Food policy analyses and prioritisation of food systems to achieve safer food for South Africa

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ABSTRACT

Food safety has become an important international public health and economic issue since the first and only publication of global estimates on the burden of food borne diseases by the World Food Organisation in 2015. The consumption of unsafe food has had a detrimental effect on public health and economic development due to productivity loss, chronic diseases, and death because of the consumption of unsafe food. The challenges that constrain the provision of safe food in South Africa's food systems and potential solutions were identified through a systematic literature review and meta-analysis. Identified potential solutions were then ranked through stakeholder interviews. Twelve actions from various thematic focuses were prioritised as no-regret solutions using Best-Worst scaling. The prioritised no-regret actions include research and technology actions such as the multi-sectoral collaboration of researchers to develop strategies to deal with the complexity of food systems and identify priorities for interventions, adopting technological innovations throughout the value chain to improve food safety, strengthen laboratory diagnostic services, and conducting more research studies on the use of easy-to-understand food safety labels to improve awareness. The no-regret options prioritised are feasible and provide the basis for policy interventions to improve food safety and achieve developmental goals. This study recommended harmonising the legislative framework to improve stakeholder collaboration and accelerate the much-needed transformation of the food systems.

List of acronyms

WHO-FERG	World Health Organisation-Food Epidemiology Reference Group
SPS	Sanitary and Phytosanitary Standards
WTO	World Trade Organisation
SDG	Sustainable Development Goals
PRISMA	Preferred Reporting on Systematic Review and Meta-Analysis
BWS	Best Worst Score
GAP	Global Good Agricultural Practices
CAC	Codex Alimentarius Commission
IPPC	International Plant Protection Organisation
UNFSS	United National Food Systems Summit

1. Introduction

Globally, food safety is considered an important public health, trade and developmental issue (Grace et al., 2019; Anon., WHO, 2022). Food safety is essential to achieve positive health and economic outcomes from the food systems (FAO, IFAD, UNICEF, WFP and WHO, 2023). Food safety involves several sectors such as water, energy, trade, agriculture, education and health (Morse et al., 2018). Food safety systems involve measures, standards and controls to prevent food contamination with pathogens or chemicals during the production, processing, storage, transport and distribution of food and in the household (FAO, 2020).

Food safety refers to all microbial and chemical hazards, whether chronic or acute, that may contaminate and make food injurious to the consumer (FAO, 2020). Food-borne diseases are illnesses caused by consumption or exposure to contaminated food (Grace et al., 2019). Food-borne diseases cause illnesses and sometimes deaths creating health and economic burdens hampering the development of a country (Anon., WHO-FERG, 2015).

Food safety and nutrition are inextricably linked, with unsafe food creating a vicious circle of diseases and malnutrition, affecting mostly children and the elderly (Anon., WHO-FERG, 2015). The 2015 World Health Organisation-Food Epidemiology Reference Group (WHO-FERG)

released the first and only estimates on the burden of Food-borne diseases and reported that food-borne diseases have a health burden equal to or greater than malaria, HIV/AIDS, or tuberculosis. The WHO-FERG 2021–2024 is currently updating the estimates data on the burden of food-borne diseases, which will be published in 2025 (Anon., WHO, 2022).

In 2018, The World Bank reported an estimated US$95.2 billion per year of total productivity losses associated with food-borne diseases in low- and middle-income countries and an annual cost of US$15 billion spent on treating food-borne diseases globally (Jaffee et al., 2019). The World Bank and WHO agreed to publish estimates of the economic impact of food-borne diseases based on the updated WHO data in 2025 (Anon., Food Safety News, 2023).

The national food safety measures such as the permit systems for food processing, import and export regulations, food hygiene legislation, and quarantine systems amongst others were developed from the international standards such as Sanitary and Phytosanitary Standards (SPS) of the World Trade Organisations (WTO) to ensure food safety (Anon., WTO, 2010).

In South Africa, the national food control systems are responsible for implementing the national food safety measures through inspection and enforcement by national and local authorities (Adeniyi et al., 2021). However, the food control systems are prone to corruption or fraud. For example, role players may influence government decisions on food safety standards, or inspection outcomes for financial gain. Officials implementing the food safety measures often have limited training and access to scientific data. Lack of specialist training and expertise makes it difficult to detect and adequately investigate irregularities in the food systems (Anon., UNODC, 2023). Different agencies and ministries share the responsibility of food safety measures and control systems with overlapping and sometimes contradicting mandates, thus making it susceptible to corruption (Mphaga et al., 2023).

The evidence of food safety in low- and middle-income countries is still limited. Therefore, the full health and economic impact of unsafe food are unknown. Food safety in developing countries should be strengthened to ensure healthy and sustainable food systems. Policy innovations are required to improve food safety measures in developing countries (Grace et al., 2019). Hawkes et al. (2020) suggested that policy actions can transform food systems. Transforming food systems will entail identifying challenges to the food systems and possible solutions.

Understanding the links between food safety hazards, food control systems and health will help policymakers develop better evidence-based policies with clear pathways to transform food systems. Transformed food systems are likely to address the global burden of food-borne diseases and food-related non-communicable diseases (WHO, 2020). This study reviewed and analysed food safety and health-related policies in South Africa to establish no-regret options to transform the food systems towards safer foods. No-regret options are justifiable, with specific measures, and a clear pathway to impact transforming food systems under any future circumstance (Hawkes et al., 2020).

2. The relationship between food safety and food systems

Food safety is an outcome of the food systems and a result of actions or inactions by role players who operate within the food environment. Food safety is vital for food and nutrition security as well as the growth and transformation of the food systems, which need to feed the growing population. Role players in the food systems include farmers, food handlers, processors, distributors, regulators, consumers, scientists, educators and media (Jaffee et al., 2019).

Food systems involve a web of interconnected activities, from food production, processing, distribution, marketing, consumption and waste disposal. Food systems are constantly shaped by different forces, drivers, structural changes and decisions by many stakeholders that could affect their sustainability (Anon., CFS, 2021). Food systems go beyond the value chain to environmental and socio-economic drivers and food

security outcomes (Hendriks et al., 2023). Food systems are crucial to dietary patterns, nutritional status, as well as health of the population (Anon., WHO, 2022). The interconnectedness of food systems affects food safety. How food is produced, processed, marketed, handled and consumed determines the safety status of the food.

The inter-continental trade openness may affect food safety due to the increased movement of food across borders, meaning poor handling of food from one source may affect many people in the region (Simola et al., 2022). The capacity to manage food safety risks for exports in many countries appears to be considerably stronger than the capacity to protect their domestic consumers (Jaffee et al., 2019). Regional trade openness may improve food systems if actions are taken to improve food safety. Failure to improve food safety may seriously impact regional and continental development.

WHO's (2022) Global strategy for food safety suggested that food safety can be achieved by strengthening national control systems, through policy innovations. Harnessing technological innovations could strengthen risk assessment and quick identification of challenges arising from global changes and transformation (Hendriks et al., 2023). Improving stakeholder engagement in all sectors of the food systems will enable effective use of resources to identify challenges and develop no-regret policy innovations to improve food safety (Anon., WHO, 2022).

Improving food safety will be crucial in achieving Sustainable Development Goals such as SDG 1 of ending poverty. Food-borne diseases can also impact SDG 2 of ending hunger as they have multiple interactions with nutrition. The health burden of food-borne diseases is comparable to that of malaria, HIV/AIDS, and tuberculosis (Anon., WHO-FERG, 2015), meaning SDG 3 of good health and wealth may not be achieved if food-borne diseases continue to compromise immunity (Jaffee et al., 2019). SDGs 1,2 and 3 also contribute to the achievement of SDG 6 (clean water and sanitation), 8 (decent work and economic growth), 12 (sustainable production and consumption of food) and 17 (partnership for the goals) (Anon., WHO, 2022).

3. Methodology

3.1. Study area and data collection

The study was conducted using an online structured systematic review of published and grey literature. The data search for the review records was not limited to any country. Semi-structured online interviews were conducted using Google Forms. Lastly, the validation interview was also conducted online using Google Meet to validate the data collected from online semi-structured interviews. The participants for the interviews were stakeholders in the food systems from all nine provinces of South Africa.

A qualitative exploratory strategy was adopted for this study, and it involved a structured systematic review, as illustrated in Fig. 1. Stakeholder interviews were used to get their perceptions of South Africa's food safety policy framework.

3.1.1. Online database search

A systematic literature review was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) to identify challenges that constrain the provision of safe food. A search strategy was developed for a literature database using the following keywords: food safety, safe food, food-borne disease, food-borne illness, food systems, food hygiene, food value-chain and food value chain. Boolean operator keywords and their synonyms were used to broaden the search and yield more results. The Boolean operator "OR" was used to connect synonyms to cover the concept adequately. Table 1 lists the keywords and syntax of phrases used to search for literature sources.

These terms were searched in September 2021 and updated in October 2022 across several databases including Scopus (Elsevier Inc., Netherland), Web of Science (Clarivate Analytics., United States),
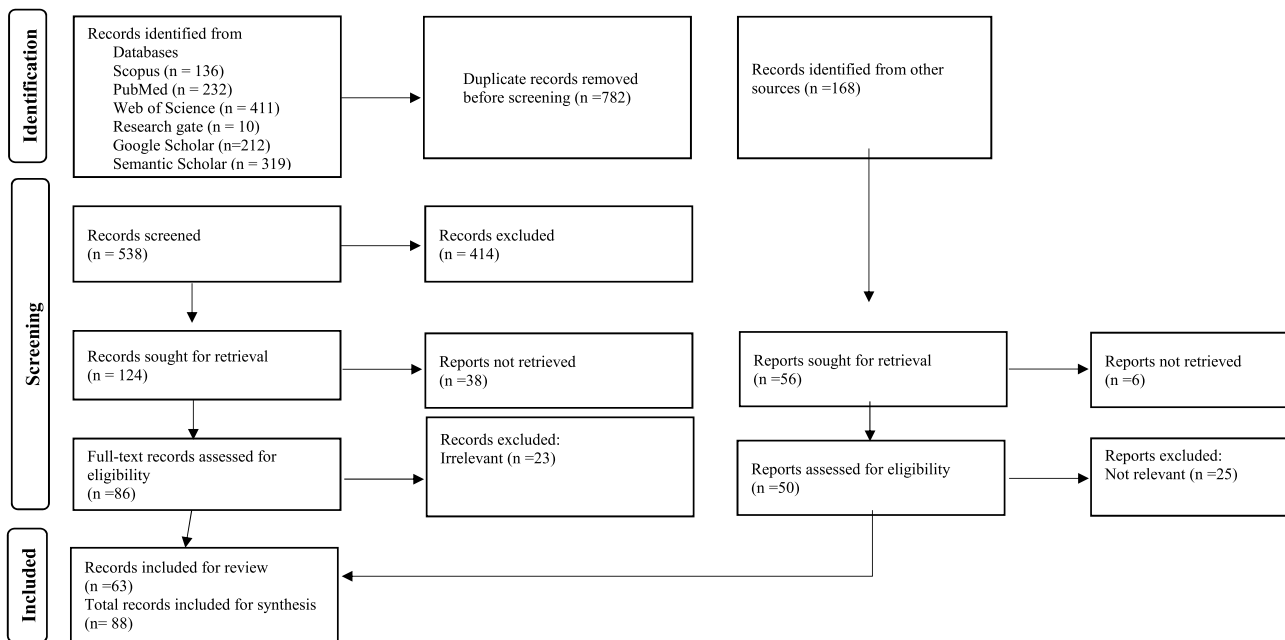
Fig. 1. PRISMA 2020 Review flow chart for systematic reviews which includes databases, registers and grey literature, *adopted from Page* et al*., (2020)*.

Table 1
Keywords and syntax used for search of the literature.

No	Keywords and syntax
1	Food safety OR safe food* OR foodborne disease OR food-borne disease OR food-borne illness* OR safe foodstuff* OR food hygiene
2	Challenge* OR problem* OR obstacle* OR issue*
3	Food system* OR food value-chain OR food value chain
4	2011–2022

Source: Author (2022).

PubMed (United States National Library of Medicine), Google Scholar, Semantic Scholar, Research gate and Science Direct, which are extensively used to produce systematic literature reviews in the field of life, health, and social sciences (Adeniyi et al., 2021; Thaivalppil et al., 2020). All identified sources were listed to Mendeley (Elsevier Inc.) to remove duplicates and collate the references. A complementary search for grey literature was conducted in October 2022 through Google. The grey literature review period was also between 2011 and 2022.

A structured screening form was used to assess the relevance of titles, abstracts and documents identified. The relevance assessment was based on the food safety context and documents issued or published between 2011 and 2022 were considered. All identified records were loaded to Mendeley software for screening using the inclusion criteria mentioned above.

3.1.2. Stakeholder interviews

The purposive sampling method was used to identify participants for semi-structured interviews. Stakeholders in the food systems were selected based on the assumption that they possess knowledge and experience in food safety and food-borne diseases and would be able to provide the desired information. Invitations to participate were sent to selected stakeholders a week before interviews through either email or Short Message Services (SMS). Individuals who were available and willing to participate and expressively share opinions were considered for the interviews.

A semi-structured questionnaire was used to conduct interviews with stakeholders. The questionnaire and consent forms were forwarded to selected participants with instructions for the interviews through Google forms. Informal street food vendors without access to the internet were handed a hard copy of the questionnaire.

3.2. Data analysis

The content analysis was used for synthesis using Atlas. ti 9. Atlas. ti is a Computer Aided Qualitative Data Analysis Software used to manage analysis for qualitative data using codes and annotations (Smith, 2002). The data from the PRISMA systematic review was synthesised by recording the details for all identified documents in a table format.

Best-worst scaling (BWS) method was used to analyse data from the semi-structured interviews. An aggregate BWS score was calculated and interpreted by using a standardised interval scale, which is calculated by dividing the square root of the frequency of the best by the frequency of the worst for each attribute.

4. Results and discussion

4.1. Key challenges hindering the food systems from providing safe food

A total of 192 quotations on challenges hindering the provision of safe food in food systems were generated using a coding system, producing a total of 34 challenges after Atlas. ti analysis of the systematic review records, as illustrated in Fig. 2.

According to Fig. 2, the main challenges hindering the provision of safe food are lack of training and capacity building as well as fragmented institutions. Thirteen records (13) cited the lack of training and capacity building as the leading constraint hindering food systems in providing safe food, as illustrated in Fig. 2. This finding concurs with Boatemaa et al. (2019), who cited the lack of training on food safety as one of the major challenges in South Africa's food retail sector.

Fig. 2 shows that a total of nineteen records (11) from the review cited institutional challenges such as fragmentation of policies and eight records (8) from the review cited lack of stakeholder collaboration within the food systems. Poor stakeholder collaboration is attributed to failures of the food safety systems to ensure safe food.

As shown in Fig. 2, five records (5) reported poor enforcement of existing regulations and lack of regulation for food handling and distribution as a hindrance to ensuring the provision of safe food. This report concurs with Grace et al. (2015) that the domestic food safety enforcement capacity in developing countries is weak. Jaffee et al.
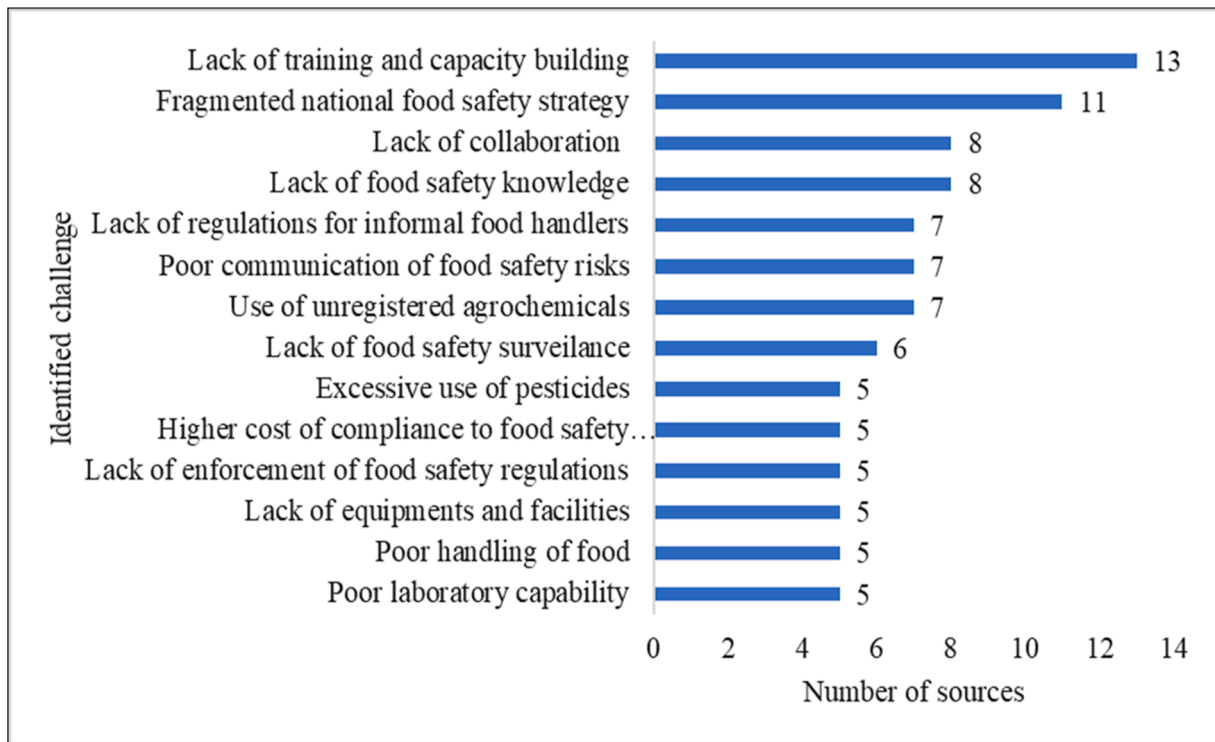
Fig. 2. Key challenges cited in five or more records, *Author (2022)*.

(2019) also reported that developing countries often prioritise the enforcement of policies on food produced for export markets.

Seven records (7) reported that poor regulation of informal street food vendors and traditional domestic foods present food safety risks. The traditional slaughtering of animals was reported as a significant risk for zoonotic transmission during the slaughtering and consumption of meat.

Fig. 2 shows that five records (5) cited a lack of enforcement, poor laboratory capabilities due to a lack of facilities and low technology adoption. This may lead to poor detection and response to food-borne hazards.

4.2. Solutions to constraints of safe food provision in South Africa

There is a consensus that most developing countries cannot ensure safe food for both domestic and international consumers. However, food-borne diseases are preventable and can be managed with sound policies and approaches (FAO, IFAD, UNICEF, WFP and WHO, 2023). This section discusses the identified possible solutions from the review analysis.

Following the identification of food safety challenges through the PRISMA systematic review, the methodology adopted by Hawkes et al. (2020) was used to identify possible solutions to the identified food safety challenges hindering the provision of safe food. A total of Eighty-eight 88 records were analysed using *Atlas. ti*. A total of thirty-four (34) potential actions were identified through the systematic review as possible solutions. The consolidated solutions with more than one solution to food systems problems are illustrated in Fig. 3.

The following sub-sections discuss key thematic areas from the *Atlas. ti* analysis reflecting the recommendations of potential solutions.

4.2.1. Agricultural actions

Several agricultural actions were identified as potential solutions to ensure safe food production. Out of eighty-eight records (88), six (6) records from the review recommended that organising smallholder farmers in associations and promoting the adoption of global best

agricultural practices (GAP) can ensure the production of safe food. Several developed countries have managed to reduce food-borne diseases quickly by reducing contaminations at the farm level (Grace et al., 2015). Therefore, promoting the adoption of GAP is likely to reduce contaminations and contribute to improved food safety. However, some reports suggest a low impact of GAP on domestic food safety compared to food produced for export. The low impact of GAP on local food safety can be attributed to the lack of incentives for domestic producers.

As shown in Fig. 3, five (5) records from the review reported that discouraging the excessive use of agrochemicals can produce safe food. This involves changing the mindset of farmers on the use of chemical fertilizers and pesticides and implementing strict measures to curb the irresponsible use of antibiotics at the farm level.

4.2.2. Education, training and public awareness actions

Most of the reports from the review focused on education, training and public awareness. Fig. 3 shows twenty (20) records out of 88 records suggested that providing food safety training to food handlers and other role players in the food systems will likely improve food safety.

Training initiatives are effective in improving food safety in some countries. The is a need to develop a food safety communication strategy to promote reporting, diagnosis and handling of food-borne diseases. The underreporting of food-borne diseases in developing countries (Anon., WHO-FERG, 2015) often complicates linking food contamination with diseases or mortality.

4.2.3. Public institutions actions

Fifteen (15) records from the review were of the view that the promotion of multi-stakeholder engagement and consultations at all levels might improve efforts to identify food safety problems and possible solutions with mutual accountability.

Fig. 3 shows, that four (4) records from the review supported the establishment of a single food safety authority with a focused integrated plan of action. A single central food safety authority will improve collaboration and shorten the response time for tracing and recalling food products during outbreaks. For example, in South Africa, the
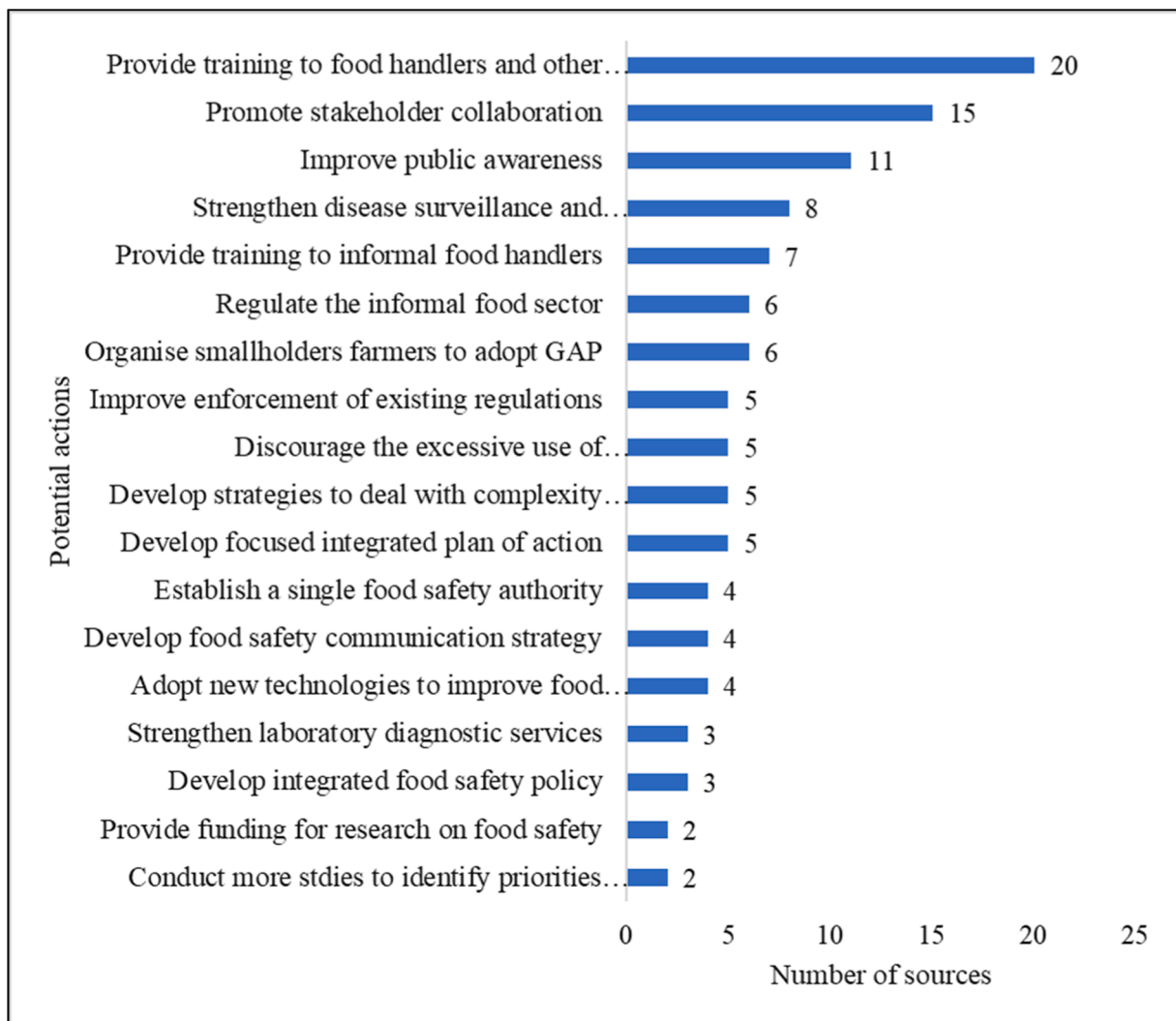
Fig. 3. List of identified potential solutions to constraints to safe food provision, *Author (2024)*.

Departments of Health, Trade and Industry and Agriculture, Rural Development and Land Reform have pieces of legislation to manage food safety but operate in silos with little success (Boatemaa et al., 2019).

4.2.4. Supply chain actions

As illustrated in Fig. 3, four (4) actions were suggested for challenges related to the food supply chain. Actions such as the development of food product tracing systems, and food product tracing systems will reduce the availability or marketing of fake and unsafe food.

4.2.5. Regulatory and enforcement

The review analysis produced several potential regulatory and enforcement actions that can be implemented to transform food systems to provide safe food. Six (6) records suggested the regulation of the informal food sector to improve food safety. This attributes the under-regulation of the informal sector in South Africa to the consumption of unsafe food.

Three (3) records from the review cited that enforcement of existing regulations could improve food safety. However, they did not indicate how enforcement of existing regulations can be improved.

4.2.6. Research and technology actions

A total of fifteen (15) research and technology actions were generated after *Atlas.* to analysis. As shown in Fig. 3, Four (4) records from the analysis recommended the adoption of new technologies to reduce food

contamination at the farm level. The adoption of new technologies has the potential to reduce food-borne diseases.

Fig. 3 shows that Five (5) records suggested more research on developing strategies that could deal with the complexity of food systems. The complexity of food systems in South Africa has made it challenging to develop effective food governance policies. Dealing with complexity will enable the development of integrated strategies to manage risks associated with food safety.

Two (2) records recommended more studies on identifying priority areas for interventions. Currently, there are no indicators for food safety. Research on developing indicators for food safety would help set priority areas for food safety risk management.

4.3. Potential solutions identified from stakeholder interviews

4.3.1. Proportional representation of participants according to their sector

Semi-structured stakeholder interviews were conducted using online forms to provide a ranking of the recommended actions from the systematic review. This sub-section reports on the outcomes of the stakeholder interviews. The interview participants consisted of stakeholders from various sectors of the food systems as illustrated in Table 2.

Table 2 indicates that the majority of the participants (36.4 %) were from the food regulation, government officials, inspection and enforcement agencies. Followed by participants from the education, research and training sectors with 27.3 %. 22.7 % of the participants

Table 2
Proportional representation of participants according to their sector.

Name of industry or sector	*n =* 22	Percentage
Regulators, Government officials, Inspection and enforcement agencies	8	36.4
Researchers, Academics, Educators, Media and advertising	6	27.3
Farmers or Food producers, Food processors, Food handlers, Distributors, Wholesalers and Street vendors	5	22.7
Food consumers	3	13.6

Source: Author (2022).

were from the food production, handling and processing sector. Consumers only constituted 13.6 percent of the participants.

4.3.2. Rankings of actions by votes percentage, BW score and interval scale

Thirty-four potential solutions identified from the systematic review analysis were presented to the participants in the Google form format to select actions that could transform the food systems for a safer food system. The outcome of the actions rankings is illustrated in Table 3 below as top and bottom-ranked actions. The average percentage for most votes was 82.4 percent. Actions with above-average votes were considered top-ranked, and those with below-average were bottom-ranked, as shown in Table 3. Only seventeen potential actions were considered top-ranked actions using the Best-Worst scores.

No action received consensus at this stage although research and technology actions received higher votes from the participants. Table 3 shows the interval scale and the significant difference between the top and bottom-ranked actions. The top-ranked actions ranged from 2.51 to 4.58 intervals, and the bottom-ranked actions ranged from 1.09 to 2.12 intervals.

4.4. No-regret solutions prioritised from validation interviews

4.4.1. Prioritisation of actions by sector

Table 4 illustrates the proportion of participants in the interviews and their respective sectors in the food systems.

The validation interviews were conducted online using Google Forms to enable participants to validate the rankings of the actions and establish a consensus on actions to be considered as no-regret actions. Invitations to participate in the validation interviews were distributed to 22 participants who were part of the initial interviews. Only fourteen participants from various food systems sectors participated in the validation and prioritisation interviews (63 % completion rate).

4.5. The thematic focus of 12 prioritised actions

Fig. 4, illustrates the proportion of the thematic focus of the twelve (12) prioritised actions. Most of the actions (six) prioritised fall under the research and technology theme, followed by legal and regulatory, and education, training and awareness both with two actions.

Fig. 4 shows that the twelve prioritised actions were from five areas of thematic focus. The proportional distribution of prioritised actions reflects how the participants considered each theme significant. The dominance of research and technology actions in the prioritised actions was somewhat surprising because most of the records from the review focused on education, training and public awareness. That was an indication that the prioritisation of actions was purely based on the participant's perception of the potential impact of the actions, not the frequency of records in the systematic review.

4.6. List of actions prioritised with consensus and their thematic focus

Table 5 shows the actions with a hundred percent consensus from the validation interviews. Only twelve (12) actions out of seventeen (17) actions achieved the hundred percent (100 %) consensus for validation.

Table 3
Ranking of actions by votes percentage, BW score and Interval scale.

Actions	Most votes %	Least votes%	BWS score	Interval scale
Researchers should collaborate on developing pro-active food safety strategies	95.5	4.5	0.90	4.58
Mandatory and regular health screening of food handlers	90.9	9.1	0.81	3.16
Improve enforcement of existing policies and regulations.	90.9	9.1	0.81	
Develop strategies and programmes to control the sale of fake foods.	90.9	9.1	0.81	
Strengthen food-borne disease surveillance and early warning systems	90.9	9.1	0.81	
Develop a food safety communication strategy	90.9	9.1	0.81	
Use of visible, easy-to-understand food labels and media tools to improve public awareness of food safety	90.9	9.1	0.81	
Develop strategies to deal with the complexity of food systems	90.9	9.1	0.81	
Conduct more studies to identify priorities for interventions	90.9	9.1	0.81	
Organise smallholder farmers into associations to adopt global best agricultural practices	90.9	9.1	0.81	
Adopts new technologies for testing, monitoring and tracing in the food system	86.4	13.6	0.72	2.51
Strengthen laboratory diagnostic services	86.4	13.6	0.72	
Train food handlers and all other role players in the food systems	86.4	13.6	0.72	
Provide food safety training to informal food handlers	86.4	13.6	0.72	
Increase access to clean water to promote Good Agricultural Practices (GAP)	86.4	13.6	0.72	
Conduct more research studies on the use of food safety information labels and observational studies	86.4	13.6	0.72	
Establish a central food safety authority to deal with all import, export and local food control to protect consumer	86.4	13.6	0.72	
Establish specialised laboratories for analysis of food safety hazards.	86.4	13.6	0.72	
Revise agricultural and food legislative framework and develop a national policy on food safety	81.8	18.2	0.63	2.12
Improve hygiene in post-harvest handling, processing and manufacturing practices	81.8	18.2	0.63	
Adopt new technologies to reduce contamination at the farm level.	81.8	18.2	0.63	
Provide funding for research on food systems transformation	81.8	18.2	0.63	
Create a funding base to support research on food safety policy development	81.8	18.2	0.63	2.12
Develop an industry-led food safety culture	81.8	18.2	0.63	
Adopt a whole systems approach to reduce food contamination	81.8	18.2	0.63	
Develop legislation to recognise and regulate the informal food sector	81.8	18.2	0.63	
Develop food product tracing systems	77.3	22.7	0.54	1.84
Conduct in-depth food systems assessment to complement food safety risk analysis and strengthen institutions	77.3	22.7	0.54	

Table 3 (*continued*)

Actions	Most votes %	Least votes%	BWS score	Interval scale
Mild preservation and disinfection to reduce chemical residues in food products	72.7	27.3	0.45	1.63
Promote multi-stakeholder engagement and dialogues at all levels	72.7	27.3	0.45	
Regulate raw materials and food ingredients	72.7	27.3	0.45	
Restrict importation of pesticides and chemical fertilizers	57.1	42.9	0.13	1.09
Develop sensory protocol devices to detect the SARS-Covid-19 in food products.	57.1	42.9	0.13	
Discourage excessive use of agrochemicals	57.1	42.9	0.13	

Source: Author (2023).

Table 4

Proportion of participants who validated the prioritised actions by sector ($n = 14$).

Name of industry or sector	Percentage
Regulators, Government officials, Inspection and enforcement agencies	38.5
Researchers, Academics, Educators, Media and advertising	15.4
Farmers or Food producers, Food processors, Food handlers, Distributors, Wholesalers and Street vendors	15.4
Food consumers	30.8

Source: Author (2024).

Those are the actions that were prioritised to be considered as no-regret actions to transform the food systems.

4.6.1. Research and technology actions

Hendriks et al. (2021; 2023) reported that research and technology innovations have the potential to accelerate the transformation of food systems. Table 5 shows six actions that were considered for prioritisation under the theme of research and technology. As illustrated in Table 5, collaborative research was prioritised. This finding concurs with the report by Hendriks et al. (2023), who suggested the importance of knowing how different actions by different actors in the food systems affect the food systems. Therefore, collaborative research will contribute to coherent and evidence-based actions on food system transformation.

The second priority action under the research and technology theme was developing strategies to deal with the complexity of the food systems (Table 5). Adeniyi et al. (2021) argued that the complexity of the food systems has limited the progress towards food and nutrition security, and effective food governance in South Africa. The food safety system is a component within the multi-layered food system, therefore research on the complexity of the food systems will contribute to achieving safer food systems. The One-health concept is an example of the strategies developed to deal with the complexity of the food systems. Scientists developed the One-health approach to manage the risk of

Table 5

List of actions prioritised with consensus and their thematic focus.

| No-regret actions	Thematic area of focus
Researchers should collaborate on developing pro-active food safety strategies	Research and technology
Develop strategies to deal with the complexity of food systems	Research and technology
Conduct more studies to identify priorities for interventions	Research and technology
Adopts new technologies for testing, monitoring and tracing in the food system	Research and technology
Strengthen laboratory diagnostic services	Research and technology
Conduct more research studies on the use of food safety information labels and observational studies	Research and technology
Mandatory and regular health screening of food handlers	Legal and regulatory
Improve enforcement of existing policies and regulations.	Legal and regulatory
Strengthen food-borne disease surveillance and early warning systems	Public institutions
Use of visible, easy-to-understand food labels and media tools to improve public awareness of food safety	Education, training and awareness
Train food handlers and all other role players in the food systems including informal food handlers	Education, training and awareness
Increase access to clean water to promote Good Agricultural Practices (GAP)	Agricultural

Source: Author (2024).
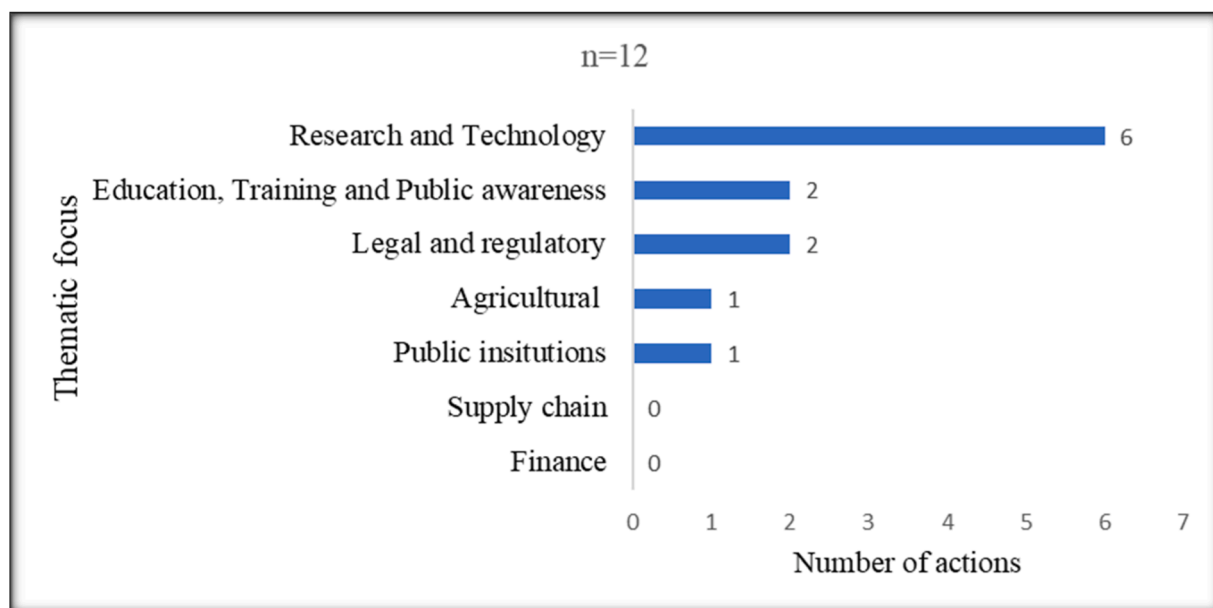
Fig. 4. Proportion of thematic focus of the prioritised actions,
Source: Author (2024).

zoonosis (pathogens infecting animals and humans) in a whole-system approach (Unnevehr, 2022).

The third priority research action identified from this study was identifying intervention priorities (Table 5). Research plays an important role in gathering evidence for priorities. Resources for managing food safety risks can be allocated appropriately when the priority areas are known. Policies for interventions are sometimes political but evidence is significant to ensure proper decision-making for interventions.

Adopting technologies was the fourth priority action considered as no-regret from this study (Table 5). Adopting technological innovations such as whole-genome sequencing and block-chain technology throughout the food value chain can improve food safety systems. Whole-genome sequencing is used for the identification and tracking of specific food-borne pathogens, tracing of food to reduce food fraud and tracing the sources of anti-microbial resistance within the food value-chain.

The fifth priority action under this theme was strengthening the laboratory diagnostic services (Table 5). Managing the food safety risks entails accurate and timely diagnosis of food-borne pathogens. Adopting food testing technologies and capacity building is likely to reduce the time taken to properly detect and identify food-borne pathogens to improve epidemiological investigations.

The last priority action under this theme was conducting research studies on the use of information labels and observational studies to improve food safety (Table 5). Researchers use specific tools and methods to establish and validate the robustness of their studies. There is polarity within the research communities between research-driven and demand-driven approaches to gathering evidence. However, scientific research is not the only way to gather evidence to drive policy intervention. Scientific research is among many knowledge producers. For example, the HLPE centres now recognise the importance of local and lay knowledge to support policy innovations (Hendriks et al., 2023). Therefore, the use of simple observation studies and information labels can be useful to gather evidence and enable proper policy interventions.

4.6.2. Legal and regulatory actions

Two actions under legal and regulatory theme received consensus to be prioritised as no-regret actions (Table 5). The first priority action under this theme was to introduce a regulation that will enable a mandatory and regular health screening for all food handlers in both formal and informal sector. Food handlers throughout the value chain can transmit food-borne pathogens. This is backed by the findings from Siluma et al. (2023) who reported unhygienic meat handling practices such as 67 percent irregular washing of hands and 83 percent less usage of hand gloves in both commercial and informal meat traders in the Vhembe district of South Africa.

Very few interventions have targeted the pathogen transmission between the food-handler and food products. Mandatory health screening played a crucial role in controlling the spread of the Covid-19 virus in many parts of the world during the 2020 outbreak. However, this intervention will require a specific value-chain for food-borne pathogens. Each value-chain may require screening for a specific food-borne pathogen at different intervals. For example, food handlers in the meat value chain will require screening for zoonotic pathogens, while handlers in the fruit sector will require screening for different Phytosanitary pathogens.

The second priority action under the legal and regulatory theme was to improve existing policies and regulations enforcement. This finding does not support overhauling the legislative framework to improve food safety but strengthening the enforcement of the existing pieces of legislations related to food safety governance systems. This finding concurs with the Anon., WHO (2022) global strategy for food safety which prioritised strengthening national food control systems through strengthening compliance, verification and enforcement of legislations. However, the Anon., WHO (2022) strategy recommended the establishment of a modern, harmonized and evidence-based framework for food legislation. The current food legislation policies in South Africa are outdated and fragmented thus negatively impacting the food systems governance (Boatemaa et al., 2019). Different government departments (national, provincial and local) are involved in food systems governance with fragmented, overlapping initiatives, and sometimes duplication of roles.

4.6.3. Public institutions actions

One action under the public institution's theme received consensus (Table 5). Strengthening food-borne disease surveillance and early warning systems was prioritised in this study. Food-borne disease surveillance programmes are key to any food safety system (Anon., WHO, 2022). The public sector is dominant in the South African food control system (Adeniyi et al., 2021). Due to the limited capacity of the public sector, one of the best approaches to managing food safety risks is to develop continuous surveillance programmes, which involve all the role players in the food systems to ensure an evidence and risk-based approach. The evidence and risk-based approach is a modern approach that uses scientific information gathered through surveillance to direct more resources to the critical part of the food value-chain. The evidence-based surveillance system provides information on the presence and level of different food hazards in the food value-chain.

4.6.4. Education, training and awareness actions

Two actions out of three actions under the education, training and awareness theme received consensus (Table 5). The first priority action under this theme was using visible, easy-to-understand tools to improve awareness of food safety. Several studies have reported the lack of knowledge on food safety among school children and older consumers as a serious challenge (Thaivalppil et al., 2020; Wanniarachchi et al., 2023; Unnevehr, 2022). The lack of knowledge of food safety hazards by children and elderly consumers often leads to improper handling and storage of food products. The use of visible, easy-to-understand tools is likely to improve the food safety knowledge of vulnerable groups. Visible and easy-to-understand tools include posters, charts, infographics and videos.

The second priority action under this theme was the provision of food safety training to food handlers and all other role players in the food systems. All role players in the food systems need to have adequate knowledge of food safety issues. This finding concurs with several other studies conducted on the knowledge and practices of food handlers (Young et al., 2020; Boatemaa et al., 2019; Nyawo et al., 2021; Madilo et al., 2023; Siluma et al., 2023). Most studies demonstrated poor knowledge of food safety and hygienic practices. Training interventions have been widely offered to food handlers in the formal sector to implement food safety management systems. However, those interventions did not demonstrate the synergies between food safety, nutrition and economic development. This study finds that training interventions should be offered to all role players in the food systems, including informal street food vendors, to raise awareness of synergies and trade-offs between food safety, nutrition and sustainable development.

4.6.5. Agricultural actions

One agricultural action received consensus for prioritisation (Tabel 5). The promotion of GAP through the provision of clean water was prioritised in this study. Water is an important input for food production. Water can be a carrier of many microbial pathogens, such as *E. coli*, *Salmonella* and *Cryptosporidium*. GAP was introduced to minimize microbial food safety hazards in the fresh fruits and vegetables industry. The provision of clean water is significant to enable sustainable food production systems with proper Sanitary and Phytosanitary practices at the farm level. However, Grace et al. (2015) argued that promoting GAP without introducing proper incentives will have less impact on food safety. Many actions on food systems transformation were discussed during the 2021 food systems summit but very little attention was paid

to this important ingredient of the food systems (FAO, IFAD, UNICEF, WFP and WHO, 2022). In South Africa, the provision of clean water has always been attributed to human health without paying attention to the food system part where the provision of clean water throughout the value chain is vital.

5. Policy implications

The findings from this study provide the basis for policymakers to review the food policy framework and develop interventions to transform the food systems for improved food safety. The World Trade Organisation (WTO) agreement on the application of the international standards on Sanitary and Phytosanitary (SPS) measures made provisions for member states to develop their national food safety measures. Article 2.2 of the WTO agreement calls for the national food safety framework to be based on science. The no-regret actions from this study will form a precursor to developing policy interventions that are locally developed and science-based (Anon., WTO, 2010).

The findings are vague on strategies to deal with the complexity of the food systems but revealed that collaborative research is key to dealing with the interconnectedness of the food systems.

The SPS Agreement also encourages member states to harmonize their SPS measures to the international standards developed by the Codex Alimentarius Commission (CAC), the International Plant Protection Convention (IPPC) and the World Organization for Animal Health (WOAH) (Anon., WTO, 2010). This study prioritized the need to develop a research policy framework to compel multi-sectoral collaboration and funding of food systems research. The study reported the need to develop easy-to-understand food safety information materials. The marketing and advertising regulations can be amended to include mandatory easy-to-understand food safety information on marketed products in line with the CAC standards. The lack of food safety information and knowledge can also be addressed through basic education and training policy framework.

This study prioritised inter-connected actions; therefore, a whole system integrated approach is necessary to accelerate food systems transformation to achieve multiple goals simultaneously. This study further recommends a harmonized legislative framework to compel all role players in the food systems to play their respective roles in the implementation of food safety measures. Article 3.1 of the WTO agreement requires member states to harmonize measures based on international standards and recommendations (Anon., WTO, 2010). Harmonized food safety measures will improve food safety control in international trade. One sector or actor's inability to ensure food safety will negatively affect the transformation of the food system. Therefore, policymakers in South Africa should review the food legislation and regulatory framework to ensure a smooth transformation of the food systems, in line with international standards.

6. Conclusions

This study demonstrated that research and technology actions are critical to solving challenges and offer opportunities to improve food safety through food systems transformation. More collaborative research is required to identify key drivers in the food safety systems. Researchers must collaborate to develop strategies to deal with the complexity of the food systems and improve food safety risk management.

This study prioritised improving enforcement of the existing policies but was vague on what exactly can be done to strengthen enforcement. To strengthen the enforcement of food policies, a competent authority should conduct regular verifications, inspections and audits of food business operators with proficient and competent staff.

This study also prioritised strengthening the surveillance of foodborne diseases. Strengthening surveillance entails developing a strategy, adopting technologies to trace food-borne pathogens, developing

laboratory capability to identify and link food pathogens with the disease, and strengthening multi-sectoral stakeholder coordination.

Two (2) education, training and awareness actions were also prioritised. The use of pictorial and other easy-to-understand food safety warnings in all public spaces was prioritised as well as the provision of training to all role players in the food systems. However, these actions must be accompanied by mechanisms to monitor public perceptions to ensure effectiveness. Training of role players in the food systems could result in good agricultural practices and improved food processing and handling.

The provision of clean water was also prioritised in this study. However, this study relates clean water with GAP to produce safe food. The provision of clean water is critical to ensure both sustainable production and consumption of safe food (Hendriks et al., 2021).

Due to the complexity and interconnectedness of the food systems, new forms of food system governance must be established to facilitate multi-sector collaboration to foster synergies and coherence in transforming the food systems. United Nations Food Systems Summit (UNFSS) of 2021 and the WHO Global Food Safety Strategy projected that food systems transformation through policy innovations will have multiplier effects Therefore, the implementation of a no-regret policy approach is recommended to accelerate food systems transformation.

Ethical statement

This study was conducted in line with ethics guidelines of the University of Pretoria ethics committee. Ethics approval for this study was granted on 9 February 2023 (Ethics reference number: NAS260/2021) by the UP ethics committee. The participants completed consent form prior participation in the interviews. The consent form guaranteed privacy of personal information of the participants and that only their opinions will form part of the publication of the results.

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CRediT authorship contribution statement

Tshilidzi Isaac Dama: Writing – review & editing, Conceptualization, Data curation, Formal analysis, Methodology, Investigation, Project administration, Software, Writing – original draft. **Olwethu Loki:** Writing – review & editing, Supervision, Conceptualization, Methodology. **Wegayehu Fitawek:** Writing – review & editing, Supervision, Conceptualization, Methodology. **Sikwela M. Mpuzu:** Writing – review & editing, Conceptualization, Methodology.

Declaration of competing interest

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

Data availability

I have shared the link to the data sets.

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Further reading

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