From Food Safety to Food Defence: Institutional Fragmentation, Regulatory Risks, and National Security in Kenya's Meat Subsector

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ABSTRACT

Food defence is an important aspect of public health preparedness and national security, as deliberate contamination of food systems can affect population health, economic stability, and public confidence. Although Kenya has established regulatory systems for food safety, there is limited empirical evidence on how well these systems address intentional contamination. This study examined food defence governance in Kenya's meat subsector by evaluating the regulatory and institutional framework, assessing employee awareness and institutional preparedness, and exploring the implications of existing gaps for public health and national security.

A convergent parallel mixed-methods design was used, with the Kenya Meat Commission serving as a case study. Quantitative data were collected from 119 employees through structured questionnaires, while qualitative data were obtained from key informant interviews with representatives from the Directorate of Veterinary Services, Kenya Bureau of Standards, Ministry of Health, and Kenya Meat Commission management. Relevant legislation, policies, and operational guidelines were also reviewed. Quantitative data were analysed using descriptive statistics, chi-square tests, and multiple linear regression, while qualitative data were analysed thematically following Braun and Clarke's approach. Findings were integrated through triangulation.

Kenya has a relatively well-developed food safety system but lacks a dedicated framework for preventing and responding to intentional contamination. While employees reported high awareness of food defence concepts, institutional preparedness was weaker, particularly in relation to vulnerability assessments, simulation exercises, and coordinated emergency planning. Qualitative findings pointed to fragmented institutional mandates, limited inter-agency coordination, and the absence of a clearly designated lead agency for food defence. Regression analysis showed that weaknesses in inspection and monitoring systems were significantly associated with increased perceived public health risks ($\beta = 0.267$, $p = 0.003$), while the Preparedness Index was the strongest predictor of perceived national security implications ($\beta = 0.975$, $p < 0.001$).

Kenya's main challenge in food defence lies not in the absence of institutions, but in the continued reliance on a food safety approach that does not fully address intentional contamination. The study contributes to food defence scholarship by demonstrating that institutional coordination, regulatory recognition, operational preparedness, and security resilience provide a useful analytical framework for understanding food defence governance in lower- and middle-income countries. Strengthening food defence will require clearer policy direction, better coordination among agencies, routine vulnerability assessments, workforce training, and integration of food defence into broader public health and infrastructure protection efforts. This study provides empirical evidence from a lower-middle-income country and advances understanding of food defence governance in African food systems.

Keywords: Food Defence; Food Safety; Public Health; National Security; Food Governance.

INTRODUCTION

Safe, secure and resilient food systems are essential to public health, economic growth and national security. The World Health Organization (WHO) further notes that the global economic burden and productivity loss stemming strictly from unsafe food reached US$ 310 billion in a single year, highlighting its massive toll on economic stability (Lake et al., 2026). Although food safety programmes have primarily been designed to prevent unintentional contamination from biological, chemical or physical hazards, the complexity of food supply chains is making deliberate contamination, food sabotage and other intentional events likely to impede food production and distribution (Manning et al., 2019). These risks can arise from economically motivated adulteration, insider threats, organized criminal activity, cyber threats to food systems and acts of terrorism on critical food infrastructure (Chukwugozie et al., 2024).

As a result, food defence has emerged as a critical component of public health preparedness and national security, complementing traditional food safety systems by addressing intentional rather than accidental threats. The importance of food defence has been highlighted internationally since the enactment of food defence regulations including the United States (U.S.) Food Safety Modernization Act (FSMA) requiring facilities to develop and implement a written food defense plan, the Food Defense Plan Builder, and vulnerability assessment tools (U.S. Food and Drug Administration, 2023).

These programmes appreciate that contemporary food systems constitute critical infrastructure that when compromised can lead to general outbreaks of disease, economic losses, loss of consumer trust and national instability. International organisations, such as the Food and Agriculture Organisation (FAO), the World Health Organisation (WHO), the World Organisation for Animal Health (WOAH) and the Codex Alimentarius Commission, have also called for more attention to be paid to preparedness for deliberate contamination in addition to food safety.

But in many low- and middle-income countries, food governance is still focused on food safety, food hygiene and prevention of diseases. Regulatory systems are generally designed to react to existing hazards, zoonotic diseases and accidental contamination, and very little focus has been given to intentional threats to food supply chains. However, food systems have been rendered more vulnerable to deliberate interference as a result of rapid urbanization, growth of regional trade, dependency on longer and more complex value chains and new transboundary security threats.

Such advancements have led to an increased awareness of the importance of food defence as a part of the broader public health protection effort and not just a specialized security issue (Grace, 2015). The livestock sector plays a significant role in the overall national economic development, food security, employment and livelihoods of households in Kenya. The meat subsector is an important contributor to local consumption and provides for regional and international trade, thus playing an important role in public health and economic sustainability (MOALD, 2023).

Kenyan food governance is shared among several institutions such as the Directorate of Veterinary Services, Kenya Bureau of Standards, Ministry of Health, county governments and other food and public health regulatory institutions. These institutions have collectively created a broad regulatory system on food safety. The degree of coverage of these systems on intentional contamination, however, is not well known. Some recent research in Africa has identified the lack of coordination between agencies responsible for food governance and the lack of surveillance systems, as well as inconsistent regulatory enforcement and fragmented mandates for food agencies. In Kenya, this directly led to the development of the Food and Feed Safety Control Co-ordination Bill (Parliament of Kenya, 2023) to improve food governance in the country.

In spite of the progress made in the understanding of food safety and food fraud, limited empirical food defence governance research has been conducted, especially for the African livestock value chain. Research published to

date has largely concentrated on the issue of microbial contamination, foodborne illness, food hygiene and compliance with regulations, with little research identified on the question of institutional preparedness for deliberate contamination and the subsequent risk to public health and national security (Boto and Mofolo, 2018).

The study therefore aimed at: (i) evaluating the effectiveness of the regulatory and institutional framework in protecting the meat supply chain from deliberate contamination in Kenya; (ii) assessing awareness of the employees and the institutional preparedness in the Kenya Meat Commission for food defence; and (iii) analysing implications of any weaknesses in food defence for public health and national security. This study drew quantitative and qualitative data from regulatory institutions and the meat processing industry, which supplied empirical evidence to the growing area of food defence governance in Africa, and offered policy recommendations to enhance the resilience of critical food systems to intentional threats.

LITERATURE REVIEW

Food Defence, Regulatory Governance and National Security

From Food Safety to Food Defence

The traditional approach to food safety has been centered on prevention of unintentional hazards in the food production, processing, storage and distribution process that could pose a risk to consumers. The risks associated with these hazards are biological (such as disease-causing organisms or pathogens) chemical (such as residues from chemical agents, food additives, and packaging materials) and physical (such as poor hygiene practices, inadequate handling practices and environmental exposure) (Bogadi et al., 2025). Preventive systems like Good Manufacturing Practices (GMP), Good Hygienic Practices (GHP), and Hazard Analysis and Critical Control Points (HACCP) have gained global acceptance to control these risks and have led to significant improvements in public health all over the world (FAO, 2023).However, today's food systems are subjected to a wider range of risks than accidental contamination.

These include: Contamination on purpose, sabotage, adulteration on purpose, and food fraud. High-profile food fraud cases coming to public attention include the adulteration of Chinese milk products with addition of melamine to illicitly increase apparent nitrogen content, thus implying increased protein content (Abid et al., 2025; Xiu and Klein, 2010). Dairy, meat, fish and seafood, oils and fats, tea, spices, and honey are naturally considered as most susceptible to fraud (Onyeaka et al., 2022). According to Spink and Moyer, (2011), food fraud is defined as “any economically motivated deception, including substitution, dilution or mislabelling of food products, for financial gain”. They proposed seven types of food fraud: adulteration, counterfeit product, diversion of products outside of intended markets, over-run, simulation, tampering and theft.

Food defence is the protection of food systems from deliberate contamination, sabotage, and other malicious acts using various strategies, policies and practices (FDA, 2014). Food defence differs from food safety, which relies on the premise that food systems could be subjected to unintended hazards, and considers that food systems could be subject to deliberate actions by a malicious party, such as a disgruntled employee, criminal networks or a terrorist group (FSIS, 2014). Consequently, food defence includes the use of vulnerability assessment, access control, personnel reliability programmes, surveillance and emergency preparedness (Manning and Soon, 2016). The goal of food safety and food defence is the same: to ensure that safe food is provided for consumption, but they have very distinct assumptions and approaches.

Food safety is about the control of unintentional contamination while food defence is about intentional contamination that takes advantage of the vulnerabilities of a system. Whereas their ultimate goal of protecting public health matches, they require different risk assessment approaches, mitigation strategies, and institutional competencies to achieve food protection. Increasingly, effective food governance demands to combine both approaches in a comprehensive food protection system that can cope with accidental and deliberate risks.

Food Systems as Critical Infrastructure

Food systems are seen as key infrastructure components because of their importance in providing public health, economic stability and social cohesion and are increasingly recognised as critical infrastructure that underpins national resilience and sustainable development (Morris, 2023; WHO, 2022). Today's food supply chains are very complex and extend from the production stage through processing, distribution networks and retail chains, across national and international boundaries. They are also highly interconnected with other critical infrastructure sectors, including transportation, energy, water supply, communication systems, public health services, and financial systems, meaning that disruptions in one sector can rapidly cascade across the entire food system (United Nations Office for Disaster Risk Reduction [UNDRR], 2022). Any disruption in these systems can, therefore, have impacts that extend beyond the food safety issue. The United Nations Office for Disaster Risk Reduction (2022) thus recommends a systems-based approach to disaster risk reduction framework integrating food system resilience into broader critical infrastructure protection and emergency preparedness planning.

A public health approach is critical to food systems, guaranteeing access to safe and nutritious food. Unexpected and deliberate interruptions can cause the entire population to fall ill, raise the cost of health services and decrease the wellbeing of the people. From an economic perspective, food systems promote livelihoods, trade and national income, especially in economies where agriculture and livestock production is a key contributor to the country's gross domestic product. Disruptions may lead to food shortages, price fluctuations, trade restrictions, and loss of investor confidence (UNDRR, 2022).

Food systems are now being more consistently included in national resilience and security plans as recognition of these risks. Many high-profile cases of food fraud and deliberate contamination have proven that food supply chains can be exploited to create economic disruption, loss of public trust, and social instability (Medeiros et al., 2026). As a result, governments and international organizations are now focusing on the need for protection of food systems when planning critical infrastructure protection strategies (Bogadi et al., 2025).

This change has resulted in the creation of regulatory frameworks and guidance to further strengthen food defence. For instance, the United States Food Safety Modernization Act (FSMA) has enacted the Intentional Adulteration Rule, which calls for a vulnerability assessment of food facilities and the development of mitigation strategies (U.S. FDA, 2016).

Food Defence in African Food Governance

Historically, food governance systems across Africa have been concerned with food safety, i.e., managing foodborne diseases, enhancing hygiene and building up food inspection capacity (WHO, 2022). Although these have helped to promote better public health outcomes, food defence has not been given the same attention within policy and regulatory environments. Research has identified food governance issues in Africa, such as low enforcement capacity, poor laboratory facilities, weak traceability systems, and fragmented institutional frameworks (Onyeaka et al., 2022; Sirma et al., 2023; Chukwugozie et al., 2024). Such challenges impact food safety, but also hinder the ability to respond to food fraud or intentional contamination. The gaps in mandates, overlapping mandates and lack of coordination between the regulatory agencies have been identified as a challenge (Kang'ethe et al., 2019). The institutional characteristics could impair preparedness against intentional contamination, by restricting information exchange, integrated surveillance and quick response. Ensuring food security, jobs and trade, food defence governance is particularly important for Kenya's livestock and meat industry, which is of strategic importance to the country in terms of its food systems, employment and trade.

Food Defence and National Security

Food defence has been elevated from a technical food safety matter to a national security problem, at least in part because of the increasing awareness of food systems as critical infrastructure (UNDRR, 2016). Widespread

impacts can result from deliberate contamination of food supply chains, impacting beyond the immediate public health impacts. An intentional contamination can result in a foodborne illness outbreak spreading throughout a community with a resulting increase in morbidity and mortality and a strain on healthcare services from a public health standpoint (WHO, 2026). From an economic perspective, these events can lead to product recalls, trade restrictions, disruption to supply chains, and significant losses throughout agricultural value chains (Spink and Moyer, 2011). On a social level, they have the potential to create anxiety, misinformation and a loss of confidence in regulatory institutions within the public sphere (UNDP, 1994).

This study applied the human security theory which offers a valuable framework for analysing the interlinked effects, because it focuses on the security of people against threats to health, livelihoods and wellbeing (Sen, 1999). Human Security Theory is a breakthrough in the shift of the traditional, state-based approaches to the concept of security to the people-centered one. This theory was officially established in the United Nations Development Programme (UNDP) Human Development Report of 1994, which highlighted the fact that real security is the immunity against endemic insecurities like hunger, illness, and repression, and also against the unforeseen instabilities like armed conflict, a collapse in the economy, and natural calamities. In this context, food defence failures have a direct impact not only on technical or regulatory aspects, but also on human security and the stability of a country. Therefore, the integrity of food systems is fundamental to protecting the health of the people, economic stability, and social cohesion. Although these connections have grown increasingly apparent, scientific studies on food defence in the national security context are few and far between, especially in the context of Africa (Grace, 2015; Kang'ethe et al., 2019). The majority of studies remain on food safety issues, regulatory compliance and/or food fraud, with limited attention to the impact of the institutional vulnerabilities in these food defence governance on the overall public health resilience and national security.

Knowledge Gap and Contribution of the Study

The literature suggests that although there has been considerable development over the past decade to improve food safety systems, food defence is still under-developed, especially in developing nations like low- and middle-income countries (Onyeaka et al., 2022). Past studies have concentrated on foodborne diseases, food fraud and regulatory compliance, and have paid limited attention to the empirical study of institutional preparedness to deliberate contamination in African food systems (Grace, 2017). Boto and Mofolo (2018) in their review highlighted food safety as a critical part of the food system in Africa with foodborne disease burden featuring heavily in the continent (Lake et al., 2026). In Kenya, specific baseline assessments of the livestock sector have remained strictly limited to mapping hygiene compliance and on unintentional biological contamination, such as Salmonella and E. coli prevalence in abattoirs (Sirma et al., 2023; Hoffmann et al., 2023). The regulatory fragmentation, limited enforcement capacity and coordination issues in food safety governance in Kenya have been noted in studies (Abid et al., 2025; Kang'ethe et al., 2019; Njiru et al., 2025). However, these scholars have not examined how these structural deficiencies directly weaken food defence readiness. In addition, there are not many studies that combine quantitative analysis of employee awareness and the qualitative analysis from the regulatory institutions. This study aims at filling these empirical, institutional, and methodological gaps, by assessing the governance of food defence in the meat subsector in Kenya, focusing on the Kenya Meat Commission and relevant regulatory agencies. Methodologically, this study utilizes a convergent mixed-methods approach by pairing quantitative assessment of frontline employee awareness with a qualitative, thematic analysis of institutional governance and regulatory coordination.

METHODOLOGY

Research Design

The study used a convergent parallel mixed methods approach, aimed at assessing food defence governance effectiveness in the meat subsector in Kenya and its implications for public health and national security. A mixed methods approach was deemed suitable as food defence is a complex issue involving measurable organizational

practices along with other institutional, regulatory and governance processes which cannot be fully captured by a single methodological approach.

Case Selection: Kenya's Meat Subsector and the Kenya Meat Commission

The study used a case study design on the meat subsector in Kenya and the Kenya Meat Commission (KMC) was the main case. Case study methodology is especially suitable for the study of phenomena in the present where the boundaries between the phenomenon and its operating environment are not clearly delineated, as is often the case in the study of "real world" and "contemporary" phenomena. The Kenya Meat Commission was chosen as a critical case because of its strategic position in the Kenyan livestock industry. KMC is one of the largest integrated meat processing and marketing institutions of the country, which sources livestock from various production systems and serves domestic and export markets. This includes slaughter, processing, storage, distribution, and quality assurance and places it into regular contact with various national regulatory organisations for veterinary public health, food safety, food standards and disease surveillance.

Quantitative Component

Study Population and Sample Size

The quantitative component focused on employees of Kenya Meat Commission who had direct influence on the activities of food production, processing, quality assurance, meat inspection, food safety management, storage, logistics and other operational functions. These staff members were deemed to have the most practical knowledge on the vulnerabilities in the food supply and the preparedness of their institutions for food defence.

The sample size required was based upon Yamane's (1967) formula for finite populations:

$n = N / (1 + Ne^2)$; N = 170, e = 0.05; Square the margin of error (e^2): (0.05^{2}=0.0025); Ne^2 : 170*0.0025=0.425; n = 170 / (1+0.425); 170 / 1.425 = 119

Where n is the desired sample size, N is the entire population of interest, and e is the desired level of precision (0.05 for 95% confidence level). The resulting sample size was therefore 119 respondents. The 5% margin of error was selected to provide a conventional level of precision corresponding to a 95% confidence level, which is widely used in empirical social and health research. However, because the sample was derived for overall population estimates rather than specifically powered subgroup comparisons, analyses involving small demographic or occupational subgroups were interpreted cautiously.

The sampling frame comprised KMC employees involved in meat production and those available within the identified operational functions during the study period. Any limitations arising from staff availability for example staff on leave or inaccessible departments were considered when interpreting the findings.

Sampling Procedure

The respondents were selected using purposive sampling to ensure that the respondents had direct involvement in the meat value chain. Eligible employees were those involved in processing, quality assurance, inspection, veterinary, engineering, logistics, stores and production management. Administrative staff who have no day-to-day operational duties connected with food production or food safety were not included because they had limited involvement in food defence activities.

Questionnaire Design

Data were gathered through a structured questionnaire, comprising closed-ended questions and five-point Likert-scale questions that ranged from Strongly Disagree to Strongly Agree. The instrument was organized into five

sections covering: socio-demographic characteristics, awareness of food defence concepts, effectiveness of regulatory and institutional frameworks, institutional preparedness for deliberate contamination and perceived national security implications of food defence weaknesses.

The food defence questionnaire was created based on food defence literature on intentional contamination, vulnerability assessment, food defence planning, institutional preparedness and food governance, including Manning and Soon (2016), Manning (2019), U.S. Food and Drug Administration guidance on intentional adulteration (FDA, 2016), and relevant Kenyan food safety and regulatory policy documents. The questionnaire was contextualised to the Kenyan meat subsector by incorporating terminology and institutional responsibilities relevant to KMC, the Directorate of Veterinary Services, the Ministry of Health and the Kenya Bureau of Standards.

In order to ensure relevance and content validity to the study goals, the instrument was pretested for clarity and relevance prior to administration. Before pretesting, the questionnaire was reviewed by four experts with expertise in veterinary public health, food safety, food defence and/or research methodology to assess content relevance, clarity and coverage of the study constructs.

Reliability and Study Variables

The internal consistency of the items on the Likert scale was determined using Cronbach's alpha. The measurement scales were considered to have satisfactory internal consistency where Cronbach's alpha was 0.70 or higher. Employee awareness, regulatory and institutional effectiveness, and institutional preparedness were considered the main independent variables. The dependent variable was perceived national security implications of food defence weaknesses, operationalised across four dimensions: public health security, food supply security, economic security, and public confidence in food systems.

Qualitative Component

Qualitative data were gathered using semi-structured Key Informant Interviews (KIIs) with key informants from food governance and public health protection institutions. The interviewees included staff members from the Directorate of Veterinary Services (DVS), Kenya Bureau of Standards (KEBS), Ministry of Health (MoH) and the top management of the Kenya Meat Commission. Participants were selected using a purposive sampling method based on their work responsibilities, technical knowledge, and experience in food regulation, standards development, meat inspection, and policy implementation. Their roles gave them an opportunity to provide informed perspectives on institutional preparedness and coordination in food defence governance.

The interview guide covered a range of thematic areas such as: regulatory and policy frameworks for food defence, institutional preparedness and emergency response systems, food defence surveillance and vulnerability assessment systems, inter-agency coordination and the challenges and opportunities for strengthening food defence governance. Field notes were taken during the interviews with participants' consent. Thematic analysis was used to analyse qualitative data adopting the six-step approach by Braun and Clarke (2006). The analysis included a familiarization process with the data, initial coding, theme development and refinement, and an interpretation of recurring patterns of food defence governance and institutional preparedness.

Document Review

In addition, a structured review of policy, legislative and institutional documents was conducted to complement the primary data. The following key documents were reviewed: the Meat Control Act, the Public Health Act, the Food, Drugs and Chemical Substances Act, the Standards Act, Kenya Meat Commission operational manuals, veterinary inspection guidelines and some policy documents prepared by DVS, KEBS and the Ministry of Health. Content analysis was used to identify provisions of food defence, institutional responsibilities, surveillance

systems, emergency preparedness and regulatory coordination in documents. The findings from the quantitative survey and qualitative interviews were compared with and contextualised using the documentary evidence.

Data Integration

The integration process involved comparing and converging findings from the three data sources. Where there were areas of commonality, confidence was increased in the results; where there were areas of difference, there were opportunities for further interpretation of institutional and operational factors which affect food defence governance. This approach strengthened the credibility and comprehensiveness of the findings by providing a more holistic picture of food defence preparedness than could have been achieved from a single source of evidence.

Ethical Considerations

Approval for the study was given by the National Defence University–Kenya (NDU-K) and the National Commission for Science, Technology and Innovation (NACOSTI) provided approval to proceed with the research. The Kenya Meat Commission also gave permission to carry out the study. Participation was voluntary and written informed consent was obtained from all respondents prior to data collection. The participants were given assurances that they would be treated anonymously and that their personal identity would not be disclosed and that they could withdraw at any time from the study without any consequences. All data collected were anonymised and used for research purposes only.

FINDINGS

A Food Safety System without a Food Defence Architecture

The findings indicate that Kenya has a food governance system but one which is mainly geared towards conventional food safety and not food defence. The document review showed that the following key legal documents provide a regulatory basis for food hygiene, disease control, meat inspection, certification and consumer protection: Food, Drugs and Chemical Substances Act, Public Health Act, Meat Control Act and Standards Act. These tools, however, do not explicitly offer a comprehensive toolkit for the prevention, detection or response to intentional contamination of food systems. This pattern was verified by key informant interviews. Respondents from regulatory institutions noted that Kenya's food governance system is more developed with regard to accidental contamination than to intentional threats. One of the respondents in the Directorate of Veterinary Services commented that:

“Most of our regulations are directed towards food safety and public health, and food defence as protection against deliberate contamination is not well captured.”

Similarly, a respondent from Kenya Bureau of Standards commented:

“In Kenya, most institutions prioritize accidental contamination over intentional contamination, making food defence still at its infancy stage.”

The results indicate that the current food governance structures constitute a framework for food safety management, but are not yet a specific food defence system. Regulatory inspection systems were seen as fairly good in terms of supporting compliance with hygiene regulations, disease monitoring and product certification, but not effective enough in identifying insider threats, sabotage or intentional adulteration. This leaves a food governance system that can manage routine food safety checks but is not well equipped to deal with deliberate contamination events.

Awareness with Limited Preparedness

Overall, the study revealed that there was high awareness among the staff of the Kenya Meat Commission on food defence related concepts (Table 1). High levels of awareness were recorded for food defence concepts (M = 4.21, SD = 0.62), deliberate contamination risks (M = 4.25, SD = 0.75), knowledge of reporting mechanisms for suspicious activities (M = 4.15, SD = 0.77) and awareness of institutional food defence plans (M = 4.19, SD = 0.68).

Table 1 Employee Awareness of Food Defence Concepts (n = 119)

Statement	Mean	SD
Awareness of food defence concepts	4.21	0.62
Awareness of deliberate contamination risks	4.25	0.75
Knowledge of reporting mechanisms for suspicious activities	4.15	0.77
Awareness of institutional food defence plans	4.19	0.68

Source: Author (2026)

Further analysis revealed that employees reported relatively high awareness of the possibility of intentional food contamination (M = 4.24, SD = 0.65), vulnerable points in the meat supply chain (M = 4.21, SD = 0.77), and potential perpetrators like disgruntled employees, criminal groups, and terrorists (M = 4.16, SD = 0.80). However, the results also revealed a distinction between awareness and practical preparedness. Formal training to prevent intentional contamination, formal training on emergency response procedures and food defence recorded comparatively lower scores (M = 3.97, SD = 0.84). The mean score for vulnerability assessment practices was also lower (M = 3.94, SD = 0.85). This indicates that staff may be aware of food defence principles but may lack specific and systematic training in practical food defence preparedness tools.

This was also echoed in qualitative evidence. One KII said:

“There is a lack of awareness among many employees and even managers regarding the concept of food defence.”

Another KII observed:

“Key gaps include limited awareness of food defence concepts, absence of vulnerability assessments, weak access control and surveillance systems, and lack of formal incident response protocols for intentional contamination.”

These findings therefore indicate a gap between general awareness and institutionalised preparedness. The relatively high scores for food defence awareness may partly reflect social desirability or respondents' tendency to report knowledge of food defence in a favourable manner. However, the study mitigated this limitation through triangulation with key informant interviews and documentary review. The qualitative evidence did not show a corresponding level of operational preparedness. Instead, key informants repeatedly identified gaps in training, vulnerability assessment, surveillance, access control, incident-response protocols and dedicated institutional resources.

Facility-Level Confidence Versus System-Level Vulnerability

One of the key findings of the study is the disparity between facility-level confidence and concerns at the system

level. Based on the quantitative results obtained from KMC staff, respondents perceived a relatively high level of preparedness within KMC (Table 2). The majority of respondents reported having well defined emergency response procedures (84.0%), regular food defence training (81.5%), vulnerability assessments (79.0%), mechanisms to identify preparedness gaps (82.4%) and food defence and prevention of intentional contamination as a high priority for management (87.4%).

Table 2 Institutional Preparedness Indicators (n = 119)

Preparedness Indicator	**Yes (%)**	**No (%)**
Clearly defined emergency response procedures exist	84.0	5.0
Regular food defence training is conducted	81.5	6.7
Vulnerability assessments are conducted	79.0	7.6
Regular preparedness drills/simulation exercises are conducted	34.5	41.2
Adequate mechanisms exist to identify preparedness gaps	82.4	5.0
Management prioritizes food defence and prevention of intentional contamination	87.4	5.0

Source: Author (2026)

However, although positive perceptions were expressed, simulation exercises were found to be a major weakness. Only 34.5% agreed that KMC regularly conducts drills or simulation exercises for preparedness against intentional contamination incidents, 41.2% disagreed and 24.4% were unsure. This was the lowest readiness indicator, and reflects a possible lack of regular testing of internal response capability. A more conservative view was expressed in qualitative interviews. Key informants noted that preparedness for an outbreak or routine food safety incidents is more advanced than for intentional contamination or sabotage. One respondent observed:

“If it happens in a case of disease outbreak, institutions are better equipped, but deliberate contamination or sabotage remains a challenge.”

Another respondent noted:

“There are no dedicated structures or personnel responsible for food defence.”

KMC may have internal systems that employees perceive as effective, while key informants expressed greater concern about the wider national food defence system. This is significant because gaps in national coordination, regulation, intelligence sharing and sector-wide response mechanisms cannot be inferred from preparedness within a single facility.

Food Defence Gaps as National Security Vulnerabilities

The study revealed that gaps in food defence governance have consequences that go beyond the typical food safety context. Food defence gaps were linked to public health threats, economic disruption, vulnerability of food supplies, and loss of public confidence in institutions (Table 3). The highest percentage of high compliance was seen in employees with over 15 years of experience (45.4%) and the highest percentage of low compliance was observed in employees with 1–5 years of experience (40.8%). This points to the need for further research into the possibility of influencing compliance with food defence practices through institutional familiarity and practical experience. The association between work experience and compliance level in Table 3 was not statistically

significant, $\chi^2(6, N = 119) = 5.91$, $p = .433$; the observed differences should therefore be interpreted descriptively. In the broader inferential analysis, a statistically significant association was observed between work experience and institutional preparedness ($\chi^2(3, N = 119) = 28.93$, $p < .001$) indicating a relatively strong association.

Table 3 Cross-tabulation of Work Experience and Compliance Level (n = 119)

Work Experience (Years)	**Low Compliance n (%)**	**Moderate Compliance n (%)**	**High Compliance n (%)**	**Total**
1–5	20 (40.8)	20 (40.8)	9 (18.4)	49
6–10	10 (25.0)	18 (45.0)	12 (30.0)	40
11–15	5 (26.3)	8 (42.1)	6 (31.6)	19
Over 15	2 (18.2)	4 (36.4)	5 (45.4)	11
Total	37	50	32	119

Source: Author (2026)

Regression analysis further showed that weaknesses in inspection and monitoring systems significantly predicted perceived public health risks associated with deliberate contamination (Table 4; B = 0.267, p = 0.003). This finding indicates that greater perceived weaknesses in inspection and monitoring systems were associated with higher perceived public health risks related to deliberate contamination.

Table 4 Regression Analysis Predicting Public Health Risks

Predictor Variable	B	p-value
Inspection and Monitoring Weaknesses	0.267	0.003

Source: Author (2026)

The broader multiple linear regression model further showed that the indices of awareness, policy and preparedness were statistically significant predictors of perceived national security implications (Table 5). The Preparedness Index was the strongest predictor ($\beta = 0.975$, $p < 0.001$), followed by the Awareness Index ($\beta = 0.267$, $p < 0.001$). The Policy Index was negatively related to national security implications ($\beta = -0.237$, $p < 0.001$), indicating that increased perceived policy and regulatory effectiveness was associated with lower perceived national security implications.

The regression model explained 82.23% of the variance in perceived national security implications ($R^2 = 0.8223$), with an adjusted R^2 of 0.8176. The overall model was statistically significant, $F(3, 115) = 177.3$, $p < 0.001$, indicating that the three predictors jointly provided a statistically significant explanation of variation in perceived national security implications.

The Preparedness Index had the largest standardised coefficient ($\beta = 0.975$, $p < 0.001$), indicating the strongest statistical association with perceived national security implications among the predictors included in the model. The Awareness Index also showed a positive and statistically significant association ($\beta = 0.267$, $p < 0.001$). In contrast, the negative coefficient for the Policy Index ($\beta = -0.237$, $p < 0.001$) suggests an inverse association, whereby stronger perceived policy and regulatory arrangements were associated with lower perceived national security implications.

Multicollinearity was assessed using the correlation matrix and variance inflation factors (VIF). The correlations among the independent variables ranged from r = 0.485 to r = 0.744, while the VIF values were approximately 2.24 for the Awareness Index, 2.78 for the Policy Index, and 1.62 for the Preparedness Index. These values indicate that multicollinearity was not sufficiently high to present a serious concern in the regression model.

Because the study collected data at a single time point and the dependent variable was based on respondents' perceptions, the regression coefficients indicate statistical associations rather than causal effects. The high explanatory power of the model should therefore be interpreted as evidence of a strong relationship between the measured food defence dimensions and perceived national security implications rather than proof that these factors independently cause national security outcomes.

Table 5 Regression Analysis on Food Defence Systems and National Security Implications

Predictor Variable	Coefficient (β)	Standard Error	p-value
Intercept	0.045	0.195	.819
Awareness Index	0.267	0.055	<.001
Policy Index	-0.237	0.068	<.001
Preparedness Index	0.975	0.055	<.001

Model statistics: $R^2 = 0.8223$; adjusted $R^2 = 0.8176$; $F(3, 115) = 177.3$, $p < 0.001$; residual standard error = 0.2508.

Source: Author (2026)

DISCUSSION

The food safety – food defence gap

The major result of this study is that Kenya has a fairly well-established food safety system but has not yet established a food defence system. Legislation, institutional requirements and working practices reflect a high level of concern for food hygiene, disease prevention, veterinary inspection, quality assurance and certification. All these functions have made significant contributions to the management of traditional food safety hazards and public health protection. The results, however, do suggest that the same regulatory system is less able to predict, prevent and react to intentional contamination of the food value chain. This separation is key as it is based on different risk assumptions for food safety and food defence. Food safety is concerned primarily with unintentional hazards that may arise during food production and distribution, whereas food defence focuses on vulnerabilities that may be exploited through intentional acts. While both approaches ultimately aim to safeguard consumers, implementation of the protective measures is very different. Key food defence measures, including vulnerability assessments, personnel security, intelligence sharing, access control and preparedness planning, but are poorly defined in Kenya's current regulatory framework.

The results confirm those of Manning and Soon (2016) who observed that many food systems focus largely on conventional food safety but invest relatively little in deliberate contamination. Onyeaka et al. (2022) also point out that regulatory systems in most African countries still have a primary thrust on compliance with hygiene standards and prevention of food-borne diseases while the growing threats of food fraud, sabotage, and intentional adulteration are often overlooked. The present study is an extension of this literature because it shows that there is an imbalance at both the regulatory-policy and institutional-practice levels. One key finding from this study has been that the lack of food governance institutions is not the problem. Kenya has an extensive system of

veterinary public health, standards, disease surveillance, meat inspection and consumer protection agencies. Instead, the challenge is that these institutions have developed around a food safety paradigm without food defence being recognised as a separate regulatory role. As a result, preparedness for deliberate contamination is not explicitly included in existing policies, procedures and institutional arrangements for food safety activities.

This finding contributes to food defence scholarship by demonstrating that the principal governance challenge in an LMIC context may not be institutional absence, but institutional adaptation. Existing food safety institutions can provide an important foundation for food defence, but they do not automatically provide the capabilities required to identify intentional threats, assess vulnerabilities, manage insider threats, share intelligence or coordinate rapid responses. Thus, strengthening food defence in Kenya may require the integration of a security-oriented layer into existing food safety governance rather than the creation of an entirely separate institutional system.

Institutional Fragmentation and the Limits of Reactive Regulation

The results also indicate that legal and regulatory frameworks, together with effective institutional coordination, are important determinants of food defence capacity. While there are a number of well-established institutions in Kenya's food governance system, qualitative evidence pointed to poor coordination, overlapping mandates, and unclear institutional responsibilities as key challenges to food defence preparedness. The results concur with Kang'ethe et al. (2019), who found institutional fragmentation and inadequate coordination to be long-standing challenges in food governance in Kenya. Their study was on food safety, but in the current study, these governance traits are even more important when dealing with intentional contamination. Food defence may require more rapid and coordinated action than routine food inspection, including timely information sharing, coordinated surveillance, intelligence gathering and joint operational planning among agencies involved in agriculture, veterinary services, public health, food standards, law enforcement and national security.

The implications of this fragmentation extend beyond administrative inefficiency. Deliberate contamination can cross institutional and sectoral boundaries, meaning that an incident originating within a food facility may require simultaneous action by veterinary authorities, public health agencies, food standards bodies, law enforcement, security agencies and emergency-response institutions. Consequently, fragmented mandates may create delays in threat recognition, information sharing, decision-making and incident response.

The Food and Feed Safety Control Co-ordination Bill, 2023, therefore represents an important opportunity to strengthen the institutional architecture for food governance in Kenya. Its relevance to food defence is particularly important because a coordinated food safety system could provide a platform for integrating intentional contamination risks into national food governance. However, legislative coordination alone may not be sufficient. The effectiveness of such a framework would depend on whether food defence responsibilities, information-sharing mechanisms, surveillance arrangements, vulnerability assessment and emergency response are clearly defined and operationalised.

Specific coordination mechanisms could include a clearly designated coordinating authority, formal inter-agency information-sharing protocols, joint risk assessments, coordinated surveillance, joint inspection and response procedures, and regular multi-agency simulation exercises. Such mechanisms would help move food defence from a predominantly reactive model towards a more anticipatory and risk-based approach.

The Kenya Meat Commission illustrates this contrast, as employee perceptions differed from those of regulatory key informants. The majority reported having confidence in the preparedness of the facility, which is indicated by the fact that they have internal procedures, management commitment and awareness programmes. There were, however, deeper concerns related to system-wide preparedness discussions by the key informants, especially the lack of a dedicated food defence policy, limited preparedness testing and uncertainty regarding institutional leadership in the event of deliberate contamination.

The apparent contradiction is an important distinction between organisational preparedness and system resilience. A single food processing establishment can have effective internal controls in place, but these are not sufficient to offset any shortcomings in national levels of surveillance, institutional fragmentation and inter-agency coordination. The preparedness of individual facilities is thus only one aspect of food defence; the effectiveness of governance arrangements that connect multiple institutions across the food system is also important.

This distinction can also be understood in terms of organisational capacity and system resilience. Organisational capacity refers to the knowledge, resources, procedures and competencies available within an individual institution, whereas system resilience reflects the capacity of interconnected institutions to anticipate, absorb, respond to and recover from disruptive events. The findings suggest that KMC may possess elements of organisational capacity while the wider food defence system remains less resilient because of weaknesses in coordination, preparedness testing and institutional responsibility.

This is underlined by the comparatively small number of respondents who indicated that they conduct regular exercises involving simulation. If the preparedness plan is not tested regularly, it may provide only limited assurance of institutional readiness in the event of an incident. Reactive inspection systems are good at identifying hygiene deficits and regulatory non-compliance, but are less able to detect deliberate threats beforehand. This finding aligns with international guidance advocating a proactive approach to identifying vulnerabilities, scenario-based drills, and ongoing food defence preparedness assessment practice rather than relying only on conventional food inspection approaches.

The finding also has implications for multi-level governance. Food defence operates across facility, county, national and international levels, with vulnerabilities at one level potentially undermining controls at another. Strengthening food defence therefore requires both horizontal coordination among agencies and vertical coordination between food establishments, regulatory authorities and national emergency and security structures.

Food defence as human security and critical infrastructure protection

The study illustrates that food defence failures are not limited to operational and regulatory issues, but have implications for public health, economic resilience and national security as well. Results of regression analysis showed that the lack of inspection and monitoring systems was significantly related to the perceived public health risk and preparedness was the strongest correlate of the perceived national security implications. While the findings are perception-based and do not represent actual contamination events, they suggest that institutional preparedness is recognised as important to safeguarding food systems against intentional threats. The findings are in line with the Human Security Theory that expands the definition of security from territorial defence to protecting individuals from threats to their health, livelihoods and wellbeing. From this point of view, deliberate contamination of food systems is a multidimensional security problem as it poses a threat to multiple aspects of human security. Intentional contamination can lead to foodborne disease outbreaks, reduce access to safe food and undermine household livelihoods, but can also lead to loss of public trust in institutions and significant economic losses along the agricultural value chain.

The findings extend the application of Human Security Theory by showing how weaknesses in food defence governance can connect institutional vulnerabilities with multiple dimensions of human security. A deliberate contamination event could affect health security through illness and mortality, economic security through disruption of production and trade, food security through interruptions in supply, and social security through anxiety and loss of confidence in public institutions. The Kenyan case therefore demonstrates that food defence can be understood as a human security issue rather than solely as a technical component of food safety.

The results also support the increasing awareness of food systems as critical infrastructure. Modern food supply chains are very interdependent, so that when one processing plant is affected, it can impact the whole market chain from the production line to transportation, distribution and sale, as well as export markets. The meat

subsector is pivotal in food security, job creation and regional trade in the Kenyan context. The potential impacts of deliberate contamination extend beyond affected enterprises to market stability, export competitiveness and consumer confidence. These wider considerations indicate that food defence is not just a technical development of food safety. Instead, it must be integrated into broader national resilience and critical infrastructure protection plans along with all other critical sectors that would support national wellbeing.

The critical infrastructure perspective is particularly relevant because food systems are interdependent with other essential systems. A major disruption in meat processing and distribution could affect transport and logistics, agricultural livelihoods, trade, markets and healthcare demand. Conversely, disruptions in energy, water, transport or communication infrastructure could themselves weaken the capacity of food facilities to maintain safe and secure operations. Food defence should therefore be understood within a wider system of interdependent critical infrastructure rather than as an isolated facility-level concern.

Taken together, Human Security Theory and the critical infrastructure perspective provide complementary explanations of the findings. Human Security Theory highlights the consequences of food defence failures for people, livelihoods and wellbeing, while the critical infrastructure perspective highlights the potential for cascading effects across interconnected sectors. The contribution of this study is therefore not to replace these theoretical perspectives but to demonstrate their relevance to food defence governance in an LMIC setting and to show that institutional coordination and operational preparedness are important links between food-system vulnerabilities and wider security outcomes.

Incorporating food defence into the public health preparedness, emergency management, and national security planning framework would enhance the country's ability to anticipate and respond to new threats to food systems. Such integration should be accompanied by practical mechanisms for vulnerability assessment, intelligence sharing, preparedness testing and coordinated response.

Policy implications and priorities

The findings suggest that policy interventions should be prioritised according to their urgency and their potential to strengthen Kenya's overall food defence capability.

Most urgent priorities. The immediate priority should be to establish clear institutional responsibility and coordination for food defence. The Food and Feed Safety Control Co-ordination Bill, 2023, provides an important opportunity to strengthen the institutional architecture for food governance. Food defence should be explicitly incorporated into this framework, including provisions for intentional contamination, vulnerability assessment, information sharing, surveillance and coordinated emergency response. A clearly designated coordinating mechanism should also be established to bring together the Directorate of Veterinary Services, Ministry of Health, Kenya Bureau of Standards, Kenya Meat Commission and relevant security and emergency-response agencies.

Medium-term priorities. The second priority should be to strengthen operational preparedness at critical food facilities. This should include routine food defence vulnerability assessments, facility-specific food defence plans, access-control measures, suspicious-activity reporting mechanisms and regular training of frontline personnel. Importantly, simulation and tabletop exercises should be conducted periodically to test whether institutional response arrangements are functional in practice.

Long-term priorities. In the longer term, food defence should be integrated into Kenya's broader public health preparedness, national security and critical infrastructure protection frameworks. Investment in surveillance, traceability, early-warning systems and secure information-sharing mechanisms should support this integration. Food defence should also be incorporated into relevant professional training and continuing professional development programmes to ensure that the necessary technical and institutional capacity is sustained.

This prioritised approach recognises that strengthening food defence is unlikely to be achieved through a single legislative or institutional intervention. Immediate clarification of responsibility and coordination should provide the foundation for medium-term improvements in facility preparedness, while longer-term integration into national resilience and critical infrastructure protection frameworks can strengthen the sustainability of the system.

CONCLUSION

The single most important finding of this study is that Kenya's principal food defence vulnerability is not the absence of food governance institutions, but the limited incorporation of deliberate contamination threats into an otherwise established food safety governance system. Kenya has multiple institutions and regulatory mechanisms addressing food hygiene, disease surveillance, meat inspection, quality assurance and certification. However, these arrangements remain predominantly oriented towards accidental and conventional food safety hazards, with comparatively limited attention to vulnerability assessment, intentional contamination, insider threats, preparedness exercises and coordinated response.

The study found that Kenya has an established food safety infrastructure but lacks a sufficiently developed food defence architecture. Documentary analysis and key informant interviews identified the absence of a dedicated food defence framework, fragmented institutional mandates, limited inter-agency coordination and inadequate preparedness for deliberate contamination events. At the facility level, employees generally demonstrated awareness of food defence concepts; however, practical preparedness was weaker, particularly in relation to vulnerability assessments, simulation exercises and preparedness testing. The difference between relatively high facility-level confidence and concerns expressed by key informants about system-level preparedness indicates that organisational capacity at individual facilities does not necessarily translate into resilience of the wider food system.

The quantitative findings further support the importance of preparedness and governance. Weaknesses in inspection and monitoring were significantly associated with perceived public health risks related to deliberate contamination ($B = 0.267$, $p = 0.003$). In the broader regression model, awareness, policy and preparedness were significant predictors of perceived national security implications, with preparedness being the strongest predictor ($\beta = 0.975$, $p < 0.001$). The model explained 82.23% of the variance in perceived national security implications ($R^2 = 0.8223$; adjusted $R^2 = 0.8176$; $p < 0.001$). These findings should nevertheless be interpreted as perception-based associations rather than evidence of causal relationships or actual deliberate contamination events.

The unique contribution of this study is its demonstration that food defence in a lower-middle-income country context is fundamentally a governance and preparedness problem as much as a technical food safety problem. The Kenyan case shows how established food safety institutions can coexist with important food defence gaps because of institutional layering, ambiguity of mandates, limited inter-agency coordination and inadequate operational preparedness. The study therefore extends food defence scholarship by connecting food defence governance with Human Security Theory and critical infrastructure protection, demonstrating how weaknesses in food defence can have implications extending beyond food safety to public health, food supply continuity, economic resilience and public confidence in institutions.

The findings have several specific policy implications. First, Kenya should establish a clear national food defence policy and institutional coordination mechanism, with deliberate contamination explicitly incorporated into the national food safety governance framework. The Food and Feed Safety Control Co-ordination Bill, 2023, provides an important opportunity to strengthen this coordination architecture.

Second, critical food facilities should be required to conduct routine vulnerability assessments and maintain facility-specific food defence plans, including access control, suspicious-activity reporting and personnel training. Third, regular simulation and preparedness exercises should be institutionalised to test the capacity of facilities

and agencies to respond collectively to deliberate contamination incidents. Fourth, food defence should be integrated into broader public health preparedness, critical infrastructure protection and national resilience planning, supported by strengthened surveillance, traceability and secure information-sharing systems.

These measures should be implemented progressively, beginning with clarification of institutional mandates and coordination, followed by strengthening facility-level operational preparedness, and ultimately by integration of food defence into national security, public health preparedness and critical infrastructure protection frameworks.

Several limitations should be acknowledged. The study used the Kenya Meat Commission as a single case within the meat subsector and therefore may not be representative of all food sectors or food establishments in Kenya. The quantitative findings were based on self-reported perceptions of awareness, preparedness and national security implications rather than independently verified preparedness assessments or documented deliberate contamination events. In addition, access to sensitive institutional and security information was necessarily limited. Nevertheless, the use of a convergent mixed-methods design and triangulation of questionnaire findings, key informant evidence and documentary analysis strengthened the credibility and contextual interpretation of the findings.

Future research should extend this analysis to other strategically important food value chains, including dairy, poultry, fisheries and horticulture, and should examine food defence preparedness across multiple institutions and counties. Comparative studies across sub-Saharan African countries would also help determine how different regulatory and institutional arrangements influence food defence capability.

Future research should additionally consider the role of artificial intelligence, blockchain-enabled traceability, digital surveillance and predictive risk analysis in strengthening food defence, particularly in resource-constrained settings. Such research would contribute to developing context-specific approaches for building resilient food systems capable of protecting both population health and national security.

In conclusion, strengthening Kenya's food defence does not require abandoning the existing food safety system; rather, it requires extending it. The next step is to move from a predominantly food safety-oriented model towards an integrated system that can anticipate, prevent, detect, respond to and recover from deliberate threats to the food supply.

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