

## Review Paper

### Environmental hygiene in outdoor food markets in Africa: a scoping review

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#### ABSTRACT

Outdoor food markets represent important locations where foodborne illnesses and other infectious diseases can spread. Countries in Africa face particular challenges given the importance of these markets in food supply and low rates of access to safely managed water and sanitation. We undertook a scoping review of evidence related to disease transmission in food markets in sub-Saharan Africa, North Africa and identified 46 papers for data extraction and synthesis. Vendor behaviour or awareness was reported in the majority of papers and about half reported on market infrastructure. Fewer studies have been reported on regulatory environments or food contamination. Studies on water supply, sanitation and handwashing facilities focused on the presence of services and did not evaluate quality, thus conclusions cannot be drawn on service adequacy. Studies of vendor behaviour were primarily based on self-reporting and subject to bias. Most studies reported high levels of vendor awareness of the need for hygiene, but where observations were also conducted, these showed lower levels of behaviours in practice. Our findings suggest that there are limited studies on environmental hygiene in outdoor food markets and this is an area warranting further research, including into the quality of services and addressing methodological weaknesses.

**Key words:** handwashing, drainage, sanitation, solid waste, vendor behaviour, water supply

#### HIGHLIGHTS

- First scoping review on environmental hygiene in outdoor food markets.
- Studies did not report on the adequacy of water supply, toilets, handwashing facilities, waste management or drainage reviewed.
- Reports of handwashing among vendors were primarily based on self-reporting.
- We suggest a minimum package of services to support the development of national standards for services.

#### INTRODUCTION

Infectious diseases associated with water and/or food were responsible for over 400 million illnesses and 300,000 deaths in 2010 (WHO 2015). Diarrhoeal and infectious disease agents are among the leading causes of foodborne illnesses, with the highest disease burden reported in the African region (WHO 2015). Outdoor food markets have been shown to be important in cholera epidemics (Tauxe *et al.* 1995; Luque Fernández *et al.* 2011; Luquero *et al.* 2011) and these settings became a focus of activity during the West African Ebola crisis (Figuíé 2016). Outbreaks of respiratory disease have also been linked to outdoor food markets (Howard *et al.* 2020; Nadimpalli & Pickering 2020), including SARS-CoV-2 (Holmes *et al.* 2021), novel influenza H5N1 (Wan *et al.* 2011) and SARS-CoV (Guan *et al.* 2003). Poor personal hygiene of food handlers, poor food preparation practices and the lack of environmental hygiene in outdoor food markets are commonly reported causes of disease outbreaks (Koo *et al.* 1996; de Sousa 2008; Grace 2017).

While the importance of handwashing in the control of diarrhoeal and respiratory disease is widely recognised (Prüss-Ustün *et al.* 2019), adequate quantities of safe water, soap or sanitiser are required to sustain handwashing practices (Howard *et al.* 2020). More broadly, water, sanitation and hygiene (WASH) as an operational framework and set of interventions is increasingly recognised as a necessity in containing outbreaks (Hannah *et al.* 2020; Howard *et al.* 2020). In food

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markets, the prevention of outbreaks is recommended through a broader framework of environmental hygiene (European Environment Agency no date; Budge *et al.* 2022). This includes the provision of sanitation infrastructure that safely removes human and animal faecal waste, clean and uninterrupted water sources, handwashing facilities, solid waste disposal and surface drainage. However, progress in developing such comprehensive environmental protection in outdoor markets in Low- and Middle-Income Countries (LMICs) remains slow and the necessary infrastructure, norms, guidance and regulations are often absent.

Despite evidence of contamination in food markets (Grace *et al.* 2010; Sun *et al.* 2019), their ubiquity in African cities (Roesel & Grace 2014; Prüss-Ustün *et al.* 2019; Abwe 2020; Hannah *et al.* 2022) and the importance of WASH in reducing infectious disease burden (Biran *et al.* 2012; Hannah *et al.* 2020), little research has considered the role of environmental hygiene in controlling transmission in outdoor food markets. Furthermore, while there are norms and guidance around food hygiene in high-income countries, which may be applied to LMIC producers and their goods for export (European Parliament & Council of the European Union 2002; 2004), well-established standards and regulatory frameworks do not exist for food markets in Africa (Ezirigwe 2018; Morse *et al.* 2018; Aworh 2021). Actions, therefore, are taken on an *ad hoc* basis in response to outbreaks, meaning a failure to develop proactive, preventive measures to ensure healthy and resilient outdoor food markets across Africa.

The lack of consistent guidance on environmental hygiene in these key settings means that outdoor food markets continue to contribute to disease transmission and in particular, to the rapid spread of epidemic disease. Previous reviews have focused on street vendors selling ready-to-eat foods in LMIC settings, including microbiological quality, hygiene and food handling practices among vendors, infrastructure assessments (Rane 2011; Alimi 2016; Abrahale *et al.* 2019; Sun *et al.* 2019; Makinde *et al.* 2020) or vendor knowledge, awareness and practices (Wallace *et al.* 2022). However, no reviews have focused on the infrastructure or services available in outdoor markets, where the majority of fresh foods in Africa are sold (Roesel & Grace 2014).

## Review objectives

This scoping review was conducted to systematically map and synthesise the research on environmental hygiene in outdoor food markets in sub-Saharan and North Africa to provide an evidence base on which to base recommendations for future action, as well as to highlight existing gaps in knowledge. We assessed peer-reviewed literature from countries across the continent for assessments of the presence and quality of water supply and sanitation services, handwashing stations, solid waste disposal and drainage facilities in outdoor food markets and vendor behaviour and awareness around the frequency of handwashing, use of toilets, use of soap, risk of diseases from contaminated foods and disposal of food and other solid waste.

## METHODS

The scoping review was designed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher *et al.* 2009).

### Eligibility criteria

No restrictions were placed on the date of publication. Studies in countries outside North or sub-Saharan Africa and those without titles, abstracts or full-text available online were excluded. The full list of countries considered for this review is given in Supplementary Information, Table S2. Only studies with full text in English were included in the review.

### Information sources and search strategy

From 26 May 2021 to 8 June 2021, PubMed, Scopus, Web of Science and CAB abstracts were searched for peer-reviewed literature. In addition, reference lists of identified papers were hand-searched to identify additional papers. The search strategy was drafted by the first author and refined through team discussion. The search terms included keywords related to drinking water, sanitation, handwashing and hygiene facilities in food markets, their use by vendors, national and local regulations that apply to such settings and evidence from interventions (Table 1). The search results were then filtered by country of author affiliation in each data base, to limit results to countries in North and sub-Saharan Africa. These were exported into EndNote X9 (Clarivate, Philadelphia, PA). After removing duplicates, the title, abstract and full-text were screened by the first author.

**Table 1** | Search terms used in PubMed, Scopus, Web of Science and CAB abstracts

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(water OR sanit\* OR hygien\* OR handwashing OR safety) AND (food) AND (market\* OR vendor\* OR handl\*) AND (practice\* OR program\* OR intervention OR regulation)

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### Inclusion and exclusion criteria

Studies were included in the review if they provided a situational analysis of (a) Water supply, sanitation or hygiene-related infrastructure and services or (b) Vendor hygiene behaviours and awareness in outdoor food markets in countries in North and sub-Saharan Africa. Studies were excluded if they focused on non-market settings such as restaurants or mobile food carts. Studies that reported on food contamination, without an assessment of services in markets or vendor practices were excluded.

### Full-text review and data charting

The titles and abstracts were screened by two authors (A.N. and O.R.) and any disagreements were resolved through discussion. The first author reviewed the full-text of the studies that met the inclusion criteria. Data were extracted from each study and entered into the data charting form given in Supplementary Information, Table S1 using Microsoft Excel (version 2204). In addition to data on services and vendor behaviour and awareness, data were also extracted from discussions of legal frameworks and policies covering environmental hygiene and assessments of microbial contamination of food. Data on the study location, types of food sold by vendors, assessment topic, characteristics of assessments and contaminants detected on food samples were also extracted.

## RESULTS

The database search generated 2,970 results. After removing duplicates, title and abstract screening, 72 studies were considered for full-text review. Twelve studies were added following a hand search of bibliographies, with a total of 84 studies chosen for full-text review. Of these, 38 did not meet the inclusion criteria and were rejected. In total, 46 studies were selected for data extraction and synthesis, the details of which are given in Supplementary Information, Table S3. [Figure 1](#) shows a PRISMA flow diagram for the review.

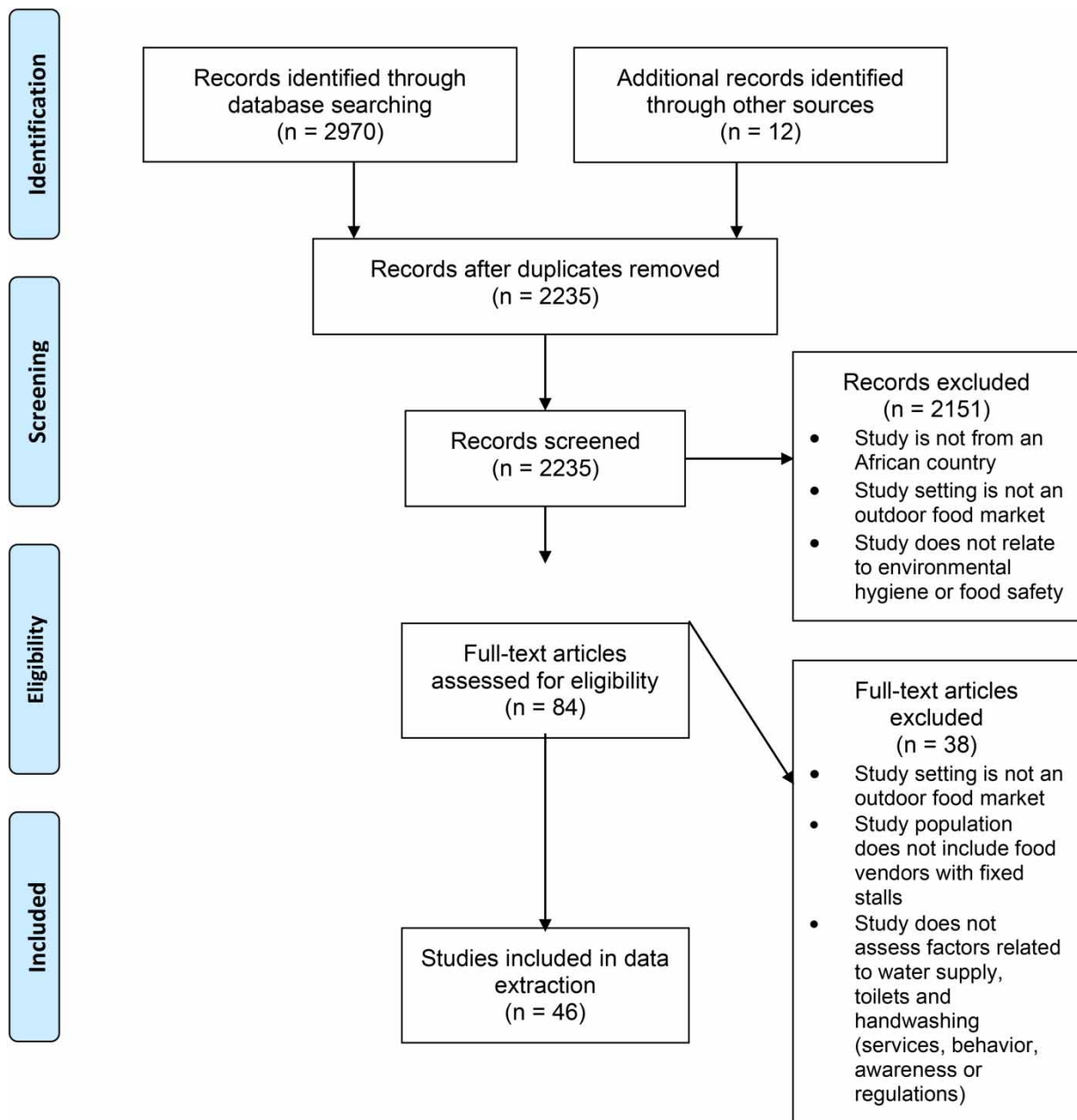
### Study settings and topic

The study count by country and type of food sold is shown in [Table 2](#). In some studies, vendors sold more than one type of food, e.g. both raw and cooked fish. These studies were categorised separately to account for the different hygiene and handling risks and pathogens commonly associated with raw and cooked foods and to identify whether food handling behaviour differed depending on the type of food sold. Twenty-one studies were set in formal markets and included a sub-set of vendors from the market in the study. Twenty-five studies assessed vendors from clusters of stalls distributed across a town or city. The study setting and sample size are presented in Supplementary Information, Table S3.

The study count by topic or objective of the assessment is also shown in [Table 2](#). Several studies had more than one topic of assessment and are counted under multiple categories. Although initially, our aim was to review studies on market infrastructure and vendor behaviours and awareness, after the full-text review, we decided to also extract data on regulations and evidence of food contamination. This allowed us to explore weaknesses in regulatory environments and reports of associations between food contamination and service vendor behaviours. The studies included in the review included the following topics or had the objective to assess: (1) Infrastructure/service; (2) Vendor hygiene behaviour and awareness; (3) Institutional and regulatory environment; and (4) Microbial contamination of food.

#### 1. Studies assessing infrastructure and/or service levels

Infrastructure/service assessments included visual assessments of drinking water supply, toilets, handwashing stations, solid waste disposal and drainage in the markets ([Table 3](#)). Of the 46 included studies, 23 (50%) collected data on the water supply available in the market. The majority of the water supplies found in markets were municipal piped supplies ( $n = 15$ ; 33%) or boreholes ( $n = 11$ ; 24%). Several markets had more than one type of water supply. Twelve studies (28%) collected data on access to toilets at the market, seven of which reported the type of toilet present (16%), while one study reported the absence of toilets in the market ([Abdalla et al. 2009](#)). Where reported, the toilets were maintained by private



**Figure 1** | PRISMA flow diagram of the literature search and screening for the scoping review on environmental hygiene in outdoor food markets in Africa.

operators (Samikwa *et al.* 2019), local council employees or the community (Lazaro *et al.* 2019). None of the identified studies reported on water quality, the quantity of water available per vendor, the number of toilets or handwashing facilities per vendor or the average distance between vendors and these services. Twelve (26%) studies reported the availability of handwashing facilities to market vendors. Seven of these also assessed the availability of soap (16%), which was available at four locations. In five studies, these facilities were available at the vendor's stalls; in one study, they were 15 and 21 m from the market. The rest of the studies did not indicate the distance between handwashing facilities and the points of sale. The type of water supply at the handwashing stations was reported by four studies (9%), where two had piped water. Vendors at the other two locations washed their hands with water stored in containers. Of the six studies (14%) that reported on handwashing facilities near toilets, four found facilities with running water available near toilets. The others did not

**Table 2** | Characteristics of evidence sources

Study characteristic		Count	% of total (n = 46)					
Number of studies included by country of study location	Burkina Faso	1	2					
	Cameroon	1	2					
	Ethiopia	3	7.0					
	Ghana	15	35					
	Kenya	4	9					
	Malawi	3	7					
	Nigeria	6	12					
	South Africa	8	14					
	Sudan	1	2					
	Tanzania	1	2					
Number of studies included by type of food sold	Uganda	3	7					
	Cooked food	36	78					
	Raw and cooked fish	1	2					
	Raw fish	1	2					
	Raw meat (poultry, pork or beef)	2	5					
	Raw vegetables	3	7					
	Cooked food and raw fruit	3	7					
Number of studies included by study assessment objective and type of food sold	Type of food sold							
	Raw meat and fish		Raw vegetables and fruit		Cooked food	Total		
Study assessment topic	<i>n</i>	% <sup>a</sup>	<i>n</i>	% <sup>a</sup>	<i>n</i>	%	<i>n</i>	%
Infrastructure/services	3	7	2	4	26	57	31	67
Vendor behaviour	6	13	3	7	24	52	33	72
Vendor awareness	3	7	1	2	18	39	22	48
Institutional and regulatory environment	1	2	1	2	8	17	10	22
Contamination of food	2	4	2	4	6	13	10	22

<sup>a</sup>Percent data are calculated from the total number of studies (N = 46).

Note: Studies with more than one topic of assessment were counted under multiple categories.

comment on whether the handwashing facility was with a toilet or independent of it. Studies did not report on access to handwashing stations for the public.

Eighteen studies (39%) collected data on the availability of municipal or private solid waste collection. Between 7 and 80% of vendors had access to waste receptacles (bins, plastic buckets and gunny bags) (Chukuezi 2010; Muyanja *et al.* 2011; Holm *et al.* 2017; Mwove *et al.* 2020; Nkosi & Tabit 2021). Other vendors disposed of their solid waste (e.g., food waste or plastic bags) in open drains or in pits behind their stalls (Muyanja *et al.* 2011; Lenetha *et al.* 2019; Marutha & Chelule 2020). Only one study reported evidence of a waste collection service in one of the three locations studied, where each vendor paid an equivalent of 0.05 USD to municipal cleaning services to take the waste to a landfill (Muyanja *et al.* 2011). There were no reports of organic and non-organic waste separation.

Five studies (11%) collected data on drainage in markets, of which drainage was present in three locations (Martins 2006; Muyanja *et al.* 2011; Lawan *et al.* 2015; Bagumire & Karumuna 2019; Lenetha *et al.* 2019). Of these, 50–56% of vendors reported pouring wastewater into the stormwater drain in two locations, while two studies did not report on the use of drains by vendors.

## 2. Studies assessing vendor hygiene behaviours and awareness

The studies on vendor behaviours (*n* = 33, 72%) collected data on the frequency of handwashing after certain activities related to food handling. The majority of these studies described self-reported behaviour by vendors (23 of the 33 studies on vendor behaviour). Data on rates of compliance among vendors were extracted and plotted in Figure 2. Between 13

**Table 3** | Type of infrastructure or service assessed in the studies included in the review

Type of infrastructure/service assessed	Study count (n) <i>n</i> = 46	Percent of total
<b>Water supply</b>	<b>23</b>	<b>50</b>
<i>Municipal supply (taps)</i>	15	
<i>Municipal water tank</i>	1	
<i>Private seller</i>	3	
<i>Rainwater harvesting</i>	1	
<i>Wells (including boreholes/protected wells)</i>	11	
<i>Type of supply not reported</i>	4	
<b>Toilets</b>	<b>12</b>	<b>28</b>
<i>Pit latrines</i>	4	
<i>Flush toilets connected to septic tanks</i>	6	
<i>VIP latrine</i>	1	
<i>Type of toilet not reported</i>	4	
<i>No toilet available</i>	1	
<b>Handwashing facilities</b>	<b>13</b>	<b>28</b>
<i>Availability of running water</i>	4	
<i>Availability of soap</i>	7	
<i>No data reported on running water or soap</i>	3	
<i>No handwashing facilities available</i>	2	
<b>Drainage</b>	<b>5</b>	<b>11</b>
<b>Solid waste collection (municipal or private collection service)</b>	<b>18</b>	<b>39</b>

Note: Several studies reported multiple types of water supplies and toilets available to vendors.

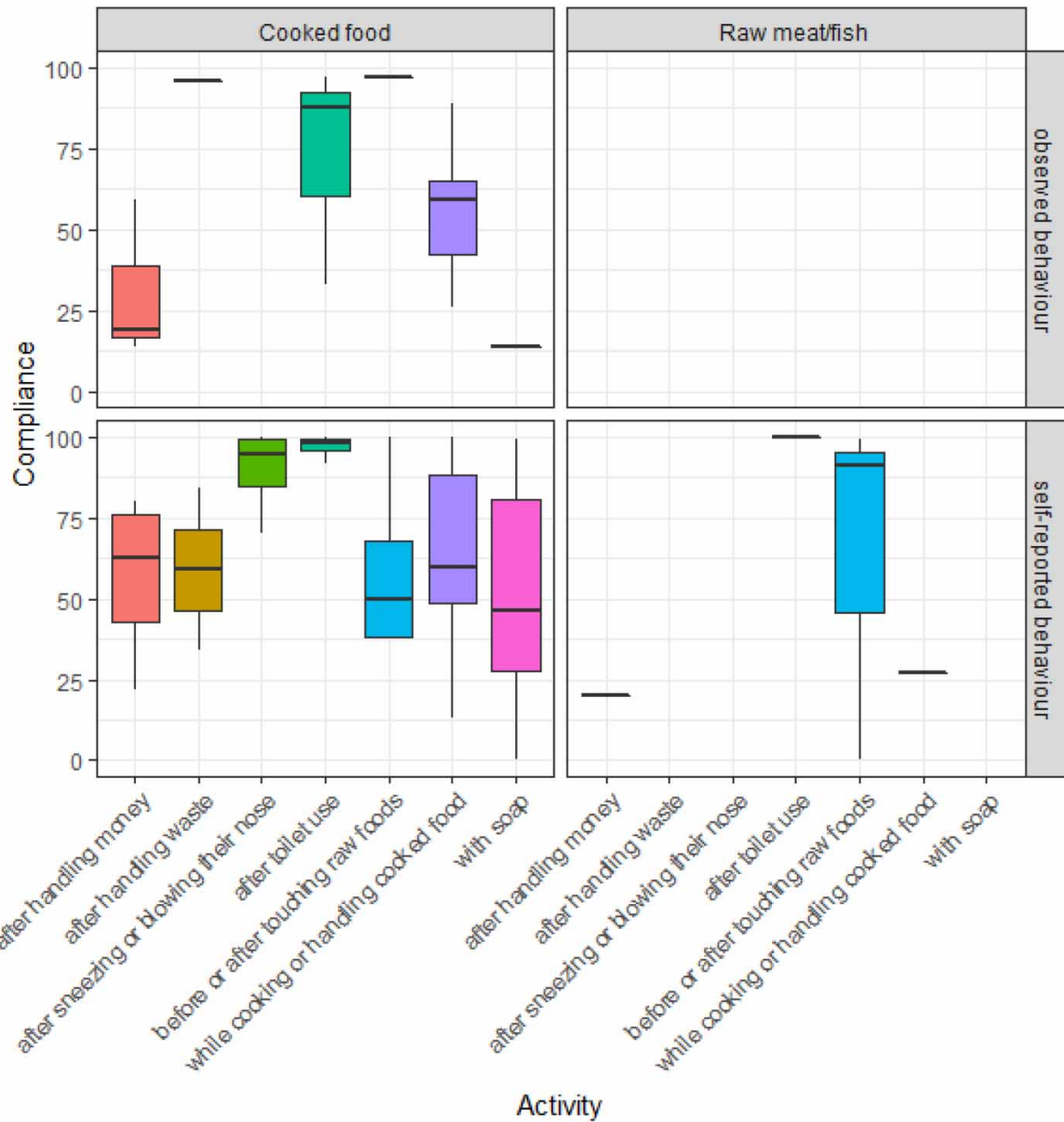
and 90% of vendors claimed to wash their hands ‘always’ or ‘frequently’ after using the toilet, handling cash, before handling food and after handling raw meat. Only one study reported vendors’ motivations for handwashing (Wainaina *et al.* 2020), where 59% of the respondents said disease prevention was the reason for handwashing, followed by personal hygiene (39%) and economic incentives (2%).

There was evidence of the association between hand hygiene and formal training in food safety and hygiene. Hassan & Fweja (2020) reported statistical associations between the use of soap for handwashing and formal training on food hygiene and safety. Adane *et al.* (2018) found better food hygiene and safety among vendors who received service training, while Tesfaye & Tegene (2020) found higher odds of poor food handling practices among vendors who had not received any training.

Studies on vendor awareness of the need for handwashing ( $n = 22$ , 48%) provided mixed evidence (Table 4). In the 11 studies where vendors were asked about the need for handwashing before or after specific activities, the majority gave a positive response (Table 4). Two of these studies additionally reported observed behaviour and noted discrepancies between vendor awareness and behaviour (Lawan *et al.* 2015; Wainaina *et al.* 2020). While 90% of the vendors surveyed by Wainaina *et al.* (2020) were aware of the need for handwashing before handling food to prevent illnesses, only 26% were observed doing so. The reported barriers to handwashing in this study were a lack of water for handwashing (18%), a lack of time (33%) and the belief among vendors that the type of food they sold did not need handwashing before handling (50%). However, the type of food sold by these vendors was not reported.

Between 39 and 96% of the vendors across six studies claimed to be aware of the need for soap for handwashing. Observed behaviour to support this was reported by Lawan *et al.* (2015), with 81% of vendors always washing their hands with soap and water, compared to 86% who claimed to be aware of the need for soap.

In findings from 12 studies (28%), vendors linked contaminated food, water or hands to illnesses including typhoid, cholera, AIDS, diarrhoea and dysentery (Abdalla *et al.* 2009; Abass *et al.* 2019; Marutha & Chelule 2020). Eight studies reported



**Figure 2** | Observed and self-reported vendor compliance (%) with handwashing regulations, disaggregated by type of food sold.

a high level of awareness of the links between handwashing and the reduction of the risk of foodborne illnesses (90–100%). The most reported source of information on food safety and hygiene in order was a supervisor or family elder, followed in declining order of prevalence by TV and radio, community programmes, environmental health inspectors and formal training in food safety.

### 3. Studies assessing the institutional and regulatory environment

Three studies (7%) reviewed national policies or monitoring guidelines for water, sanitation or hygiene infrastructure and services in markets (Lues *et al.* 2006; Lazaro *et al.* 2019; Lenetha *et al.* 2019). National acts or policies in Malawi contained no specific standards for water, sanitation and hygiene infrastructure or monitoring in public spaces where fresh fish is sold (Lazaro *et al.* 2019). Lues *et al.* (2006) found that policy in South Africa mandates the use of soap and water for handwashing

**Table 4** | Studies assessing vendor awareness of handwashing

Indicator	Number of studies	% of vendors who gave a positive response (range)
<b>Awareness of need to wash hands:</b>		
After using the toilet	5	66–100
After touching money	5	5–97
After blowing their nose	2	6–99
Before handling food	5	27–99
After touching raw meat	1	91
After handling garbage	2	15–52
Before and after food preparation	3	68–97
<b>Awareness of need for:</b>		
Soap	6	39–96
Clean towels	4	14–96
Disinfecting solution	2	2–62
<b>Awareness that contaminated food, water and hands can cause disease</b>	12	4–95
<b>Awareness that handwashing can reduce risk of food contamination and disease</b>	8	90–100

before handling food intended for direct consumption and handwashing stations must be provided with soap and disposable paper towels. Regulations governing hygiene requirements for food premises mandate environmental health practitioners to carry out inspections of all food vending stalls in South Africa (Lenetha *et al.* 2019).

Ten studies (22%) reviewed local regulations around hygiene and handwashing in markets and the challenges in enforcement. Local by-laws in Manguang Metro, South Africa require traders to lease trading sites from the Council for a fee, but the authors reported a lack of clarity on what these funds are invested in (Lenetha *et al.* 2019). Vendors reported that their stalls had not been inspected for a few years despite a national mandate for environmental health practitioners to inspect all food vending stalls (Lenetha *et al.* 2019). In Zululand District, authors found that 65% of all stalls across two municipalities had been inspected by health officials at least once in the previous year and 31% of these had received a non-compliance warning (Nkosi & Tabit 2021).

Lazaro *et al.* (2019) reported that national water and sanitation policies do not include criteria for the required number of, or the required standards for, taps or sanitation and handwashing facilities in open-air food markets. There is also a lack of clarity among local government officials in Mzuzu, Malawi on the responsibility for monitoring compliance (Lazaro *et al.* 2019).

In Ghana, the Municipal, Metropolitan and District Assemblies (MMDAs) in charge of food inspection were reported as understaffed and lacking the means of transport for site visits (Monney *et al.* 2014). Furthermore, in Ghana, officials of the local Environmental Health and Sanitation Units cited a lack of specific rules for street vendors (Forkuor *et al.* 2017; Abass *et al.* 2019).

#### 4. Microbial contamination of food

Of the 46 studies included in the review, 10 (23%) collected food samples from vendors' stalls and analysed them for a wide range of microorganisms, including foodborne pathogens. The most common microorganisms found on food samples in the reviewed studies were *Staphylococcus aureus*, *Salmonella enterica* and *Escherichia coli* (Martins 2006; Abdalla *et al.* 2009; Ouedraogo *et al.* 2018; Amare *et al.* 2019), although some bacterial counts were within national food standards (Lues *et al.* 2006; Aduah *et al.* 2021).

Only one study explored associations between food contamination and hygiene practices of vendors (Kariuki *et al.* 2017), finding that food contamination was negatively correlated with access to running tap water and handwashing before handling food but was not significantly associated with handwashing after handling raw food. Other factors negatively associated with



food contamination were access to a toilet facility, the availability of running water near the toilet and access to running water during food preparation. The highest occurrence of food contamination (85% of samples) was among vendors who did not wash their hands at all before handling food. Vendors using water from a container to wash their hands had contamination in 17% of food samples. There was a reduction in the chances of contamination if vendors also used soap (from 17.2 to 16.7%), although this was not statistically significant. Notably, vendors who washed their hands using running water and soap had no occurrences of food contamination.

## DISCUSSION

### Summary and evidence gaps

This is the first scoping review to report the evidence on environmental hygiene services, vendor hygiene behaviour and awareness, hygiene regulations and food contamination in outdoor food markets in countries across Africa. Our findings indicate limited research on environmental hygiene infrastructure and services in these settings. While visual assessments were made of water supplies, toilets, handwashing facilities, solid waste management and drainage in markets, there was no reporting of more systematic sanitary risk assessments or engineering assessments of the infrastructure. The lack of data on key aspects of water supply services, such as quantity, reliability, quality and continuity, is also notable. There is a similar lack of evidence on the quality of sanitation services. It is therefore hard to objectively assess whether the water supply and sanitation services provided in the markets are adequate and meet the demands of users.

There were substantial methodological weaknesses in the reviewed evidence on hygiene behaviours. Ten (of the 31 studies on related behaviours) reported observed vendor practices around personal hygiene, specifically, and handwashing. Observed behaviour seemed to show lower rates of compliance with handwashing requirements versus self-reported behaviour, similar to studies in other settings where courtesy and other biases have been reported (Luby *et al.* 2006; Ram *et al.* 2010). We also found weaknesses in the study design and the use of survey instruments to assess behaviours and awareness. Several studies rated compliance to a recommended set of conditions but did not describe what they were or how the rating scale was developed. Furthermore, vendor responses were not validated by observation in all but two studies. This somewhat limits the confidence in these findings, as socially desirable handwashing behaviour is often over-reported (Contzen *et al.* 2015).

It is interesting to note that studies on vendors were nearly all related to those selling cooked foods with very few dealing with raw foods, suggesting that hygiene in the handling of raw foods is under-researched. The motivations and barriers for handwashing among vendors are also under-researched (Parikh *et al.* 2022) and only one such study was identified in our review (Kariuki *et al.* 2017). These are important avenues for further research that could strengthen the case for local authorities to invest in market infrastructure and monitor the hygiene of both raw and cooked foods.

There were few reports on policies and the enforcement of hygiene behaviours in markets. Given the COVID-19 pandemic, this is somewhat surprising given the emphasis placed on ensuring hygiene behaviour and the use of personal protective equipment such as face masks in most countries (Howard *et al.* 2020). The lack of regulation will make ensuring compliance with personal hygiene measures among vendors more difficult and the apparent lack of clarity on legislation and institutional roles around hygiene in outdoor markets may explain poor levels of observed hygiene (Abass *et al.* 2019; Forkuor *et al.* 2017; Lazaro *et al.* 2019; Morse *et al.* 2018).

Pathogens were detected on food samples, which is consistent with reports of contamination in both household and non-household settings (Akhtar *et al.* 2014; Gizaw 2019). However, studies did not report the full range of microorganisms tested for and reported only those that were. Associations between contamination and vendor behaviours or environmental hygiene services in the market were largely unreported. The presence of running water and toilets in markets was associated with lower odds of food contamination, but this was investigated in only one study (Kariuki *et al.* 2017). Further work to identify behaviours and environmental factors associated with food contamination is recommended and can be used to develop targeted food safety interventions.

### Limitations

This review may not have captured the full extent of knowledge within the field because many Non-Governmental Organisations (NGOs) and agencies working within WASH-related implementation and policy hold information that is not publicly available. Improving the accessibility of such information is important. As the review was limited to publications in English, relevant studies published in French or Portuguese were not included, which may have offered additional insights.

**Table 5** | Minimum package of services for outdoor food markets

Service	Minimum set of requirements in market settings
Water supply	One tap for every 20 traders, plus sufficient to provide one tap per 200 customers. Taps located throughout the market area. Water should be continuously available at least throughout the hours of operation of the market (including loading, packing up and cleaning)
Sanitation	One toilet for every 20 traders with sufficient stances to ensure one toilet per 200 customers. Toilets should be gender separated and women's toilets should include provision for menstrual hygiene management
Handwashing stations	One handwashing station for every 15 trader plus provision for one handwashing station for every 25 customers. Handwashing stations outside each toilet. Every handwashing station should have soap and/or hand sanitiser available and this should be regularly checked (at least daily) and re-stocked
Solid waste disposal	Separated organic and non-organic waste in covered bins (minimum). One bin per 20 traders. Bins located outside market and in a secure area that is cleaned at least weekly. Organic waste collected daily
Drainage (grey and blue water)	All roofs with gutters linked to surface drainage; surface drains in market cleaned daily. Internal drains within markets sullage collection from trader stall linked to covered internal drainage system linked to soakaway or sewerage

### Minimum service packages for water supply, toilets, handwashing services, solid waste disposal and drainage

The lack of evidence on service levels and regulations suggests an absence of clear standards for services in outdoor food markets in Africa. This is in contrast to the requirements set out, often in occupational health and safety regulations, in high-income countries for similar settings. If environmental hygiene is to be improved in outdoor food markets as a strategy to protect public health, developing recommendations for what should constitute a minimum level of services would appear to be useful to help guide investments. The development of such levels of service would be best undertaken at a national level, but as a point of departure, we suggest below (Table 5) a minimum package of services that would support decision-making.

The minimum levels of services are derived from standard design manuals for rural piped water supplies, sanitation services and design for drainage and solid waste as well as from the International Labour Office (ILO) water at WASH@Work framework (ILO 2016). A number of occupational health regulations from high-income countries were also consulted. The minimum package of services presented here demonstrates a first attempt based on expert judgement but requires further research to establish a stronger empirical basis.

Such minimum packages of services provide a technical basis for improving environmental hygiene, but the development of programmes and investments will require detailed business case development covering detailed financial costing, value for money assessment and in all likelihood political economy analysis to understand drivers and barriers for change.

## CONCLUSIONS

Our review found 46 studies that examined different aspects of environmental hygiene in outdoor food markets in Africa. Fewer than half of the studies included assessments of water supply and only a quarter included sanitation and/or handwashing facilities. Solid waste management and drainage were even less well represented in the literature. None of the studies included measures of service quality. This lack of evidence around basic infrastructure and the provision of services points to the need for further studies to identify what current services are provided in these settings and to support the derivation of a minimum package of services. There were more studies on hygiene behaviour among vendors, although not among customers. These studies show relatively high awareness and self-reported behaviour for handwashing, but observations showed a more varied picture with some studies finding close corroboration with self-reported behaviour and others showing very limited corroboration. As with other settings, there is a need for further work to understand what people actually do and not simply what they report that they do in relation to handwashing. There were limited studies of regulations, which is surprising given the importance of regulations in relation to COVID. The reviewed studies point to a lack of clarity in regulatory frameworks and an absence of setting specific requirements for outdoor food markets. Finally, a number of studies were found that reported food contamination, demonstrating a wide range of pathogens found on foods in outdoor food markets. While understanding among vendors about the need for hygiene was relatively high, the levels of contamination identified demonstrate that much more needs to be done to ensure safe food. To address the issues raised in this review, we have

proposed recommended guidelines to support the development of a minimum package of services to improve environmental hygiene in these settings. Further work to understand the nature of current services, their quality and user perceptions is required. This would provide a stronger basis for the establishment of guidelines to support the development of a minimum package of services in outdoor food markets in Africa. This is the first review of its type focusing on outdoor food markets in Africa. Our findings and the evidence gaps we identify provide a basis for the development of new research and actions to address environmental hygiene.

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## AUTHOR CONTRIBUTIONS

A.N., G.H. and J.B. conceptualised the study; A.N. and G.H. prepared the methodology; A.N. and O.R. did the formal analysis; A.N. and S.B. wrote the original draft; A.N., S.B., J.B. and G.H. wrote, reviewed and edited the article; G.H. and J.B. supervised the study; G.H. did project administration and acquired funds.

## DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

## CONFLICT OF INTEREST

The authors declare there is no conflict.

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