the words of one fish wholesaler, “just looking at the fish, you will know that it is not looking healthy” (3331).

Customers, similarly, were perceived by SCAs as using visual signs and heuristics to determine quality: “A customer knows good maize

when he sees it” (3305, a 50-year-old male maize storer). While maintaining food quality in line with these signs was seen as essential to ensure sales and thus profits, food safety, per se, was not seen as a major concern among customers in five of the six of the studied supply chains. For example, respondents felt that “bad” rice was easily identified and would be discarded during processing/sorting and not sold. As one explained, “When rice is spoilt, it won’t even be edible—not to talk of eating it, you won’t be able to cook it, so you will know it is bad” (3321, a 38-year-old male rice storer). And as one 39-year-old male fish transporter noted, “I am sure I have never brought any fish with any issues, except for the one that is dead” (3314, a 39-year-old male fish transporter).

In line with this general lack of knowledge and/or concern, respondents noted that customers asked few questions related to the products’ quality – and almost none about their safety. Even for meat, for which respondents understood that poor quality could be harmful, they noted that customers did not normally ask questions about meat safety or quality. Instead, they would assume it, given the reputation of the seller and the existing relationship, or it could be easily determined through a visual inspection: “They don’t ask any questions; by seeing the meat, they know it is healthy” (3325, a 52-year-old male beef processor). For rice, SCAs reported that client questions focused only on the variety and price; for GLV and fish, customers focused almost entirely on price and judged quality only through a visual inspection. This lack of discussion on food safety also extended to conversations between the SCAs and their suppliers.

*Interviewer: Is there anything you have explained to your customers or advised them on regarding the safety of the food?*

*Respondent: Most come and don’t bother with such. They only care about the price; once they know that, then they either buy or leave. – 3308, a 45-year-old male rice wholesaler*

*Interviewer: Have they [wholesale clients] ever shown any worry concerning the quality or healthy look of the spinach?*

*Respondent: Honestly, concerning that, there is no one that has ever shown any worry.... Ever since I started this work, I have never been faced with a situation that someone bought spinach from me and after consumption it caused illness or problems. - 3326, a 36-year-old male vegetable producer*

*Interviewer: Do you ... ask questions from people you are buying fish from?*

*Respondent: Mostly there is no need to ask questions because we know the good fish. - 3327, a 19-year-old female fish post-retail processor*

This lack of concern was true even for beef SCAs. While they, more than SCAs for any other commodity, recognized the potential for their product to be unsafe (voicing various issues associated with meat and the need for controls), they were confident that the systems in place (primarily veterinarians inspecting at abattoirs) would prevent unsafe beef from ever reaching customers. They thus were not worried about safety as an issue. Similarly, unsafe meat was not seen as something that customers were concerned about, due to their trust in the system, the suppliers, and a visual inspection (as noted above). Relatively little mention was made of the possibility of contamination after slaughter: most opined that if the cow was healthy at slaughter, then the meat was okay to eat.

*Interviewer: Are [your customers] worried about the healthy state of the meat?*

*Respondent: Well, it’s hard to see the meat that is not healthy, since we always slaughter them [the cattle] in the market and the veterinary doctors test their health before slaughter. – 3325, a 52-year-old male beef processor*

Food safety or hygiene was thus generally not seen as a major motivator of customers’ choices and was not a key concern among the

SCAs. The exception to this lack of concern was cowpea. Weevils were seen as a key food quality/safety issue with cowpea (although they are not a cause of foodborne illness) and one which might prevent a sale. Customers were reported as also frequently asking questions or raising concerns about chemicals used to treat the cowpea and prevent weevil infestation.<sup>3</sup>

*Most times when people go to the market, they don’t like buying beans because they used to say they don’t know the type of medicine [chemical treatments] the farmers put in the beans... The wrong medicine [can make them harmful]. – 3304, a 50-year-old male cowpea producer*

*When they [customers] come and see the beans very clean and well processed and prepared, and then they see that it does not have any smell of chemical and when you eat it your mind will be at rest, this is what will make them choose. – 3319, a 49-year-old male cowpea wholesaler*

### 3.5. Food safety-related actions and responsibility

Most SCAs noted actions they took to ensure the food they handled was safe or of high quality. Actions to mitigate food safety risks in the beef supply chain included buying healthy-looking cattle, treating any sick cattle, ensuring the involvement of veterinarians at the abattoir, throwing away any condemned meat, and avoiding prolonged storage. One respondent each noted washing storage spaces, washing working areas, washing vehicles, washing meat, ventilation, cooking meat, and minimizing touching of meat. One wholesaler noted that, when dealing directly with end consumers, it was essential to be clean: “If you come to buy meat and you meet a butcher who is not neat, will you buy it?” (3334). Within the fish supply chain, actions were simple and focused on keeping fish alive by maintaining clean water and appropriate temperatures.

The steps taken to keep GLV safe included washing them, keeping a clean environment when selling or cooking, and covering them when selling. Farmers also mentioned avoiding the use of chemical fertilizer (instead favoring manure). Actions taken to ensure rice quality/safety were to carefully sort out stones; store rice in a clean place; protect it from rodents and insects; use insecticide in the storage area; and cover it during transit. Similarly, the actions taken to prevent quality issues with maize were to dry maize well on the farm, carefully sort out any stones/chaff, sell it quickly, use improved storage bags and seal them well, use pesticides in storage areas but limit the use of chemicals on the grain, keep storage areas clean, and prevent customers from contaminating grain with dirty hands.

*The only thing I do is that where I will want to keep it [the rice], I make sure I sweep it thoroughly to avoid sand and then worms or nails that might tear the sacks and then spray insecticides—not in the food but on the spot where I feel the insects might come to. So, a buyer likes it more when they see the food in good condition. – 3318, a 40-year-old male rice producer*

The main actions taken to ensure high-quality or safe cowpea included proper storage, ideally using new high-quality hermetic storage bags<sup>4</sup>; applying rat poison in any storage area; and sorting them carefully.

*That very sack I am talking about [PICS bag] is attached to polyethylene leather, so air cannot penetrate it, not to talk of reaching the*

<sup>3</sup> Indeed, the extensive use of storage chemicals on cowpea by traders in Nigeria and possible poisoning of consumers as a result has been noted elsewhere as a matter of public concern, which has received considerable local news coverage (Diallo, 2016).

<sup>4</sup> Though interviewees describe them as “leather”, these are PICS (Purdue Improved Crop Storage) bags, a triple-layer hermetic sealed plastic bag that can be used for grains or legumes.

*beans that will result to developing the weevils. Because weevils are also living things, so if that air is not there, it cannot survive, so even if there was a weevil that was already growing, once the beans have been put into that sack, the weevil will die. – 3319, a 49-year-old male cowpea wholesaler*

Aligning with the analysis of transporters' supply chain role above, transporters described a particularly limited role in ensuring food safety. They reported rarely or never discussing quality and safety topics with other SCAs, and they felt they had little to lose from any loss in quality or safety that occurred during transport as long as this did not visibly degrade the product (e.g., in the case of dead fish).

*I can't identify [healthier or safer foods] because it's not my work... The only way I do know is through the weight of the goods I'm carrying: some instances I carry 100 bags of grain today, and I carry the same 100 bags tomorrow, and find out that one is heavier than the other, [but] I do not know the heavier ones are healthier. – 3317, a 31-year-old male rice and maize transporter*

*No, [ensuring the safety of the food] it's not my responsibility, mine is just to deliver the goods safely. – 3330, a 40-year-old male rice transporter*

Considering responsibility for keeping the foods they handle safe; most respondents saw this as belonging to someone other than themselves. For example, cowpea SCAs generally cited the farmer, though two wholesalers also mentioned the vendor or wholesaler, one wholesaler pointed to the person responsible for storage, and a ready-to-eat food vendor cited either God or doctors. Few mentioned government authorities playing an active role in food safety, except the beef supply chain. As one noted, “there is no authority that supervises us other than God” (3315, a 50-year-old female GLV processor into ready-to-eat foods). Very few reported any interactions with government officials related to food quality or safety; nearly all interactions mentioned had to do with customs officials or transport/road safety authorities. Indeed, most interviewees mentioned government authorities in terms of what they were *not* doing – e.g., not supporting infrastructure, not fixing roads, or not controlling price increases.

The exception to this was the beef supply chain, for which actors cited the involvement of licensed veterinarians who undertook inspections at the abattoir (when cattle arrive and of meat after slaughter) as well as market-based authorities who would inspect the meat upon arrival at the market. Overall, beef SCAs had positive perceptions of the role of veterinarians—even though they could cause losses if ordering meat to be disposed of. They saw them as ensuring meat's safety and, in the process, allaying potential fears of customers.

*There is no way we will allow anything to happen to the place we store the meat because we have doctors that will ensure that everything is safe, so there is no way there's going to be an issue. – 3311, a 52-year-old male beef storer and processor*

#### 4. Discussion and conclusion

This study examined the roles and perceptions of supply chain actors as related to food safety along a set of supply chains for diverse food commodities in northern Nigeria. The results indicate several challenges in supporting food safety in these supply chains – as well as certain opportunities.

Regarding challenges, SCAs were found to have only a limited conception of food safety hazards (focused on a few narrow issues specific to a given food), to have little worry about the food they sold/handled being unsafe, and to be confident that they could detect “good” and “bad” food through simple (mostly visual) signs. Of note, no respondents mentioned aflatoxins or similar contaminants – even though it is estimated that over 60% of maize in Nigeria has high aflatoxin levels (UNIDO et al., 2010). Respondents also did not explicitly mention germs (or indirectly, hygiene or cleanliness), although microbial

hazards are responsible for most foodborne disease in the region containing Nigeria (Havelaar et al., 2015).

This limited food safety awareness aligns with prior research highlighting that Nigerian stakeholders in similar food supply chains under-emphasize the importance of food safety (Wineman & Liverpool-Tasie, 2022) and that mid-supply-chain enterprises in LMICs more broadly implement inadequate food safety practices (Reardon et al., 2021). In practice, most foodborne hazards are invisible and can be introduced at any stage—such as through storage in unclean areas, exposure to contaminants during production or transport, contamination during processing, or unhygienic handling at any point (Aworh, 2021; Fraser & Monteiro, 2009; Jaffee et al., 2018). While some of these hazards can be mitigated by actions downstream in the supply chain (e.g., consumers washing vegetables before use), this is not true of all – and consumer food safety knowledge and practices in Nigeria have been found to be imperfect (Nordhagen, 2022). As knowledge and motivation to act are often seen as essential pre-requisites to behavior change (Ajzen, 1991; Pappa et al., 2018; Rezaei et al., 2018), the results presented here suggest considerable barriers to improving food safety within the studied supply chains. As underscored by other authors, awareness-raising on the importance of food safety in Nigeria will be critical (Wineman & Liverpool-Tasie, 2022).

While some SCAs interact with end consumers and thus could be motivated by those consumers' perceptions and choices (which prior research in Nigeria has shown to somewhat include food safety, ()), most do not. This is particularly true of producers and transporters. Moreover, interviewed SCAs reported that their clients had little concern about food safety or interest in discussing it (except for cowpea). This limited importance of food safety as a motivator for buyers indicates that SCAs are unlikely to be rewarded for taking steps to ensure it.

Prioritization of price factors and worries about price fluctuations were common among SCAs, which could limit their ability to take action to prioritize food safety, were it to come at a cost—a common barrier to adopting improved food safety practices (Pappa et al., 2018). The same could be true for credit, which made some SCAs dependent on existing, repeated relationships and thus limited their flexibility in choosing clients. SCAs were also highly constrained by a lack of access to infrastructure: in particular, no respondents had access to dependable cold chain technologies, which greatly facilitate maintaining food safety (James & James, 2010). This indicates that interventions will need to work around this limitation or foster increased access. The jobs within the studied supply chains were noted as being typically taken by default or due to lacking other options, not actively sought, further limiting SCAs' likely motivation to improve their practices.

While several different SCAs were named as responsible for ensuring food safety, most respondents did not name themselves (or their role) as being among them unless explicitly asked. This suggests a need to first raise awareness of how food safety can be affected by actions all along the supply chain, before working to increase capacity to undertake any food safety-related practices. Aside from the beef supply chain, authorities were cited as playing only minor regulatory roles, and many respondents voiced negative views of the government, complaining about a lack of government support, bribery, or hassling from officials (a well-documented phenomenon in Nigeria (Onodugo et al., 2016; Resnick et al., 2019)). Future interventions with SCAs would thus need to consider both appropriate government roles and other entry points. Official interventions to improve food safety have been shown to err on the side of overly stringent regulations that can hurt or antagonize smaller SCAs (Grace et al., 2019; Miewald et al., 2013), making right-fit interventions key—particularly in an atmosphere of government mistrust. One potential alternative inroad is the associations (formal and informal) to which most respondents belonged. Though respondents were divided in terms of how useful they saw these, some did see them as supporting their work and could be receptive to messages from them. Within agriculture, farmer associations and cooperatives have been widely used to promote uptake of improved practices (Bizikova et al., 2020).

At the same time, the results revealed some potentially strong leverage points for action. Some SCAs gained satisfaction from providing others with food, and there was a strong norm that food should be sold at reasonable prices, suggesting values of solidarity and community service could be leveraged to increase concern about providing safe food (in addition to fairly priced food). Other SCAs noted the importance of their relationships with supply chain colleagues and the significance to them of repeat clients, secured through relationships of trust (a key aspect of a well-functioning supply chain (Beth et al., 2009; Liverpool-Tasie et al., 2020)). The importance of honesty and faith in being a successful businessman were also widely cited. These social norms and relationships could be leveraged to highlight joint mutual responsibility for food safety actions along the supply chain, using the concept of “supply chain responsibility” (Liu et al., 2022).

Two populations merit special attention when considering interventions with SCAs. The first is transporters. As discussed above, they tend to be less organized, less integrated within the supply chain, and see a limited role for themselves in ensuring food safety or quality. At the same time, they play a role at a critical juncture for potential contamination or exposure to heat that could lead to food safety issues. It will thus be important for interventions to think of creative ways to reach and motivate them. Second, children were noted as playing roles within all six studied supply chains. Child labor in African agriculture has been well documented (Bhalotra, 2003; Okpukpara & Odurukwe, 2006), but there is less focus on children’s roles elsewhere in food supply chains. While these roles are relatively small, each is an opportunity for contamination. Yet few interventions target children or other informal workers who fill numerous small roles within the supply chain—e.g., loaders of beef, sorters of grain. Working with such populations is complex due to their fluidity, informality, and different incentives; for children, it can also be ethically complicated. However, their ubiquity throughout the supply chain suggests that approaches that exclude them may not succeed in ensuring food safety.

Finally, two factors emergent from this study deserve mention as facilitating increased action related to food safety within the supply chain. The first of these comes in the form of a key individual, the veterinarian within beef supply chains. Numerous respondents mentioned this role, recognized its importance for ensuring safe food, and seemed to appreciate it and the benefits it brought for end consumers – and, through reputational factors, themselves. While it has been reported that many animals in Nigeria escape veterinary inspection (Okike et al., 2010), the results of the present study are encouraging about veterinarians’ role and suggest that identifying key individuals who could play a similar role in other supply chains may have merit as an intervention approach. The second facilitating factor noted was a technology: PICS-improved storage bags (Baoua et al., 2012; Moussa et al., 2014) were widely credited by cowpea SCAs for improving safety and quality and cutting losses. That these were mentioned by numerous respondents across the supply chain without any prompting speaks to their influence, despite being relatively new (first introduced in Nigeria in 2008). Finding similar technologies that offer a “win-win” in terms of increasing safety (for PICS, reducing chemical use) while increasing profits (for PICS, through improved quality and reduced loss) may help unlock sustainable food safety improvements in other supply chains.

There are several limitations to this study. First, the sample was non-random and focused on only one state in northern Nigeria; it was also relatively homogenous, with all respondents being Muslim and nearly all Hausa and male (in line with local social norms). Wider conclusions must be drawn with caution. The research was not comprehensive in its coverage of SCAs – for example, those raising live animals were excluded, as were smaller roles throughout the supply chain (e.g., loaders). The analysis was primarily descriptive, and it is not possible to attribute observed results to any particular determining factors. All data were self-reported, not observational, suggesting some response biases when it comes to food safety actions. Finally, all

data were qualitative, with no quantitative comparisons across groups due to the small, non-random sample, which is not suited to statistical inference.

Despite these limitations, this study has offered new insights into the operations of food supply chains, highlighting the challenges, motivations, and relationships of those who work within them and discussing implications for improving food safety. Given the critical role these supply chain actors play in ensuring food security, it will be important to strengthen policy and programming to better support and motivate them to uphold food safety.

### CRedit authorship contribution statement

SN designed the research; AO, AW, EL, NOC, provided input on the research design; NOC oversaw the fieldwork; SN undertook data analysis; SN wrote the paper with input from all other authors; all authors have reviewed and approved the final manuscript.

### Ethical statement

All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the National Health Research Ethics Committee of Nigeria, Protocol NHREC/01/01/2007-20/08/2021.

### 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.

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### Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.foohum.2023.06.018](https://doi.org/10.1016/j.foohum.2023.06.018).

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