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Food safety culture as a behavioural phenomenon shaping food safety

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Food safety culture (FS-culture) is a deeply embedded and evolving organisational construct reflecting the collective beliefs, behaviours, and assumptions of employees. It encompasses key elements such as commitment, leadership, risk awareness, communication, food safety management systems (FSMS), and work environment. Given its growing significance, this paper discusses FS-culture as a dynamic behavioural phenomenon interacting with FSMS. The way FS-culture is framed within various private standards may unintentionally lead food businesses to perceive it as a compliance-driven obligation rather than a behavioural phenomenon. There is a risk that FS-culture may be reduced to a component of food safety management, assessed through standardised checklists. Recent intervention studies demonstrated the complexity of identifying and implementing interventions to evolve FS-culture, and that its evolvement takes time and a myriad of efforts. Fostering FS-culture should be seen as an ongoing process of engagement, leadership, and continuous improvement, rather than a static set of measurable criteria.

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Introduction

In recent years, the food safety focus has shifted from solely technical considerations to a greater emphasis on human factors aiming to minimise the risk of foodborne diseases [1]. While the traditional emphasis on Food Safety Management Systems (FSMS) incorporates crucial technical and managerial aspects [2], the FSMS may not deeply address the influence of human behaviour [3]. It is recognised that behavioural controls are an important protective layer in a system to avoid active failures [4]. Food safety culture (FS-culture) has emerged as a significant behavioural phenomenon interacting with FSMS and other elements, primarily focusing on human factors [5]. However, despite its intangible nature, it is still debated whether FS-culture could be audited, certified, or considered a management system.

FS-culture has gained considerable prominence since 2009. While the broader concept of 'safety culture' has a longer history, triggered by major industrial accidents such as Chernobyl and the Davis-Besse nuclear incident [6], its specific application to the food safety context was first mentioned by Griffith in 2006 [7] and popularised by Yiannas in 2009 [8]. In 2010, Griffith, Livesey, and Clayton [5] established an FS-culture framework as a theoretical basis for understanding the learned and shared attitudes, values, and beliefs that could contribute to food safety behaviours. Since then, FS-culture has been analysed and discussed comprehensively. Some view it as a cornerstone of effective FSMS (e.g. [9,10]), while others emphasise FS-culture as a behavioural phenomenon that requires continuous observation and individual strategies to evolve (e.g. [12,13]). Despite all progress, FS-culture remains an emerging area as the terminology, concepts, and theoretical frameworks are still evolving.

Sharman, Wallace, and Jespersen [13] reviewed the diverse terminology used within this field. They defined FS-culture as "a long-term construct existing at the organisational level, relating to the deeply rooted beliefs, behaviours and assumptions that are learned and shared by all employees which impact the food safety performance of the organisation." A construct is a theoretical concept that encompasses concrete, observable entities at a given point, including behaviours (e.g. hand hygiene) and internal experiences (e.g. feeling motivated)

[14]. It also encompasses more abstract concepts that individuals have developed about themselves and others. Based on this definition, FS-culture could be expressed through interconnected elements or dimensions shaping the long-term construct. However, there is not yet a consensus on which essential elements determine the FS-culture construct. Along with the topic development, authors have proposed different perspectives on FS-culture.

Griffith et al. [5] pioneered the discussion on the core FS-culture elements, which were mainly based on the safety culture and organisational culture fields. They proposed six elements, namely leadership, commitment, communication, risk perception, environmental factors, and management systems, styles, and processes. Over time, alternative perspectives emerged. For example, Jespersen, Griffiths, and Wallace [15] and the Global Food Safety Initiative (GFSI) [16] proposed a five-dimensional framework encompassing people systems, adaptability, consistency, risk awareness, and values and mission. Zanin, Stedefeldt, and Luning [11], in a systematic review, found several elements and dimensions, grouping them into 12 clusters, namely, people, commitment, leadership, FSMS, risk, work environment, consistency, communication, pressure, adaptability, policy & strategy, and external environment along with some examples of how the different elements and dimensions are manifested in the literature (Figure 1). The multifaceted nature of FS-culture, encompassing diverse elements and dimensions, presents a wide array of possibilities for assessment and intervention. However, this diversity also underscores the challenges of capturing and understanding this phenomenon with simple tools. Such aspects likely explain the extensive research dedicated to developing effective assessment and intervention methods for FS-culture (e.g. [17–22]). Only recently, empirical evidence supported the validity and reliability of the core elements proposed by Griffith et al. in 2010 [5] as a theoretically grounded framework for understanding FS-culture [12].

The prevailing FS-culture is not static but can evolve, that is, it can change from, for example, reactive to proactive (e.g. [20,22,23]). Various empirical studies suggested that a proactive FS-culture positively affected food safety practices (or food safety behaviour), contributing, in turn, to the FSMS performance [20,23,24]. These positive outcomes motivated managers, regulators, and researchers to address FS-culture in their

Figure 1

Twelve clusters of food safety culture elements/dimensions identified in the literature.
Adapted from Zanin, Stedefeldt, and Luning [11].

respective FSMS frameworks. However, how FS-culture is currently approached in the food industry is not yet understood by many experts and raises several questions. Is FS-culture part of an FSMS or vice versa? Is FS-culture auditable? How is FS-culture addressed in current regulations, private standards, and guidelines? Focusing on these questions, this paper aims to discuss the role of FS-culture as a behavioural phenomenon that interacts with FSMS. This discussion examines the potential misalignment between the way FS-culture plans are implemented under private standards and the deeper understanding of FS-culture as an evolving phenomenon. We argue that food companies may approach these plans as procedural requirements, focusing on compliance rather than embracing the need for fundamental, long-term behavioural and cultural change. The article will be informed by recent literature, the positive outcomes observed in interventional studies, and the authors' opinions, providing reasons for not considering FS-culture as only a plan.

This paper is organised into three sections. First, we discuss and share our opinion on FS-culture as an auditable system. Second, recent interventional studies are presented to support the current perspective. Finally, we concluded by showing future perspectives of FS-culture field.

Food safety culture: an auditable system or behavioural phenomenon?

A keyword search for 'food safety culture' (in the articles' title) in Scopus yielded 13 articles published in 2024 and 2025. Notably, a growth trend can be observed considering the last 10 years. For example, five papers were published in 2015, 10 in 2017, 13 in 2018, 14 in 2020, 11 in 2021, and 19 in 2023. Only after 2016 were more than 10 articles published per year on average.

Historically, many FS-culture studies used observational designs that were primarily cross-sectional and aimed to associate FS-culture elements with positive food safety outcomes, such as compliance rates, risk levels, or microbiological counts. However, recent research has shifted towards using the FS-culture assessment as a diagnosis to plan interventions and investigate how different strategies can be effectively employed to evolve or cultivate FS-culture. Such strategies have been supported by concepts such as design thinking [25] and the organisational change model developed by Kotter [26]. Not only the scientific field is interested in FS-culture but also other stakeholders (such as policymakers) and practitioners (food industry) as evidenced by their rising attention to the topic. This could be due to the lack of success of traditional knowledge-based training models, which have a weak theoretical basis [27]. Notably, this increasing attention is demonstrated in different requirements of food safety standards, such as maintaining a clear plan for developing and continuing improvement of food safety and quality culture [28], and a documented FS-culture plan to support commitment and leadership actions [29]. The examination of the private standard requirements raises concerns that there is a risk that these requirements may drive the integration of FS-culture into auditable systems, thereby shifting its focus from a dynamic, behavioural phenomenon to a standardised, compliance-oriented framework.

To discuss whether FS-culture can be an auditable system and integrated into an FSMS, a clear definition of FSMS is crucial. Manning and Grant [30] defined an FSMS as a system "*designed, validated, implemented and verified to control, and where possible eliminating, any potential food safety hazards associated with a product and methods of production to ensure compliance with food safety legislation, retailer requirements and/or private third-party certification standards*". Prerequisite programmes (based on Codex Alimentarius, Good Manufacturing Practices, and legal requirements), together with the concept of Hazard Analysis and Critical Control Points (HACCP), form the cornerstones of an FSMS, and management system standards (such as ISO 9001) add managerial/organisational elements to the system [31].

In FS-culture research, there are different views on the position of FSMS. For example, Pai, Jaiswal, and Jaiswal [9] stated that FS-culture could be a component of a quality management system. This argument is supported by the Food Safety System Certification (FSSC) 22000 [29]. It is also argued that a robust and proactive FS-culture is an important foundation for the successful implementation of FSMS based on HACCP guidelines and prerequisite programmes. As opposed to a pure programme element, Wallace, Sperber, and Mortimore [1] suggest that FS-culture is a pervasive condition present in all food businesses throughout the process of implementing foundational management programmes and, later, the FSMS; that is, FS-culture transcends isolated components of an FSMS, such as prerequisite programmes (PRPs), HACCP, and other auditable private standards. This highlights the need for a positive cultural environment to facilitate the effective functioning of high-level FSMS, as opposed to a negative culture that could jeopardise food safety initiatives. In a review, Zanin et al. [11] observed that many studies considered the FSMS as an integral element/dimension to foster a proactive FS-culture. Notwithstanding the dual interpretations, we assert that FSMS serves as a foundational framework for fostering a proactive FS-culture, while, in turn, a strong FS-culture reinforces and enhances the effectiveness of FSMS. According to Manning [32], an FSMS based only on measurable factors is not sufficient to ensure safety, as it may overlook qualitative and implicit values. In particular, when it

comes to a toxic organisational climate, trying to measure it directly is inherently problematic [32].

We recognise that FS-culture, in itself, cannot be a management system that can be audited and certified, as an audit captures only a snapshot in time, and FS-culture is a long-term construct. However, a tailored science-based FSMS can cultivate a proactive/strong FS-culture when supported by adequate facilities, management and worker commitment, educational strategies, appropriate communication, and food safety values [33]. Schein [34] depicted organisational culture as a layered system. The top layer refers to the tangible (visible) culture elements called artefacts. The middle layer refers to espoused beliefs and values exerted from the organisation's stated values and rules of conduct. The deepest layer is called basic underlying assumptions, which encompasses employees' unconscious, taken-for-granted beliefs, perceptions, thoughts, and feelings. Zanin et al. [11] evaluated various methods that assess different FS-culture levels, showing that different methods are required to assess each layer. Another study from the same group demonstrated that multiple methods and data triangulation are necessary to analyse FS-culture in-depth and longitudinally [22,35]. Likewise, the study of Spagnoli et al. [26] demonstrated the need for intensive mixed-method assessment and combined data evaluation. These studies illustrate that working with FS-culture is not a simple task that can be written down in procedures nor evaluated by simple checklists during routine audits.

The assessment of FS-culture is commonly used to provide insights into its current state, allowing organisations to develop targeted interventions and strategies to enhance their FS-culture [21,26]. In recent years, the application of FS-culture has become increasingly widespread within the food industry. However, the current format of these assessments often resembles audits, which introduces several limitations. Given that FS-culture is a dynamic, long-term construct [13], audits — by nature, offering only a snapshot of a particular moment — may fail to capture the full spectrum of relevant factors influencing FS-culture. Table 1 outlines some of the key limitations of FS-culture audits and explains how these limitations could affect the accuracy and comprehensiveness of FS-culture assessments.

Over the years, the FS-culture concept gained prominence [11,38] and is now incorporated into regulations (e.g. Amended Regulation from European Union [39]), addressed in private standards (e.g. BRC, 2018 [28] and FSSC, 2020 [29]), and investigated in many academic studies [25,36,40]. However, we argue that scientists, practitioners, and policymakers should be careful not to stray from its roots in safety culture. We should recognise that a positive culture results from the logical relationship between communication and strategic actions, and is not an action in itself. Instead, the observable characteristics of a (certified) FSMS reflect the prevailing FS-culture at the artefact level [34]. In this context, the statement made by GFSI in 2018 is important [16]. The group asserts that culture exists independently of written rules, not just as a consequence of following rules or adhering to a linear framework. They also emphasise that cultural standards are often disseminated through informal conversations and reinforced through shared thoughts and actions.

Food safety regulations and recommendations may include some motivations for the FS-culture evolvement or an FS-culture plan. However, a proactive (or strong) culture could not be a mandatory requirement in public (regulations) or private standards. Table 2 shows the main regulations, private standards, and guidelines that address FS-culture. Codex Alimentarius (2022) [41] provided some elements to cultivate a positive FS-culture, such as leadership, communication, awareness, and so on. FSSC 22000 [29] (based on sub-clause 5.1 of ISO 22000:2018) emphasises the importance of leadership, communication, and employee engagement in fostering a positive FS-culture. However, the document states that FS-culture objectives should be part of the management system, including a documented FS-culture plan. The PAS 320 [42] also mentioned that the framework to support FS-culture is used for embedding the

Table 1

Limitations to use audits to assess FS-culture.

Audits limitations	Summary
Auditor	The assessment of FS-culture should not follow the same approach as an audit. Culture exists on multiple levels, including artefacts, espoused beliefs and values, and underlying assumptions [34]. To effectively evaluate the deepest level of FS-culture, the assessor must foster a closer connection with the employees within the food business, which is not an auditor requirement.
Audit tool	The tools used to audit FS-culture typically rely on a quantitative approach, using checklists and surveys. However, this method may overestimate the maturity of FS-culture and fail to assess all its levels comprehensively [22,36]. Relying on a single method to assess FS-culture can lead to inaccurate conclusions [11].
Time	Audits provide a snapshot of food production at a specific moment, capturing only a small fraction of the process [37]. In contrast, FS-culture is a long-term construct, which audits may not fully capture.

Table 2

Regulations, private standards, and guides addressing FS-culture.

Regulations/standards/guides	FS-culture requisite/recommendation
British Retail Council Global Standard for Food Safety (2018) Issue 8 [28]	Includes a requirement to maintain a clear plan for developing and continuing improvement of food safety and quality culture.
Food Safety System Certification (FSSC) 22000:2018 - version 6, part 2 [29]	Requires that as part of the organisation's commitment to cultivating a positive FS-culture, senior management shall establish, implement, and maintain FS-culture objectives as part of the management system addressing as a minimum communication, training, employee feedback, engagement, and performance measurement of defined activities covering all sections of the organisation's impact of food safety and quality. It shall be supported by a documented FS-culture plan included in the improvement processes of the management system.
Amended Regulation (EC) No. 852/2004 from the General Food Law of the European Union [39]	Describes that food business operators shall establish, maintain, and provide evidence of an appropriate FS-culture by fulfilling the requirements regarding the commitment of managers and all employees for safe food, leadership, awareness of food hazards and food safety and hygiene, open and clear communication, and availability of sufficient resources to food handling. Describes some aspects related to the management commitment, as ensuring appropriate training and supervision and encouraging continual improvement of the FSMS. States that the implementation of the FS-culture shall take account of the nature and size of the food business.
Revision of the general principles of food hygiene (CXC 1–1969) and its Hazard Analysis Critical Control Point (HACCP) annexure - Codex Alimentarius, 2022 [41]	Advises incorporating FS-culture under the topic 'management commitment' and cultivating positive FS-cultures highlighting some elements such as commitment, leadership, awareness of the importance of food hygiene, communication, and availability of sufficient resources for the food hygiene system.
Global Strategy for Food Safety 2022–2030 [45]	Motivates food safety stakeholders to foster an FS-culture and encourage the acceptance of their individual and collective responsibility for food safety.
British Standard Institute (BSI) PAS 320:2023 Developing and sustaining a mature food safety culture [42]	Provides a framework, using the plan, do, check, and act (PDCA) methodology and process approach, to support organisations in developing, maturing, and sustaining the continual improvement of their FS-culture. The framework is used for designing a strategic change plan to achieve the desired FS-culture; embedding the FS-culture change plan into the existing FSMS; evaluating the performance and sustaining continual improvement of FS-culture.
Global Food Safety Initiative - Benchmarking Requirements (Version 2024)[a] [43]	Considers that elements of FS-culture are those elements of the FSMS that the senior management of a company may use to drive the FS-culture within the company. Requirements: 1) A demonstrable commitment from all personnel to the production and safe handling of food shall be available; 2) An FS-culture assessment plan shall be established, implemented, and maintained to identify areas of improvement to drive positive behaviour. This shall include elements consisting of at a minimum: communication, training, feedback from employees, and performance measurement on food safety-related activities.

[a] GFSI is not a private standard nor a guideline but defines benchmark criteria against which private standards can be evaluated.

FS-culture change plan into the existing FSMS. The GFSI benchmarking requirements aimed to align with the latest international standards and industry best practise. In addition, elements of FS-culture were integrated into the FSMS elements, indicating a plan to assess FS-culture as a mandatory requirement [43].

Ideally, organisations should implement strategies that foster a supportive and proactive environment in which the FSMS is an integral part of the culture and not the other way around [44]. Trying to turn FS-culture into a system is tantamount to trying to mechanise behaviour, which directly contradicts the definition of a proactive/strong/mature culture. With this opinion, we are trying to build a bridge between industry and science, not to divide them. We are concerned that if FS-culture is reduced to standardised checklists within management systems, it risks being perceived as a procedural obligation rather than an ongoing long-term construct and behavioural phenomenon. Private standards can unintentionally contribute to this misperception, leading food businesses to view the plan as a procedural requirement and neglecting the underlying principles of FS-culture. To counter this, regulations and standards

Table 3

Food safety behaviours outcomes observed in FS-culture case-based studies.

Reference and study characteristics	Investigated interventions	Effects on food safety outcomes
Case study 1 Caccamo et al. [49] Country: United Arab Emirates Case study: Five-star hotel (JW Marriott Marquis) Period: 3 years FS-culture assessment: 3 times	*Rewards and incentives:* - "Rock Star Wall" to highlight and appreciate good practice - Green and red cards for positive or negative food safety behaviour - Two extra days off every alternate week *Food safety management:* - Menu-based HACCP system	- Impact on people's perceptions of whether they would be praised for identifying food safety issues, and the fairness of promotion and reward - Higher increases also in innovation and change, consistency, teamwork, and coordination - Improvements in the company's overall result
Case study 2 Nouaimeh et al. [50] Country: United Arab Emirates Case study: Large catering company (Abela & Co) Period: 2 years FS-culture assessment: 2 times	*Training and communication:* - New training activities, adjusting to the different language requirements of the employees and deploying more visual training methodologies (training scores) - Training sessions 'connection' to align key people in the organisation at supervisory levels with the strategic direction of the company *Reward:* - A daily scoring chart which created competition between the sections, with results discussed and rewarded - Enhanced monitoring system (green and yellow cards for good and bad practices).	- The most noticeable improvements were in training and communication, consistency, innovation and change, teamwork and reward - Higher scores in all categories in the second year/ assessment
Case study 3 Zanin et al. [22] Country: Brazil Case study: Institutional (military) food service Period: 21 months FS-culture assessment: 3 times	*Leadership:* - Development of a responsibility chart *Communication and Knowledge:* - Brainstorm and concept development - Updated materials and news about the benefits of food safety - Development of materials for formal and informal communication *Risk perception:* - Group discussion about potential hazards and risks *Work pressure and normative beliefs:* - Development of a sense of responsibility - Inclusion of employees of all levels of hierarchy in the same activities *Work environment:* - Needs assessment based on the risk level - Checklist to determine equipment in disuse *Management systems, styles, and process:* - Action to correct temperature monitoring - Practice of correct food defrosting - Development of the preparation flow in place - Collective development of the sanitation plan and implementation of monitoring spreadsheets	- Significant changes in the quantitative scores of the elements: knowledge, affective commitment, risk perception, and work environment - Changes in the degree of the risk, from very high to average risk - All the elements improved from the first FS-culture assessment to the last one. The prevailing FS-culture improved from reactive-active to active-proactive
Case study 4 Spagnoli et al. [26] Country: Belgium Case study: Four food processing industry Period: 32 months FS-culture assessment: 2 times but different periods for each food industry case Kotter's change model for intervention implementation	Food processing industry A *Consistency:* - Creating shared accountability mechanisms towards goals through 1) revision of procedures, 2) KPI system Food processing industry B *Commitment*: Focus groups and action plan development with workers to have a more active involvement of employees in food safety-related matters Food processing industry C *Consistency:* - Implementing feedback, recognition, and reward after systematic FS-culture checks Food processing industry D *Commitment:* - Conducting focus groups and action plan development with employees	Food processing industry A A small improvement in the 'consistency dimension' overall score even though the score was already quite high in the first assessment Food processing industry B Significative increase in Commitment score Food processing industry C - Increase only the perception of the management team - "Reward expectancy" received a reactive score in both the pre- and post-assessment - Only the indicator concerning the consistency of the standard operating procedures increased Food processing industry D - Only one indicator displayed a significant improvement. However, the main targeted indicator was not improved

Table 3 (*continued*)

Reference and study characteristics	Investigated interventions	Effects on food safety outcomes
Case study 5 Ferreira et al. [25] Country: Brazil Case study: Two commercial food services Period: 14 months FS-culture assessment: 2 times Design thinking method for intervention implementation	Food service A *Risk perception:* - Video development to address common myths and truths about food safety, focusing on the knowledge questions that scored the lowest - Hand hygiene action to improve the practise *Commitment:* - 'Pen-in-bottle' action aiming to build engagement, illustrating how the lack of effective teamwork hinders achieving the goal of delivering a quality and safe food Food service B *Risk perception:* - Video development with two outcomes: 1) correct execution of work procedures with a satisfactory outcome and promotion of the work environment; and 2) some operational noncompliance related to food safety and a foodborne diseases situation. The video addressed: - Presentation of the statistical data on foodborne diseases in the form of a newscast - Piece of music about food safety composed by the food handlers and managers	Food service A - Improvements in knowledge and commitment scores - The work pressure and normative beliefs score decreased - The prevailing FS-culture did not evolve, however, it was already a high score (active-proactive) Food service B - Improvements were identified in the score of knowledge, management systems, styles, and processes, and work environment - The prevailing FS-culture did not evolve, however, it was already a high score (active-proactive)

could explicitly emphasise that FS-culture is not a system to be audited but a complex and long-term behavioural phenomenon. This distinction is critical to prevent the development of FS-culture plans based solely on simplistic, time-bound assessments such as checklists that fail to capture the nuanced and evolving nature of organisational culture.

Food safety culture shaping food safety behaviours

This section summarises several intervention studies that serve to underline the importance of establishing an FS-culture as a long-term, behavioural, and cultural change. Recent intervention studies show that relying solely on procedural plans may not be sufficient to adequately strengthen the FS-culture. They used various soft and hard techniques targeted at employees at different hierarchical levels to evolve the prevailing FS-culture and underpinned the importance of implementing sustainable strategies that address the deepest layers of organisational culture.

There is strong evidence that a proactive FS-culture fosters a positive and preventative approach to food safety, where employees at all levels prioritise safe practices and take ownership of their roles in ensuring food safety [20,22,24,46,47]. This can lead to improved food safety behaviour, reduced likelihood of foodborne outbreaks, and enhanced consumer confidence in the safety of food products. Conversely, a reactive FS-culture, characterised by complacency, lack of communication, and unsafe behaviour, can compromise food product safety affecting consumers' health.

Various studies demonstrated that FS-culture closely links to various food safety behaviours. A study conducted in 50 grocery retail deli departments across the United States demonstrated a proactive FS-culture — characterised by strong management and employee commitment, robust training programs, and adequate infrastructure — was significantly associated with a reduced risk of *Listeria monocytogenes* contamination [24]. Similarly, research in Brazilian restaurants found that establishments with a reactive FS-culture were more likely to exhibit deficiencies in hand hygiene and violations of time and temperature control during food reception, storage, preparation, and exposure [47]. In Belgium, a study investigating the relationship between FS-culture and the costs associated with ensuring compliance and meeting customer needs identified a positive association between a strong FS-culture and cost allocation strategies, particularly in prevention and appraisal costs [40]. These findings underscore the critical role of a proactive FS-culture in affecting food safety behaviour that finally mitigates contamination risks and enhances overall food safety performance.

FS-culture is a dynamic phenomenon that can evolve, influenced by various internal and external factors [11,48]. Leadership changes, organisational structure improvements, people investment, and technological advancements can all impact the shared values, beliefs, and behaviours surrounding food safety [48]. Additionally, external pressures, such as new regulations, consumer demands, and global food safety incidents, can necessitate adaptations in the prevailing FS-culture to ensure continued compliance and competitiveness.

Therefore, understanding the evolving nature of FS-culture is crucial for organisations seeking to develop interventions based on the FS-culture elements [11,36].

So far, only a few FS-culture studies have tested interventions based on an FS-culture diagnosis. Table 3 shows five case-based studies investigating interventions linked to identified weaknesses in FS-culture elements/dimensions and highlights the effects on measured food safety outcomes. The intervention studies suggest that addressing one specific FS-culture element can lead to multiple improvements as elements seem to be interconnected [12], as empirically shown by several authors [22,25,40,49,50]. For example, Ferreira et al. [25] noticed improvements in knowledge and commitment in food service A, although the intervention focused on risk perception and commitment. In foodservice B, they targeted risk perception, but improvements were identified in the scores of knowledge, management systems, styles, processes, and work environment. Caccamo et al. [49], Nouaimeh et al. [50], and Zanin et al. [22] also highlighted improvements in other elements beyond the targeted elements. However, Spagnoli et al. [26] observed few improvements in consistency and commitment by implementing specific interventions in three of their food processing industry cases (A, C, and D).

Although not an intervention study, Spagnoli et al. [17] compiled a portfolio of 68 different FS-culture–based interventions based on two scoping reviews. This is an important addition to the field and can help researchers and practitioners. This portfolio describes various interventions that can be used to develop FS-culture. However, it is important to note that some are not yet tested and require further research to determine whether they improve FS-culture.

Conclusion

Emerging research suggests that a proactive FS-culture shapes food safety behaviours. Studies across various countries have demonstrated a link between proactive FS-culture, behaviour-related changes, and the reduction of food safety issues and quality costs. We discussed that an FSMS can foster FS-culture, but FS-culture should not be audited or certified like an FSMS. FS-culture is a long-term construct and a behavioural phenomenon that cannot be simply assessed through checklists in a short timeframe. Furthermore, FS-culture is complex and dynamic, and its elements are interconnected, as shown in intervention and modelling studies. Intervention studies targeting different weak FS-culture elements with diverse strategies demonstrated improvements in food safety outcomes besides the evolvement of the FS-culture. The intervention studies also highlighted that even if the strategies focused on weak elements, the result could be broader than that, affecting other elements. Recognising FS-culture as a dynamic phenomenon and a key risk factor for foodborne diseases requires a more holistic approach than checking a system.

New intervention studies could focus on exploring the mechanisms of intervention, that is, how certain measures affect different elements of FS-culture, including how FS-culture can be further developed at different organisational levels. It is also important to discuss how FS-culture can be developed in different types of food businesses and different national cultures. As a behavioural phenomenon, national culture, immigration, and language barriers could play a significant role in its evolvement. Finally, further theoretically grounded studies are needed. Quantitative models that empirically test the current FS-culture framework are needed to develop into an established theoretical model.

Data Availability

No data were used for the research described in the article.

Declaration of Competing Interest

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

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References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- • of special interest
- •• of outstanding interest

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