A systematic literature review of food safety management system implementation in global supply chains

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Abstract

Design/methodology/approach: It is difficult to ensure food safety from farm to fork worldwide. The paper addresses this challenge from the angle of how firms measure and improve the implementation of food safety management system (FSMS) in global food supply chains by a systematic review combined with biological mapping analysis (VOS viewer) on 81 peer-reviewed papers published from 2005 to 2020.

Purpose: The study sets to summarise managerial requirements, analyse practices and tools to measure FSMS implementation. Also, underpinned by critical success factors (CSF) theory, we explore when food firms manage FSMS, which factors are critical to their implementation to identify promising research directions for researchers and suggestions for practitioners through a comprehensive analytical lens.

Findings: Mandatory and voluntary regulations and standards are the most critical part of international requirements to assure integrated, proactive, risk-based approaches as well as continuous improvement in FSMS in global food chains. To measure FSMS, only a limited number of measurement tools for FSMS have been identified. External, internal factors, technology adoption that significantly impact the management of FSMS implementation still require more future works.

Research limitations/implications: Several FSMS research gaps observed during the content analysis of selected papers within 15 years are presented along with ten future research questions.

Practical implications: A systematised list of published papers that has been studied and reported in this research could be a useful reference point for practitioners in food industry.

1 Introduction

Extensive global sourcing of food products complicates supply chain management, typically accompanied by additional costs, heightened vulnerability and greater supply risks, global financing and funds transfer uncertainties, and lower responsiveness (Roth *et al.*, 2008). Also, food supply networks are global, complicated, and highly interconnected, leading to higher risk exposure (Trienekens and Zuurbier, 2008). As one of the greatest challenges of global food supply chains, food safety risks can have significant repercussions (Indrawan and Daryanto, 2020; Whipple *et al.*, 2009). For that reason, there is no way around it without suffering the consequences of non-compliance, regardless of whether food enterprises realise both industrial or economic benefits or not (Mensah and Julien, 2011).

Implementing an FSMS, which is made up of a group of interacting or interdependent elements forming a network to ensure that food presents minimal risk to consumers, is a regulatory requirement for every food firm in the global food chain to ensure market access (CAC, 2009; Wahidin and Purnhagen, 2018). Each firm's FSMS is a highly customised system as a result of implementing various quality assurance and legal requirements into a company's unique production, organisation, and environment (Jacxsens *et al.*, 2011). No matter how different among firms within supply chains are, the ultimate purpose of FSMS is to ensure that foods are safe concerning foodborne hazards at the time of human consumption.

Moreover, a well-performed FSMS is supposed to deliver benefits for a firm beyond food safety objectives. Namely, increasing sales revenue thanks to rising consumer confidence in the safety of the purchased food and obtaining a ticket for accessing the global food value chain (Mensah and Julien, 2011), reducing operating cost and lower insurance charges for avoided costs such as food safety incidents, recalls and complaints (Marucheck *et al.*, 2011); satisfying the need of stakeholders/customer (Fotopoulos *et al.*, 2011), enhancing a firm's reputation and promote food safety guarantee or marketing tool to access more advanced markets (Nanyunja *et al.*, 2016).

Considering the positive impacts of well-performed FSMS implementation, this paper seeks to enrich understanding of FSMS by a comprehensive representation of current knowledge, which is critically evaluated and analysed focused on the measurement and management of FSMS implementation. This study, therefore, set out to:

- Summarise managerial requirements for FSMS from the existing research,
- Analyse practices and tools to measure FSMS implementation,
- Explore when food firms manage FSMS, which factors are critical to their implementation,
- Identify promising research directions for researchers and helpful suggestions for practitioners.

2 Research methodology

In this study, we applied the method of systematic literature review, which is the use of systematic, reproducible and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyse data from the included studies based on a clearly formulated question in the review (Higgins and Green, 2011). The procedures of Denyer and Tranfield (2009) and Durach *et al.* (2017) were combined and applied in creating and building bodies of knowledge for FSMS in the context of supply chain management research (Figure 1).

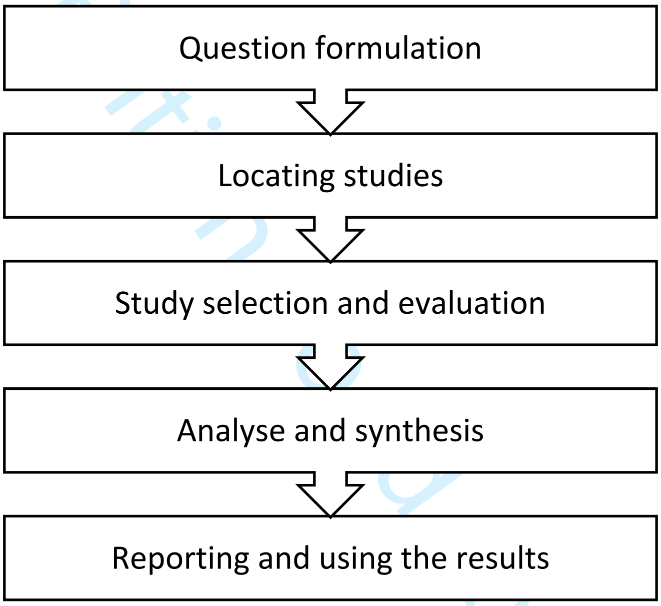

Figure 1. Systematic review methodology (adapted from Denyer and Tranfield, 2009; Durach, Kembro and Wieland, 2017).

2.1 Question formulation and locating studies

The first step is clearly formulating the research question that establishes the study focus and criteria to have a comprehensive search strategy (Denyer and Tranfield, 2009). The CIMO-logic (Context, Intervention, Mechanisms and Outcomes) was applied to specify four critical parts to be investigated in a well-built systematic review. It is constructed as “in this class of problematic Contexts, use this Intervention type to invoke these generative Mechanism(s), to deliver these Outcome(s)” (Denyer and Tranfield, 2009). Using this logic, characterised by the increasing level of global complexity and stringent food safety requirements, FSMS implementation is required to be successfully measured and improved by food manufacturers to ensure food safety. The main question of this study is: in the complexity of global supply chains (C), how do food manufacturers measure and manage (I) FSMS implementation (M) leading to safer food production (O)?

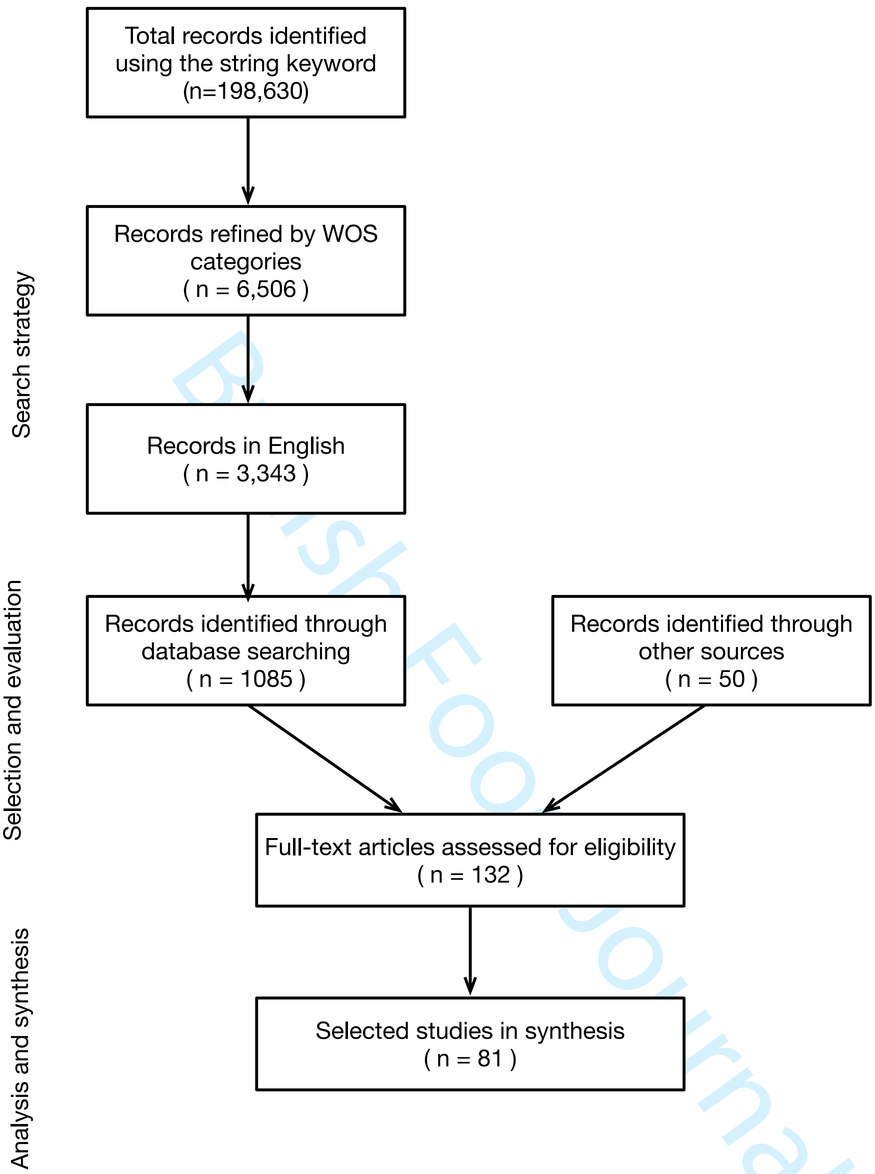

Figure 2. The SLR flow diagram (adapted from Moher et al., 2009)

A set of keywords was derived connected to the above question of the study by a brainstorming process. Web of Science (WoS) database was used in this review to search for keywords from 2005 to 2020. The complex string of keywords was constructed to reduce too generic and broad results instead of using keywords. The complex string of keywords was used for searching as the following: [‘Food safety’ OR ‘Food safety management’ OR ‘Food safety management system’] AND [‘Supply chains’ OR ‘Global supply chains’] AND [‘Management’] AND [‘Implementation’]. As seen in Figure 2, there were 198,630 records generated based on this complex string instead of using separated keywords. Then, the research results were refined by WoS Categories including only Business, Management and Operation Research Management Science, remaining 6,506 records. Also, only English articles were selected, the number of records was narrowed down to 3,343. There were 67 pages with 50 articles per page listed on Web of Science.

2.2 Study selection and evaluation

A structured extraction procedure was created to capture the critical elements of each study, including purpose, design/methodology/approach, contribution and paper type to assess the relevance of each study whether they do address the review question (Denyer and Tranfield, 2009). In this stage, there were 1,085 records chosen. Besides WoS database, other sources containing 50 documents were used, such as records identified from Google Scholar as well as reports, publications and working papers from International Organization for Standardization (ISO), World Health Organization (WHO), Food and Agriculture Organization (FAO), and Codex. In total, 1085 documents were further investigated by reading abstracts to eliminate irrelevant records regarding the research question. After this process, only 457 records remained. After further ensuring substantive relevance by reading all remaining articles in their entirety, there were only 132 articles related to the research context –global food supply chains. These articles were full text accessed to finalise the studies for the synthesis stage. 51 papers have been eliminated during this process. After this procedure, 81 records are selected, including 68 articles, 7 reviews and 6 proceeding papers relevant to the research questions and need to be further examined from 2005 to 2020 (Figure 3). The most cited study is the work of Roth *et al.* (2008) on Journal of Supply Chain, with 233 times cited from 2005 to 2020 as the highest average cited 15.53 times per year (Table I).

Figure 3. Total publication by year of selected papers

Table I. Information of top 10 cited articles in the review list

No.	Title	Authors	Source title	Publication year	Times cited
1	Unraveling the food supply chain: strategic insights from China and the 2007 recalls	Roth et al.	Journal of Supply Chain Management	2008	233
2	Product safety and security in the global supply chain: Issues, challenges and research opportunities	Marucheck et al.	Journal of Operations Management	2011	196
3	Implementation of food safety management systems in the UK	Mensah and Julien	Food Control	2011	98
4	Food safety knowledge and practices among food handlers in Slovenia	Jevsnik et al.	Food Control	2008	92
5	Food safety objective: An integral part of food chain management	Gorris	Food Control	2005	79
6	Barriers and benefits of the implementation of food safety management systems among the Turkish dairy industry: A case study	Karaman et al.	Food Control	2012	66
7	Adoption of HACCP system in the Chinese food industry: A comparative analysis	Jin et al.	Food Control	2008	59
8	Food safety performance indicators to benchmark food safety output of food safety management systems	Jacxsens et al.	International Journal of Food Microbiology	2010	56
9	A tool to diagnose context riskiness in view of food safety activities and microbiological safety output	Luning et al.	Trends in Food Science and Technology	2011	47
10	Semi-quantitative study to evaluate the performance of a HACCP-based food safety management system in Japanese milk processing plants	Sampers et al.	Food Control	2012	42

2.3 Analysis and synthesis

In this stage, the reviewed papers were analysed by breaking down individual studies into constituent parts then synthesis by making associations between elements. This work aims to develop and reorganise knowledge that is not apparent from reading the individual studies independently into a new arrangement (Denyer and Tranfield, 2009). Hence, a concise bibliometric analysis on the 81 selected papers was conducted to analyse bibliometric activity indicators of the composition and the quantitative evolution of the literature to avoid potential bias following the suggested procedure of Bresciani *et al.* (2021). VOSviewer 1.6.16 software, which is the technique of visualisation mapping, was used to conduct a similarity analysis of the selected papers. In detail, the rule of citation analysis was applied to identify the relatedness of items that are determined based on the number of times they cite each other (van Eck and Waltman, 2020). VOSviewer builds a similarity matrix by normalising the matrix of co-occurrences of the analysed elements, which in this case are represented by the common citations of authors. A bidimensional graphical map was built through a series of routines, where the nodes represent the authors and the distances between the nodes reflect their similarity in terms of shared references. In this case, VOSviewer uses the number of common citations to split authors into clusters (van Eck and Waltman, 2010). Citation analysis demonstrates that papers are connected in terms of shared citations and form to various defined thematic clusters that reflect the knowledge base characterising the dataset. Each colour cluster represents a research line of outstanding authors in this field (see Figure 4).

The clustering result returned by VOS analysis shows the presence of several thematic clusters, characterised by relevant intra-cluster links and several significant inter-cluster relationships. The rationales used to extract, synthesise and interpret the findings are in Figure 5 as the framework to check for logical links and connections amongst the various research activities within the defined topic (Burgess *et al.*, 2006). The first group provides a recap of the requirements of FSMS in the context of global supply chains (green and orange clusters). The second one, including the core clusters of pink, red, blue, and turquoise blue, aggregates the instruments to measure FSMS. The last group are the rest clusters presenting management of FSMS implementation.

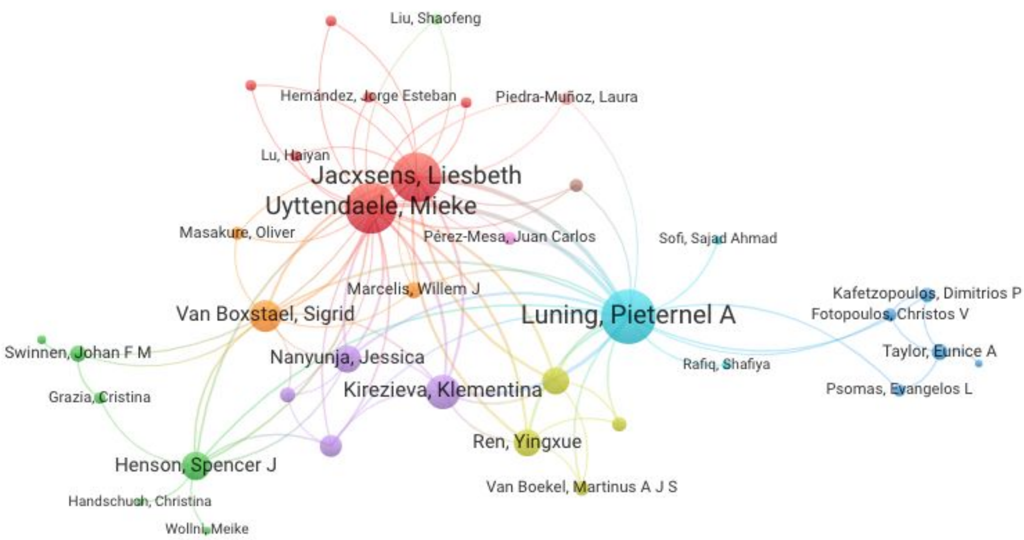

Figure 4. Network citation analysis

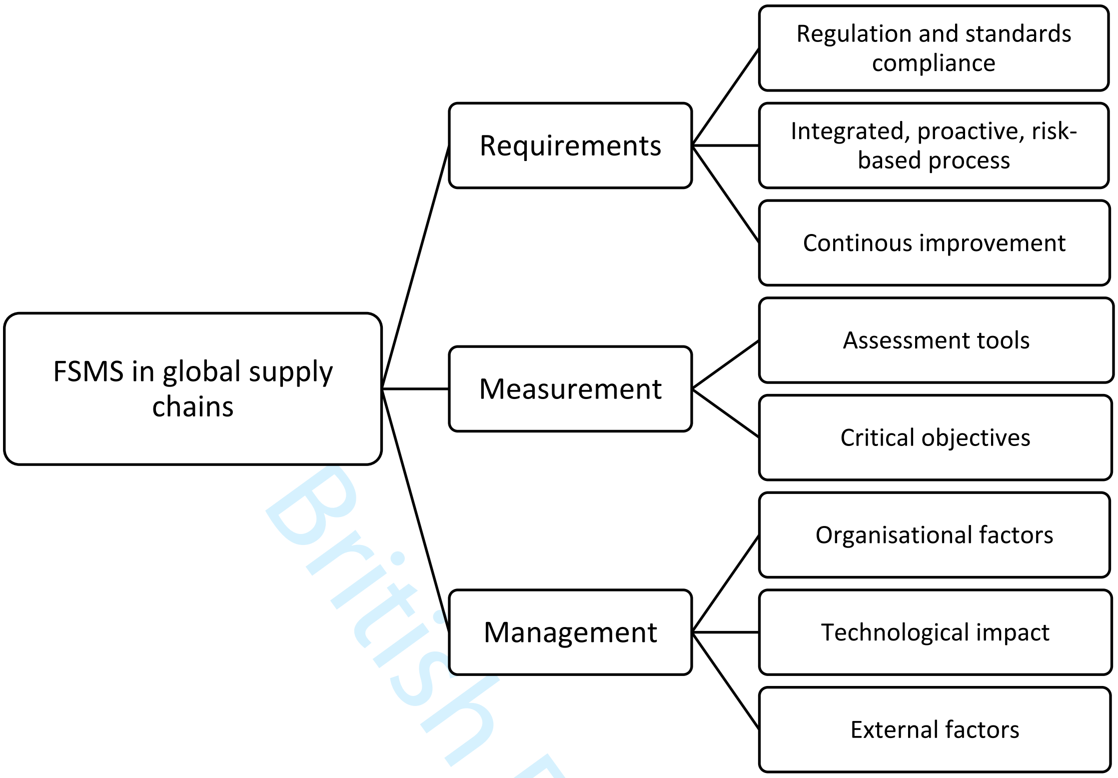

Figure 5. The classification framework

3 Research results

3.1 Requirements for FSMS in global supply chains

Given the vital role of FSMS in the food industry, the requirements for an FSMS are summarised to clarify what food firms should do to guarantee food safety. Regulations and standards compliance is the essential element of all FSMS. There has been a significant evolution toward tougher requirements and more stringent food safety governance to assure food safety globally since the 1990s. For instance, there has been an increase in the number of standards that seek to enhance food safety, including Hazard Analysis and Critical Control Point (HACCP), the British Retail Consortium's global food safety standard (BRC), the International Food Standard (IFS), the Safe Quality Food (SQF), and the ISO 22000:2005. The harmonious objective of these standards is to protect consumer health through an integrated process-based food safety management based on the basic minimum requirements acceptable for food safety and third-party audits (Mensah and Julien, 2011). Previously, these standards were considered voluntary for food operators to apply, and there is a stream in the literature discussing how these stringent standards impact food producers, especially SMEs and family businesses in developing countries (e.g. Henson and Reardon, 2005; Henson and Humphrey, 2010; Schuster and Maertens, 2013). Currently, the global recognition of these standards is performing the task of a framework for uniformity in requirements, mutual acceptance of audit procedures and audits, and reassurance in the capability and competence of suppliers. Some of them have become commonly mandatory in most countries, such as the case of HACCP.

In addition, end-product testing is not an efficient approach to ensure food safety due to unable to determine safety risks before consumption and potentially devastating effects on human life. Food safety should be based on scientific evidence and assessment of the risk to the population, and this risk assessment should be quantitative where feasible (FAO/WHO, 1997). The risk-based preventive approach is implied in FSMS by specifying the necessary minimum requirements acceptable for food safety. Based on these requirements, food manufacturers proactively prevent food safety incidents from occurring in any food chain stages that can cause end-product to be unsafe, rather than just reacting to the incidents. Thus, there are different approaches to assess food safety risks, such as the work of Gkogka *et al.* (2013) showed two different risk assessment approaches to derive the potential appropriate level of protection (ALOP) for Salmonella in chicken meat in the Netherlands. One is a "top-down" approach based on epidemiological data, and the second is a "bottom-up" approach based on food supply chain data. Wang, Li and Shi (2012) and Chan and Wang (2013) also proposed integrated risk assessment approaches to perform structured analysis of aggregative food safety risk in the food supply chain using fuzzy set theory and analytical hierarchy process. They provided structured risk assessment and established aggregative food safety risk indicators as a practical tool to incorporate the safety objectives into operations planning effectively. Furthermore, food safety assurance is based on the establishment of appropriate control measures and operational food safety management throughout the food supply chain, which form a comprehensive system fully explained or understood by understanding how each part or component interacts and influences other components (Yiannas, 2009).

It is proven that none of FSMS is perfect even it had been certificated, well-audited, and inspected. Cormier *et al.* (2007) argued that audits which include a visit to the facility and review of records, only confirm that the procedures and processes of the manufacturing system are being implemented as planned. Powell *et al.* (2013) expressed some criticism on (third party) audits and inspections and claim that they are not enough to guarantee food safety since they reflect only a snapshot in time and cannot guarantee future implementation. They also gave examples of many foodborne illness outbreaks from commercial food operators with high scores of audits or inspections. The existing research on FSMS suggests that fundamentally fulfilling the minimal requirements of regulation and standards are not sufficient

(Kafetzopoulos, Psomas, *et al.*, 2013; Kok, 2009). It is essential to strengthening FSMS and ongoing compliance with regulations and standards by continuous improvement approach that enables companies to achieve and sustain operational and business objectives. FSMS is an integrated process management system including a variety of procedures based on Deming's cycle from planning of the steps (Plan), day-to-day implementation operations (Do), verification (Check) of PRPs, control measures and system implementation, and improvement (Act) by reviewing the overall system implementation (ISO, 2005). Thus, FSMS is underpinned by the continual improvement of an integrative management philosophy that is a recurring activity to increase the ability to fulfil requirements. Specifically, this paradigm seeks continual improvement of machinery, materials, labour utilisation, product quality and safety, and production methods through the application of suggestions and ideas of team members.

3.2 Measurement of FSMS implementation

Certifying an FSMS is a must, but it does not guarantee the optimum level of managing food safety hazards and consequently absolute food safety and the quality of the end products (Fotopoulos *et al.*, 2009; Kafetzopoulos, Psomas, *et al.*, 2013; Kok, 2009). In the past, many authors indicated that the availability of a diagnostic instrument to assess the implementation of the FSMS was rather restricted (Fotopoulos *et al.*, 2009; Luning *et al.*, 2008). As a result, Luning *et al.* (2008) and Jacxsens *et al.* (2010) were the first pioneers in building the implementation measurement system of FSMS based on the diagnostic instrument (FSMS-DI) and microbial assessment scheme (MAS). They assessed a company's FSMS, including control, preventative and core assurance activities, as well as their contributions to the system, outputs under the impact of the riskiness of contextual factors. The measurement gives insight into the level of implementation of the different FSMS activities, the actual microbial implementation, and the food safety output that can be used by food business operators in firms' internal auditing process and provides evidence about major factors affecting the status of FSMS. It is designed to identify the bottlenecks in the current practice and where improvements are necessary.

Within a decade, these approaches have been widely adopted by many researchers for various kinds of food supply chains, namely fresh produce (Kirezieva *et al.*, 2013; Luning *et al.*, 2008; Nanyunja *et al.*, 2015; Sawe *et al.*, 2014), animal-based processing (Jacxsens *et al.*, 2010; Luning *et al.*, 2015), meat and dairy (Jacxsens *et al.*, 2011; Njage *et al.*, 2018), lamb (Osés *et al.*, 2012), fish processing (Kusaga *et al.*, 2014), raspberries chain (Rajkovic *et al.*, 2017) to assess the status of FSMS based on measuring the system output and the insight a company has on its performance (e.g. results of external inspections or audits, results of sampling). However, this diagnostic tool is not applied widely due to the requirement of experts' or researchers' participation in organising workshops to explain and train managers to fill out what level of all indicators and some parts of the assessments demand microbiological sampling (Jacxsens *et al.*, 2010; Kirezieva, Jacxsens, *et al.*, 2015; Luning *et al.*, 2011). Therefore, food firm managers might find these tools challenging to assess and improve their current practices continuously.

Using a different approach, Kafetzopoulos, Gotzamani, *et al.* (2013) developed an instrument for measuring FSMS by the effectiveness of the HACCP-based FSMS and its critical objectives, including identification, assessment, and control foodborne hazards. They affirmed the effectiveness of FSMS in connection to meeting its prescribed safety targets and validating this instrument in the food manufacturing sector. The simple instrument of this study contributes to encourage, facilitate, and improve food companies' self-assessment process in adopting the proper manufacturing practices concerning food safety. Though this study did not consider determinant factors that could influence FSMS implementation. A much more systematic approach would identify how FSMS interacts with other variables such as human resources, organisational attributes, and external factors that are believed to be linked to FSMS implementation, as mentioned in the above section. To fill this gap, Kafetzopoulos and Gotzamani (2014)developed this approach to propose a model for measuring the effectiveness of quality (ISO 9001) and HACCP-based FSMS thanks to their stated objectives when these systems are jointly implemented in a food company. They also investigated the critical factors for effective implementation of the ISO 9001 and HACCP systems and examined how the combined application of ISO 9001 and HACCP influences the overall implementation of the certified firms.

3.3 Managing FSMS implementation in global food supply chains

Once an FSMS has been developed, its implementation could be influenced by many factors because of a large number of stakeholders with an enormous variety of structures, logistics, and chain participants changing rapidly and continuously. When analysing the management of FSMS, the role of the critical success factor (CSF) in enabling food businesses to focus on the most crucial factors that lead to the successful achievement of their desired food-safety goals has emerged (van Asselt *et al.*, 2010; Fotopoulos *et al.*, 2011, 2009; Kafetzopoulos and Gotzamani, 2014; Nguyen, 2019). CSF theory was first introduced by John Rockart (1979).

Later, the universal definition of CSFs was given by Boynton and Zmud (1984). We also use the view of this theory to review and identify what we already know about FSMS management.

According to ISO 22000:2005, to fulfil food safety objectives, the organisation should provide adequate resources for establishing, implementing, maintaining, and updating FSMS. These resources include human resources, infrastructure, and work environment. A great deal of previous research has focused on the impact of organisational factors on FSMS implementation. For example, human resource is considered the topmost challenge in implementing FSMS, and it could attribute as determinant factors of quality and food safety effectiveness (Fotopoulos *et al.*, 2009; Kafetzopoulos and Gotzamani, 2014). The level of the FSMS implementation could be impacted by the degree of employee involvement (Fotopoulos *et al.*, 2011, 2009; Kafetzopoulos and Gotzamani, 2014; Kirezieva, Luning, *et al.*, 2015; Luning *et al.*, 2008), their efficient knowledge and skills to ensure food safety (Kafetzopoulos and Gotzamani, 2014), awareness of the relevance and importance of their activities in contributing to food safety (ISO, 2005), training programs for employees to improve the current level of the above requirements related to food safety. Sharman *et al.* (2020) also suggested an increased focus on culture, climate, and behaviour in food businesses by assessing different types of culture, climate, and employees, and concluded that different employee behaviours impact the culture and climate of an organisation. Together, these studies indicated that these critical factors from organisations highly interact with FSMS implementation and affect its success.

It is interesting to see how innovative and smart technologies impact FSMS through the high citation literature emphasising the role of blockchain, Internet of Things, artificial intelligence, machine learning, augmented reality (AR), visual reality (VR) and so on. These technologies can help food companies to achieve better transparency, traceability, and integrity to enhance food safety and consumer trust in global food supply chains (Aung and Chang, 2014; Feng Tian, 2017; Kamble *et al.*, 2020; Nguyen and Doan, 2019; Saberi *et al.*, 2019; Wang *et al.*, 2019). The collaboration between Walmart and IBM for pork in China and sliced mango imported to America from Latin America are mentioned as an innovative application in the food industry. Advanced technologies profoundly change manufacturing and operating processes by establishing smart design architectures and enhancing food safety mechanisms, providing quality assurances, and smooth supply chain disruptions from food wastage and spoilage (Kamath, 2018). The use of computer-aided design and manufacturing software, immersive and non-invasive hybrid prototyping technologies, and the ability to interact within the cyber-physical systems eliminate the need for post-process quality inspections and enables a self-optimisation control system (Kamble *et al.*, 2020). The deployment of new technologies combined with data analytics and existing industry standards support the entire supply ecosystem to benefit from such a comprehensive data snapshot. However, there are several challenges accompanied with these technologies in terms of technological obstacles, interoperability, standardisation, lack of trust issues among stakeholders, as well as legal and regulatory challenges (Chang *et al.*, 2020).

In addition, Kirezieva, Jacxsens, et al. (2015) confirmed the structure of the market and supply chain, interactive relationship between organisations within the food chain that affect FSMS implementation. To support this, the study of Kirezieva, Luning, *et al.* (2015) suggested that collaborative/supportive supply chains contribute to more advanced FSMS and good system output as firms demonstrated advanced knowledge and expertise about safety and quality management. These factors were adopted as chain characteristics in the group of the context factors (product, production, organisational and chain characteristics) affecting the design and operation of FSMS activities from several studies (Kirezieva *et al.*, 2013; Kirezieva, Luning, *et al.*, 2015; Lu *et al.*, 2020; Luning *et al.*, 2008, 2011). They emphasised that the conditions and relationships with other organisations in the chains may impact the status of FSMS. Also, many authors pointed out that implementing FSMS requires regulatory and market opportunities information, technical and financial support from these parties other parties such as non-profit organisations (NGOs), business associations, and financial institutes are significant on firm's FSMS implementation (Kirezieva, Luning, *et al.*, 2015; Qijun and Batt, 2016; Abebe *et al.*, 2020). Additionally, Chaoniruthisai *et al.* (2018); Qijun and Batt (2016); Rincon-Ballesteros *et al.* (2019) confirmed that difficulty in obtaining external funds is perceived as a significant financial barrier to adopting a certificated FSMS.

4 Gaps and future research agenda

The study presents the systematic literature review derived from the urgent need for strengthening FSMS in global food supply chains. It produces an elaborate picture of the current knowledge showing how food operators measure and manage FSMS implementation. The paper has presented those mandatory and voluntary regulations and standards that are the most critical part of international requirements to assure integrated, proactive, risk-based approaches and continuous improvement in FSMS in global food chains. To measure FSMS, it is interesting that previous researchers have successfully created and verified several assessment tools using different approaches, namely the diagnostic instrument, microbial assessment scheme, and achievement level of critical objectives of FSMS. Also, many studies provide evidence about several external and internal factors affecting the management of FSMS implementation, including organisational resources, food safety culture, climate, and behaviour. Industry 4.0 technology adoption significantly impacts the management of FSMS in global supply chains by innovative design architectures to eliminate the need for quality inspections and enable a self-optimisation control system. In terms of external factors, the structure of the market and supply chain, interactive relationships between organisations within the food chain affect FSMS implementation. To guide future research, some limitations/gaps observed during our content analysis are presented in this section, along with potential future research questions as illustrated in Table II.

Concerning the first theme related to requirements for FSMS, the harmonious objective of regulations and standards compliance is a must to protect consumer health despite significant variations in food safety governance across countries and among value chains increase the burden of auditing costs and certifications on food manufacturers. It is required that food manufacturers proactively prevent food safety incidents from occurring in any food chain stages, rather than just reacting to the incidents. Given the importance of maintaining a robust FSMS and there is no such thing as a free safe lunch due to the increasing cost of FSMS development and implementation in the food industry (Macheka *et al.*, 2013; Qijun and Batt, 2016). Very little is currently known about forming a uniformity in global recognition of regulations and standards to reduce food safety costs. Also, what factors motivate and encourage firms to create common requirements, mutual acceptance of audit procedures and audits, and reassurance in the capability and competence of suppliers.

The second theme of the analysis concerning measurement of FSMS implementation, various tools for assessing FSMS implementation has been adopted within food firms around the world (e.g. Luning *et al.*, 2008; Kirezieva *et al.*, 2013; Kafetzopoulos and Gotzamani, 2014; Kirezieva, Luning, *et al.*, 2015; Nanyunja *et al.*, 2015; Njage *et al.*, 2018). Although HACCP-based assessment emphasises that hazard analysis is the key to an effective FSMS (ISO 22000, 2005), its major drawback is that it does not give sufficient consideration to other vital elements such as prerequisite programmes, communication and system management as requirements of many standards and regulations (i.e. ISO 22000, BRC, SFQ, IFS). As Mortimore and Wallace (2013) affirm, HACCP by itself cannot control food safety because a risk-based program requires hazard analysis and risk evaluation skills along with many prerequisites and other management support activities. These instruments are required not only to be easy-to-use for managers and food safety teams as daily basis tools but also include the objective of hazard analysis along with manufacturing optimisation.

Additionally, little is known about how the complexity of manufacturing behaviours and optimisation influence FSMS. For example, current expositions have not considered the critical dimensions of manufacturing optimisation consisting of time and flexibility besides safety and cost. This limitation leads to the question of what are possible tradeoffs between these key dimensions concerning cost, time, and flexibility when food firms decide to improve their FSMS practices. There would be many fruitful areas for further work on constructing measurement metrics that must be highly customised based on the unique characteristics of each company's production and surrounding market under compliance with regulation and standards. Moreover, the outcomes of these measurements should lead to clear improvement opportunities for the current practices. Research to date has not yet determined mechanisms on how to encourage firms to seek continual improvement in FSMS. Assessing the degree to which the implementation of FSMS impacts business performance through available data at their firms such as financial performance, operational performance and food safety output would be more practical to motivate firms to review and update their systems continuously. The research question is what the relationship between FSMS and business performance is.

The last analysis theme emphasises the vital role of critical factors in managing FSMS implementation. There are highly interactions between organisational factors and FSMS implementation consisting of sufficient resources in each firm, including human resources, infrastructure, and work environment (Kafetzopoulos and Gotzamani, 2014; Nyarugwe *et al.*, 2018; Sharman *et al.*, 2020). However, each firm is unique in production, organisation, and the context in which it is operating. The previous studies have not dealt with these dynamics and differences of each enterprise, such as firm size, culture, ownership structure. Hence, what is the impact of organisational factors on the management of FSMS implementation contingent on the firm's characteristics? Moreover, although smart technologies strengthen FSMS implementation, large companies successfully apply new technologies while small and medium enterprises (SMEs) still deal with many difficulties (Kamble *et al.*, 2020). So how firms overcome the challenges associated with new technologies, especially in the case of SMEs, remains unknown.

Concerning external factors, previous studies confirm that collaborative and supportive supply chains contribute to more advanced FSMS, and chain characteristics affect the design and operation of FSMS. However, researchers have not treated the definition of a collaborative/supportive supply chain in much detail as they cannot reflect what kind of relationships in the chains as well as how organisations collaborate with others. Much uncertainty still exists about the relationship and collaboration in the value chains to create higher impacts on FSMS implementation. Additionally, there are many pieces of research concerning the abilities of a firm to obtain supports for information, finance, technology and knowledge to improve FSMS (Abebe *et al.*, 2020; Chaoniruthisai *et al.*, 2018; Qijun and Batt, 2016; Rincon-Ballesteros *et al.*, 2020). From these studies, what is not yet clear is the impacts of the organisations such as non-profit organisations (NGOs), business associations, and financial institutes on FSMS implementation of the firm.

Table II. Summary of gaps and research questions

Theme	**Gaps**	**Future research questions (RQ)**
Requirements for FSMS in global supply chains: • *Regulation and standards compliance* • *Integrated, proactive, risk-based process* • *Continuous improvement*	• Mechanism to uniform regulations and standards • Lack of common requirements, mutual acceptance of audit procedures and audits, and reassurance in the capability and competence of suppliers among firms in global supply chains.	**RQ1:** How to form a uniformity in global recognition of regulations and standards to reduce costs in fulfilling FSMS requirements? **RQ2:** What and how to motivate firms to establish common requirements, mutual acceptance of audit procedures and audits, and reassurance in the capability and competence of suppliers across firms in global supply chains?
Measurement of FSMS implementation: • *Assessment tools* • *Critical objectives*	• The complexity of manufacturing behaviours influenced FSMS remains unknown. • Possible tradeoffs between key dimensions of manufacture optimisation concerning cost, time, and flexibility when food firms decide to improve their FSMS practices. • The relationship between FSMS and business performance.	**RQ3:** How to build measurement metrics that must be highly customised based on the unique characteristics of each company's production and surrounding market under compliance with regulation and standards? **RQ4:** How to encourage firms to seek continual improvement in FSMS? **RQ5:** What is the relationship between FSMS and business performance?

Managing FSMS implementation in global food supply chains: • *Organisational factors* • *Technological impact* • *External factors*	• Impact of organisational factors regarding the dynamics and differences of each enterprise. • SMEs cannot apply smart technologies to strengthen FSMS implementation due to many challenges. • Lack of information about collaborative/supportive supply chains which impact FSMS. • The impact of external parties such as non-profit organisations (NGOs), business associations, and financial institutes on FSMS implementation of the firm.	**RQ6:** What is the impact of organisational factors on the management of FSMS implementation contingent on the firm's characteristics? **RQ7:** How do firms overcome the challenges associated with new technologies applying for FSMS? **RQ8:** In the case of SMEs, whether there are more obstacles in dealing with challenges associated with new technologies for FSMS? **RQ9:** The degree to which the organisations collaborate and support others could create higher impacts on FSMS implementation? **RQ10:** Whether the impact of other parties such as non-profit organisations (NGOs), business associations, and financial institutes are significant on FSMS implementation?

5 Concluding remarks

5.1 Theoretical and managerial implications

The current study contributes several key implications for researchers in this field. First, it is the first to our knowledge to examine measurement and management of FSMS in the context of global supply chains applying systematic literature review combined with biological mapping analysis on 81 peer-reviewed papers published from 2005 to 2020. We thus encourage future studies to discuss several uncovered gaps emerging from this study which is summarised in Table II. This study also makes ten unique research questions concerning further theoretical developments and managerial implementations to strengthen FSMS in global food trading. Second, our systematic analysis shows that only a limited number of measurement tools for FSMS have been identified. There are many dimensions related to manufacturing behaviours and tradeoffs remaining unclear. This would be a fruitful area for further work. Finally, the research analysis underpinned by CSF theory reviewing both internal and external factors for managing FSMS can also be used for future research to strengthen the effectiveness of FSMS. These CSFs are from organisational resources, the relationship and collaboration within food supply chains, as well as from the support of external parties.

Besides the theoretical implications for researchers, several managerial implications are recommended for food businesses. There is a systematised list of published practices that have been studied and reported in this research. Food firms that are seeking improvement opportunities for FSMS would be served well by this review. Also, international requirements on FSMS are provided and summarised for food businesses. Regarding measurement, many tools could assist practitioners in FSMS evaluation. Equally important, practitioners should pay more attention to different aspects of measurement tools, especially in balancing manufacturing dimensions, namely food safety, cost, time, and flexibility. Uniquely, this work has been one of the first attempts to thoroughly examine critical factors of FSMS implementation from the organisation and the supply chains. An implication of this is that these practices could be considered as a useful reference point for practitioners.

5.2 Limitations

The current review aims to analyse and synthesise the extant literature on FSMS in global supply chains guided by the main research question using CIMO logic. Mandatory and voluntary regulations and standards are the most critical part of international requirements to assure integrated, proactive, risk-based approaches as well as continuous improvement in FSMS in global food chains. To measure FSMS, several assessment tools using different approaches have been successfully created and verified, namely the diagnostic instrument, microbial assessment scheme, and achievement level of critical objectives. Also, several external, internal factors, Industry 4.0 technology adoption that significantly impact the management of FSMS implementation are presented in the paper.

However, the study has two limitations. First, the reader should bear in mind that the study is based on a strict review protocol that might not include relevant literature and non-English articles in other field sources. Second, despite the rigour of the protocol combined with biological mapping analysis software, some inadvertent errors may still have crept into our analysis. Notwithstanding these limitations, the study suggests that several interesting avenues for future research. First, among three identified themes related to FSMS, the first one seems to be well developed, while the other two need more future works. We hope this study will stimulate future research to develop more measurement tools and identify the impacts of critical factors on FSMS with the aim of food safety guarantee at any stage of supply chains. Second, the identified research questions are offered for researchers and food manufacturers potential opportunities to investigate further two aspects of FSMS, including measurement and management.

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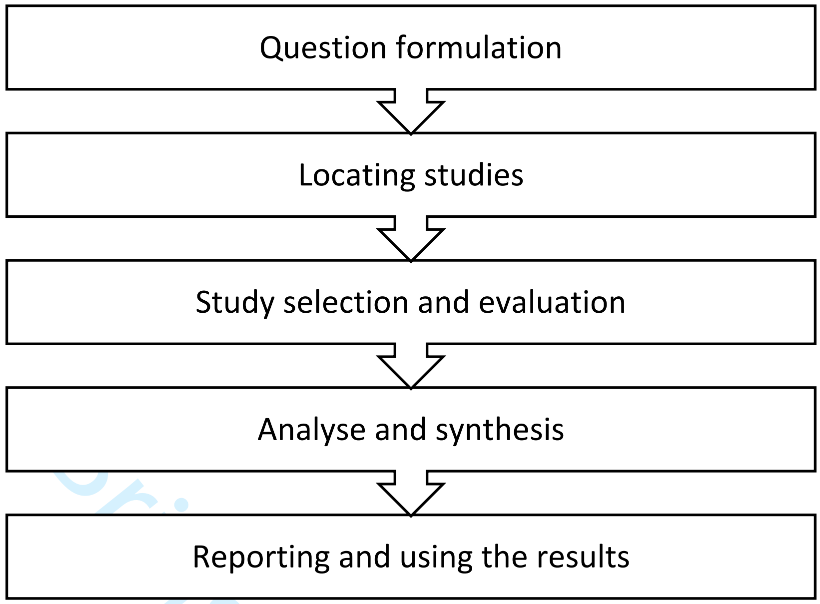

Figure 1. Systematic review methodology (adapted from Denyer and Tranfield, 2009; Durach, Kembro and Wieland, 2017).

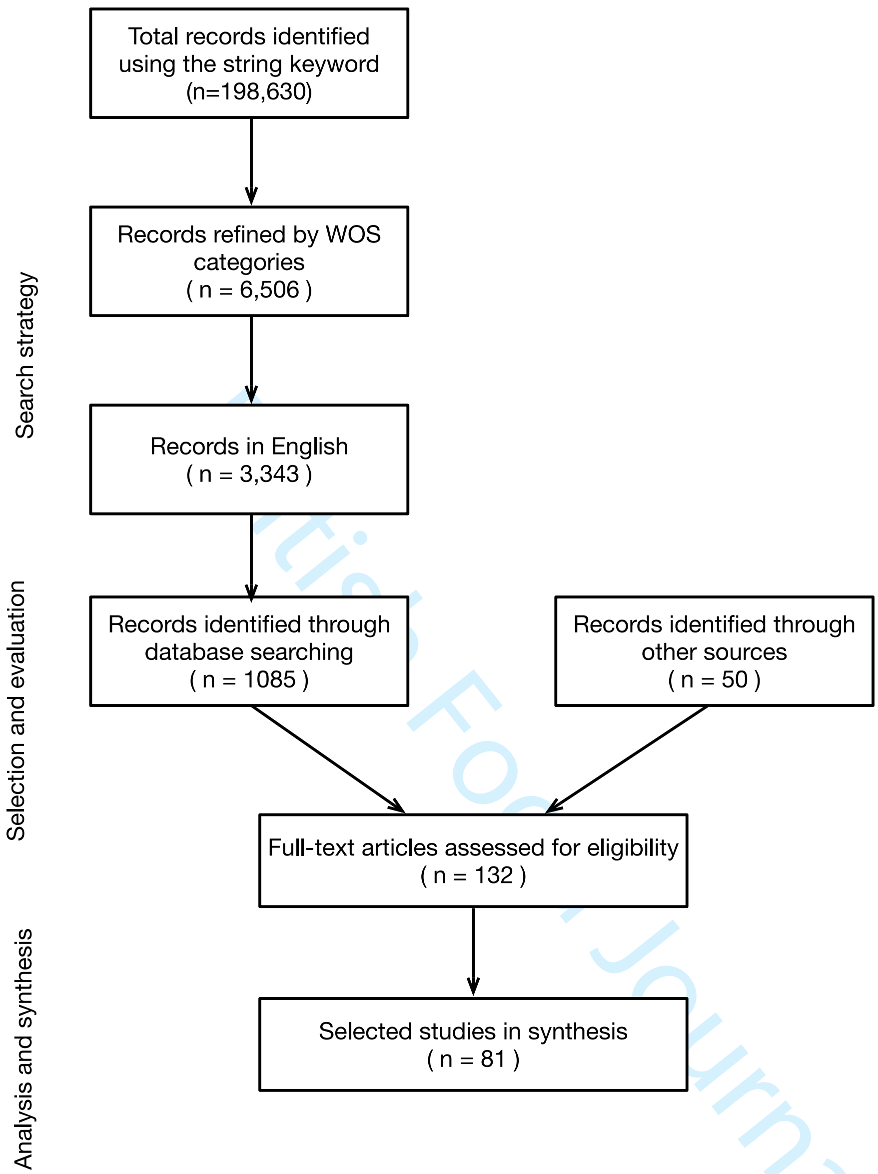

Figure 2. The SLR flow diagram (adapted from Moher et al., 2009)

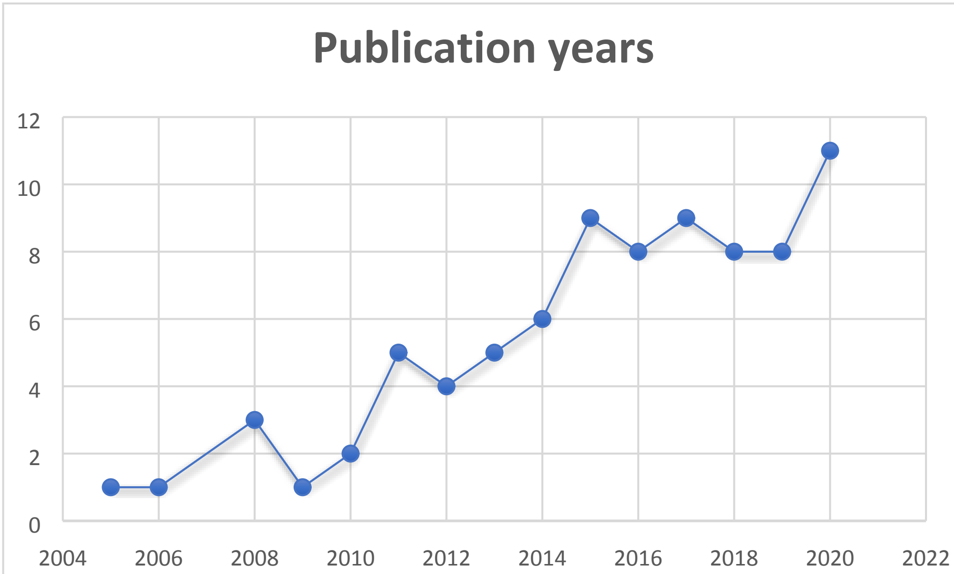

Figure 3. Total publication by year of selected papers

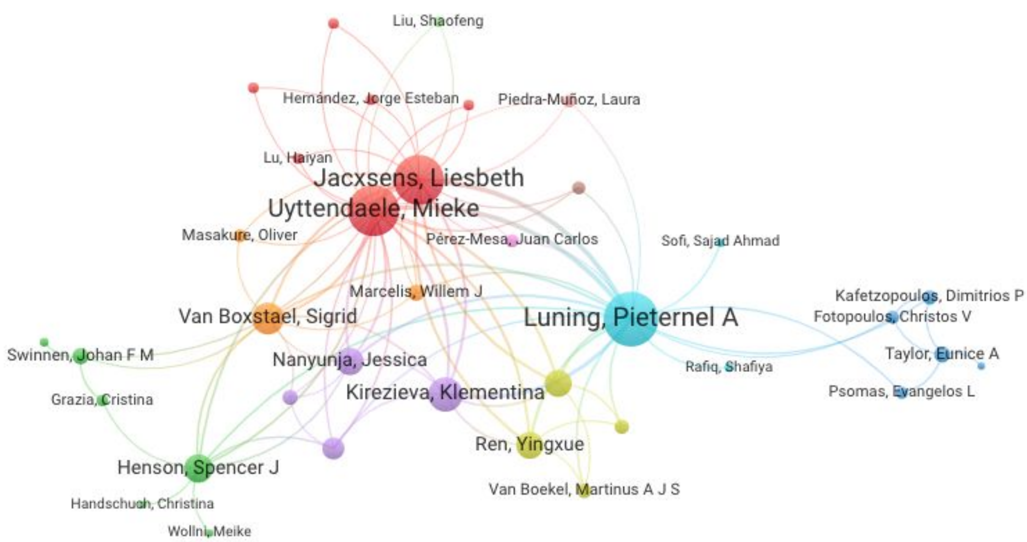

Figure 4. Network citation analysis

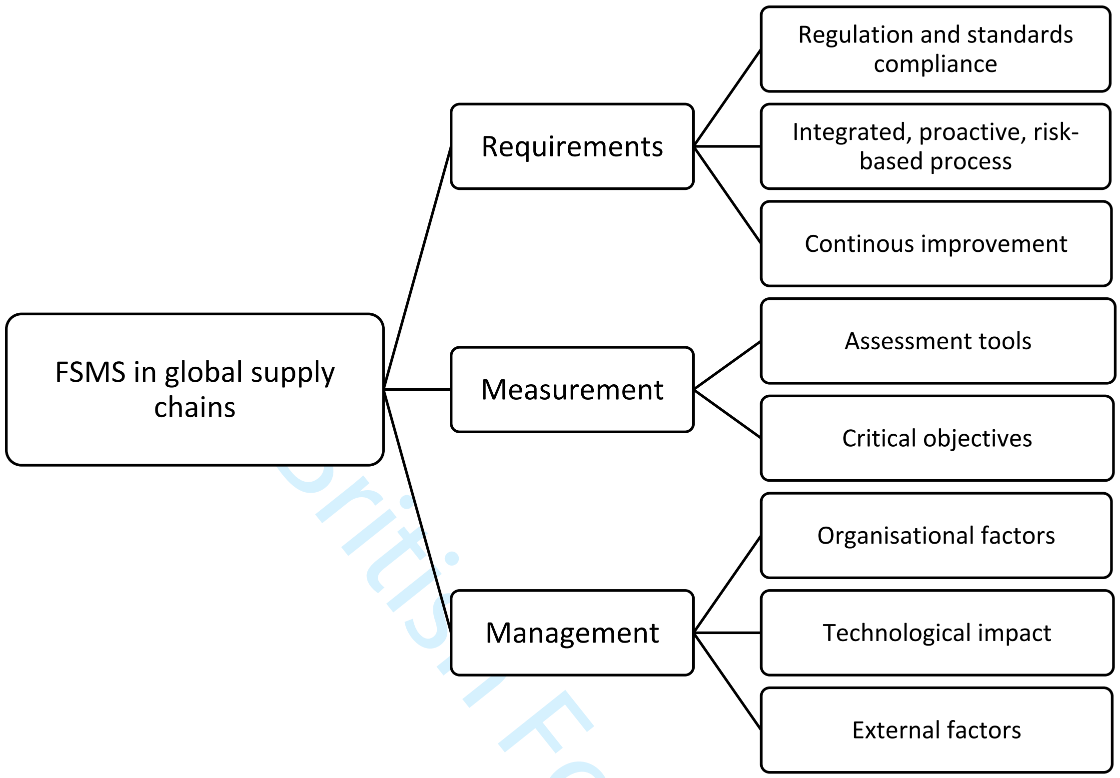

Figure 5. The classification framework

Table I. Information of top 10 cited articles in the review list

No.	Title	Authors	Source title	Publication year	Times cited
1	Unraveling the food supply chain: strategic insights from China and the 2007 recalls	Roth et al.	Journal of Supply Chain Management	2008	233
2	Product safety and security in the global supply chain: Issues, challenges and research opportunities	Marucheck et al.	Journal of Operations Management	2011	196
3	Implementation of food safety management systems in the UK	Mensah and Julien	Food Control	2011	98
4	Food safety knowledge and practices among food handlers in Slovenia	Jevsnik et al.	Food Control	2008	92
5	Food safety objective: An integral part of food chain management	Gorris	Food Control	2005	79
6	Barriers and benefits of the implementation of food safety management systems among the Turkish dairy industry: A case study	Karaman et al.	Food Control	2012	66
7	Adoption of HACCP system in the Chinese food industry: A comparative analysis	Jin et al.	Food Control	2008	59
8	Food safety performance indicators to benchmark food safety output of food safety management systems	Jacxsens et al.	International Journal of Food Microbiology	2010	56
9	A tool to diagnose context riskiness in view of food safety activities and microbiological safety output	Luning et al.	Trends in Food Science and Technology	2011	47
10	Semi-quantitative study to evaluate the performance of a HACCP-based food safety management system in Japanese milk processing plants	Sampers et al.	Food Control	2012	42

Table II. Summary of gaps and research questions

Theme	**Gaps**	**Future research questions (RQ)**
Requirements for FSMS in global supply chains:	• Mechanism to uniform regulations and standards • Lack of common requirements, mutual acceptance of audit procedures and audits, and	**RQ1:** How to form a uniformity in global recognition of regulations and standards to reduce costs in fulfilling FSMS requirements?

• *Regulation and standards compliance* • *Integrated, proactive, risk-based process* • *Continuous improvement*	reassurance in the capability and competence of suppliers among firms in global supply chains.	**RQ2:** What and how to motivate firms to establish common requirements, mutual acceptance of audit procedures and audits, and reassurance in the capability and competence of suppliers across firms in global supply chains?
Measurement of FSMS implementation: • *Assessment tools* • *Critical objectives*	• The complexity of manufacturing behaviours influenced FSMS remains unknown. • Possible tradeoffs between key dimensions of manufacture optimisation concerning cost, time, and flexibility when food firms decide to improve their FSMS practices. • The relationship between FSMS and business performance.	**RQ3:** How to build measurement metrics that must be highly customised based on the unique characteristics of each company's production and surrounding market under compliance with regulation and standards? **RQ4:** How to encourage firms to seek continual improvement in FSMS? **RQ5:** What is the relationship between FSMS and business performance?
Managing FSMS implementation in global food supply chains: • *Organisational factors* • *Technological impact* • *External factors*	• Impact of organisational factors regarding the dynamics and differences of each enterprise. • SMEs cannot apply smart technologies to strengthen FSMS implementation due to many challenges. • Lack of information about collaborative/supportive supply chains which impact FSMS. • The impact of external parties such as non-profit organisations	**RQ6:** What is the impact of organisational factors on the management of FSMS implementation contingent on the firm's characteristics? **RQ7:** How do firms overcome the challenges associated with new technologies applying for FSMS? **RQ8:** In the case of SMEs, whether there are more obstacles in dealing with challenges associated with new technologies for FSMS?

	(NGOs), business associations, and financial institutes on FSMS implementation of the firm.	**RQ9:** The degree to which the organisations collaborate and support others could create higher impacts on FSMS implementation? **RQ10:** Whether the impact of other parties such as non-profit organisations (NGOs), business associations, and financial institutes are significant on FSMS implementation?

A systematic literature review of food safety management system implementation in global supply chains

Abstract

Design/methodology/approach: Food safety is challenging to assure from farm to fork across the world. The paper addresses this challenge from the angle of how firms measure and improve the implementation of food safety management system (FSMS) in global food supply chains by a systematic review combined with biological mapping analysis (VOS viewer) on 81 peer-reviewed papers published from 2005 to 2020.

Purpose: The study sets to summarise managerial requirements, analyse practices and tools to measure FSMS implementation. Also, underpinned by critical success factors (CSF) theory, we explore when food firms manage FSMS, which factors are critical to their implementation to identify promising research directions for researchers and suggestions for practitioners through a comprehensive analytical lens.

Findings: Mandatory and voluntary regulations and standards are the most critical part of international requirements to assure integrated, proactive, risk-based approaches as well as continuous improvement in FSMS in global food chains. To measure FSMS, only a limited number of measurement tools for FSMS have been identified. External, internal factors, technology adoption that significantly impact the management of FSMS implementation still require more future works.

Research limitations/implications: Several FSMS research gaps observed during the content analysis of selected papers within 15 years are presented along with ten future research questions.

Practical implications: A systematised list of published papers that has been studied and reported in this research could be considered as a useful reference point for practitioners in food industry.

1 Introduction

Extensive global sourcing of food products complicates supply chain management that is typically accompanied by additional costs; heightened vulnerability and greater supply risks; issues concerning global financing and funds transfer; and lower responsiveness (Roth *et al.*, 2008). Also, food supply networks are global, complicated, and highly interconnected, leading to higher risk exposure (Trienekens and Zuurbier, 2008). As one of the greatest challenges of global food supply chains, food safety risks can have significant repercussions (Whipple *et al.*, 2009). For that reason, there is no way around it without suffering the consequences of non-compliance, regardless of whether food enterprises realise both industrial or economic benefits or not (Mensah and Julien, 2011).

Implementing an FSMS, which is made up of a group of interacting or interdependent elements forming a network to ensure that food presents minimal risk to consumers, is a regulatory requirement for every food firm in the global food chain (CAC, 2009). Each firm's FSMS is a highly customised system as a result of implementing various quality assurance and legal requirements into a company's unique production, organisation, and environment (Jacxsens *et al.*, 2011). No matter how different between firms within supply chains are, the ultimate purpose of FSMS is to ensure that foods are safe concerning foodborne hazards at the time of human consumption.

Moreover, a well-performed FSMS is supposed to deliver benefits for a firm that go well beyond food safety objective. Namely, increasing sales revenue thanks to rising consumer confidence in the safety of the purchased food and obtaining a ticket for accessing the global food value chain (Mensah and Julien, 2011), reducing operating cost and lower insurance charges for avoided costs such as food safety incidents, recalls and complaints (Marucheck *et al.*, 2011); satisfying the need of stakeholders/customer (Fotopoulos *et al.*, 2011), enhancing a firm's reputation and promote food safety guarantee or marketing tool to access more advanced markets (Nanyunja *et al.*, 2016).

Considering the positive impacts of well-performed FSMS implementation, this paper seeks to enrich understanding of FSMS by a comprehensive representation of current knowledge which is critically evaluated and analysed focused on the measurement and management of FSMS implementation. This study, therefore, set out to:

- Summarise managerial requirements for FSMS from the existing research,
- Analyse practices and tools to measure FSMS implementation,
- Explore when food firms manage FSMS, which factors are critical to their implementation,
- Identify promising research directions for researchers and useful suggestions for practitioners.

2 Research methodology

In this study, we apply the method of systematic literature review, which is the use of systematic, reproducible and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyse data from the included studies based on a clearly formulated question in the review (Higgins and Green, 2011). The procedures of Denyer and Tranfield (2009), Thomé *et al.*, (2016) and Durach *et al.*, (2017) are combined and applied in creating and building bodies of knowledge for FSMS in the context of supply chain management research (Figure 1).

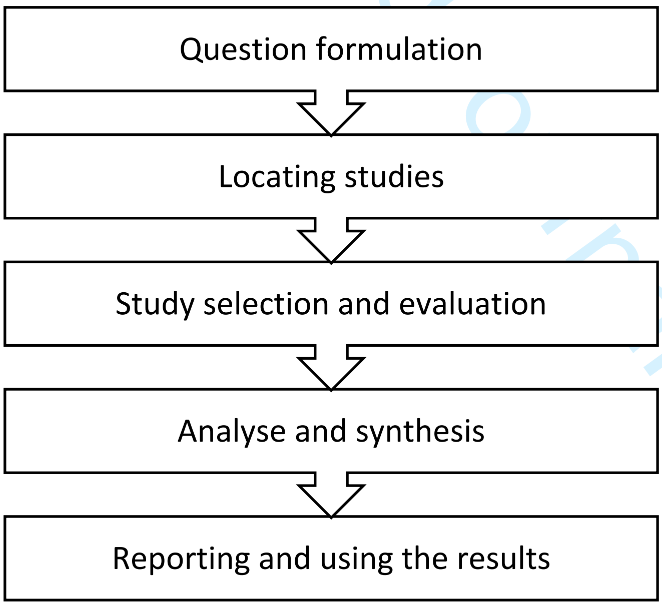

Figure 1. Systematic review methodology (adapted from Denyer and Tranfield, 2009; Durach, Kembro and Wieland, 2017).

2.1 Question formulation and locating studies

Clearly formulating the research question that establishes the study focus and criteria to have a comprehensive search strategy (Denyer and Tranfield, 2009) is the first step. The CIMO-logic (Context, Intervention, Mechanisms and Outcomes) is applied to specify four critical parts to be investigated in a well-built systematic review. It is constructed as “in this class of problematic Contexts, use this Intervention type to invoke these generative Mechanism(s), to deliver these Outcome(s)” (Denyer *et al.*, 2008; Denyer and Tranfield, 2009). Using this logic, characterised by the increasing level of global complexity and stringent food safety requirements, FSMS implementation is required to be successfully measured and improved by food manufacturers to ensure food safety. The main question of this study is: in the complexity of global supply chains (C), how do food manufacturers measure and manage (I) FSMS implementation (M) leading to safer food production (O)?

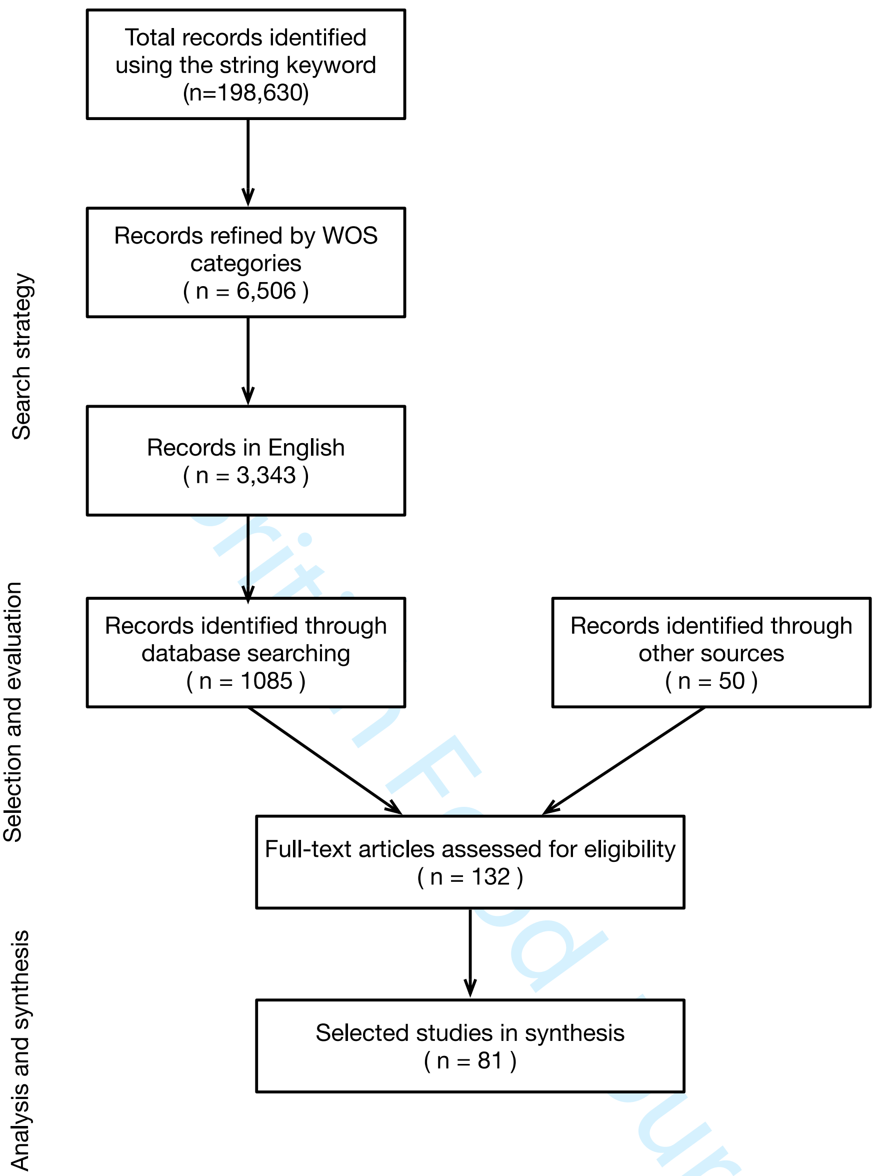

Figure 2. The SLR flow diagram (adapted from Moher et al., 2009)

A set of keywords is derived connected to the above question of the study by a brainstorming process. Then data is collected from Web of Science is used in this review to search for keywords from 2005 to 2020. The complex string of keywords is constructed to reduce too generic and broad results instead of using keywords. The complex string of keywords is used for searching as the following: [‘Food safety’ OR ‘Food safety management’ OR ‘Food safety management system’] AND [‘Supply chains’ OR ‘Global supply chains’] AND [‘Management’] AND [‘Implementation’]. As seen in Figure 2, there are 198,630 records generated based on this complex string instead of using separated keywords. Then, the research results are refined by Web of Science Categories including only Business, Management and Operation Research

Management Science, remaining 6,506 records. Also, only English articles were selected, the number of records is narrowed down to 3,343. There are 67 pages with 50 articles per page listed on Web of Science.

2.2 Study selection and evaluation

A structured extraction procedure is created to capture the critical elements of each study including purpose, design/methodology/approach, contribution and paper type in order to assess the relevance of each study whether they do address the review question (Denyer and Tranfield, 2009). In this stage, there are 1,085 records chosen. Besides the ISI database, other sources containing 50 documents are used such as records identified from Google Scholar as well as reports, publications and working papers from ISO, WHO, FAO, Codex. In total, 1085 documents are further investigated by reading abstracts to eliminate irrelevant records regarding the research question. After this process, there are only 457 records remaining. Among the remaining records, after further ensuring substantive relevance by reading all remaining articles in their entirety, there are only 132 articles related to the research context – the global food supply chain. These articles are full text accessed to finalise the studies for the synthesis stage. 51 papers have been eliminated during this process. After this procedure, there are 81 selected records including 68 articles, 7 reviews and 6 proceeding papers relevant to the research questions and need to be further examined from 2005 to 2020 (Figure 3). The most cited study is the work of Roth *et al.*, (2008) on Journal of Supply Chain with 233 times cited from 2005 to 2020 and it is the highest average cited 15.53 times per year (Table I).

Figure 3. Total publication by year of selected papers

Table I. Information of top 10 cited articles in the review list

No.	Title	Authors	Source title	Publication year	Times cited
1	Unraveling the food supply chain: strategic insights from China and the 2007 recalls	Roth et al.	Journal of Supply Chain Management	2008	233
2	Product safety and security in the global supply chain: Issues, challenges and research opportunities	Marucheck et al.	Journal of Operations Management	2011	196
3	Implementation of food safety management systems in the UK	Mensah and Julien	Food Control	2011	98
4	Food safety knowledge and practices among food handlers in Slovenia	Jevsnik et al.	Food Control	2008	92
5	Food safety objective: An integral part of food chain management	Gorris	Food Control	2005	79
6	Barriers and benefits of the implementation of food safety management systems among the Turkish dairy industry: A case study	Karaman et al.	Food Control	2012	66
7	Adoption of HACCP system in the Chinese food industry: A comparative analysis	Jin et al.	Food Control	2008	59
8	Food safety performance indicators to benchmark food safety output of food safety management systems	Jacxsens et al.	International Journal of Food Microbiology	2010	56
9	A tool to diagnose context riskiness in view of food safety activities and microbiological safety output	Luning et al.	Trends in Food Science and Technology	2011	47
10	Semi-quantitative study to evaluate the performance of a HACCP-based food safety management system in Japanese milk processing plants	Sampers et al.	Food Control	2012	42

2.3 Analysis and synthesis

In this stage, the reviewed papers are analysed by breaking down individual studies into constituent parts then synthesis by making associations between elements. The aim of this work is to develop and reorganise knowledge that is not apparent from reading the individual studies independently into a new arrangement (Denyer and Tranfield, 2009). Hence, a concise bibliometric analysis on the 81 selected papers is conducted to analyse bibliometric activity indicators of the composition and the quantitative evolution of the literature to avoid potential bias. VOSviewer 1.6.16 software, which is the technique of visualisation mapping, is used to conduct a similarity analysis of the selected papers (van Eck and Waltman, 2010). In detail, the rule of citation analysis is applied to identify the relatedness of items that are determined based on the number of times they cite each other (van Eck and Waltman, 2020). VOSviewer builds a similarity matrix by normalising the matrix of co-occurrences of the analysed elements, which in this case are represented by the common citations of authors. A bidimensional graphical map is built through a series of routines, where the nodes represent the authors and the distances between the nodes reflect their similarity in terms of shared references. In this case, VOSviewer uses the number of common citations to split authors into clusters (van Eck & Waltman, 2010). Citation analysis demonstrates that papers are connected in terms of shared citations, and form to various defined thematic clusters that reflect the knowledge base characterising the dataset, with each color cluster representing a research line of outstanding authors in this field (see Figure 4).

The clustering results returned by VOS analysis shows the presence of several thematic clusters, characterised by relevant intra-cluster links and several significant inter-cluster relationships. The rationales used to extract, synthesise and interpret the findings are in Figure 5 as the framework to check for logical links and connections amongst the various research activities within the defined topic (Burgess *et al.*, 2006). The first group provides a recap of the requirements of FSMS in the context of global supply chains (green and orange clusters). The second one including the core clusters of pink, red, blue, and turquoise blue aggregates the instruments to measure FSMS. The last group are the rest clusters presenting management of FSMS implementation.

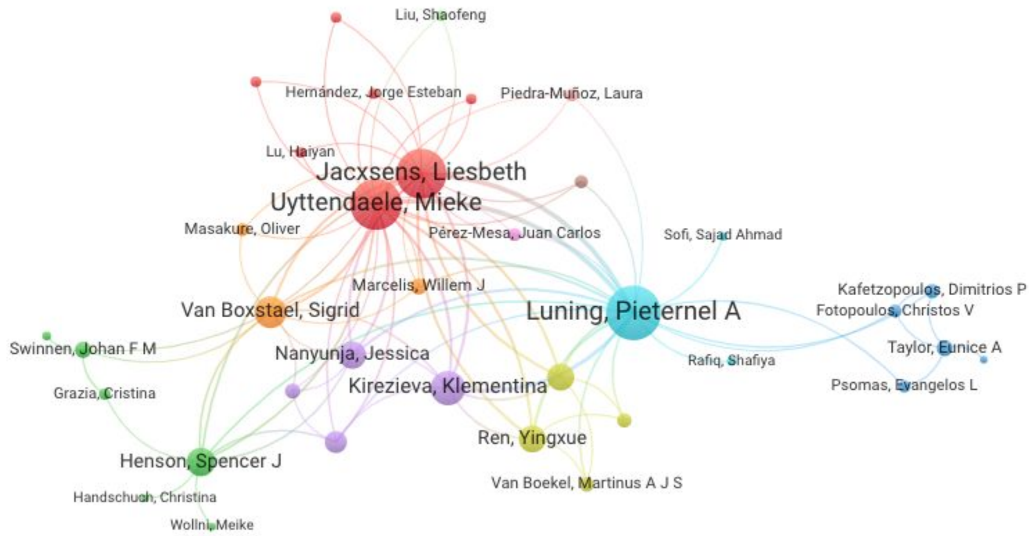

Figure 4. Network citation analysis

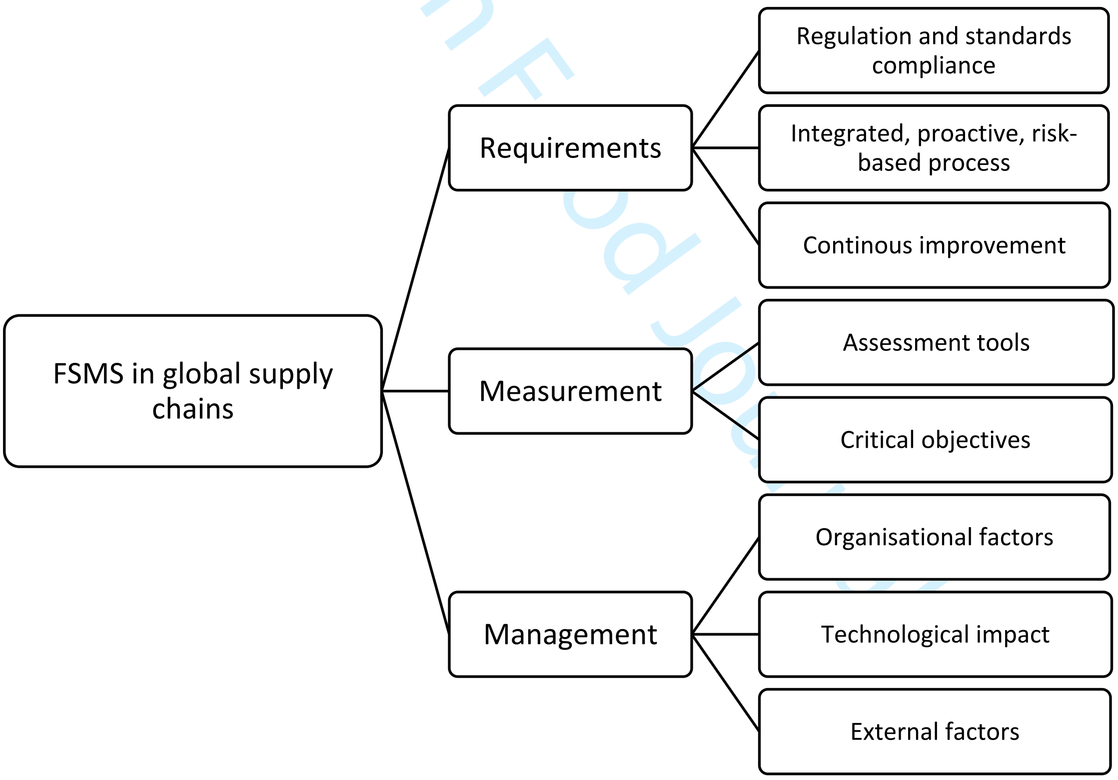

Figure 5. The classification framework

3 Research results

3.1 Requirements for FSMS in global supply chains

Given the vital role of FSMS in the food industry, the requirements for an FSMS are summarised to clarify what food firms should do to guarantee food safety. Regulations and standards compliance is the essential element of all FSMS. There is a significant evolution toward tougher requirements and more stringent food safety governance to assure food safety globally since the 1990s. For instance, there has been an increase in the number of standards that seek to enhance food safety including Hazard Analysis and Critical Control Point (HACCP), the British Retail Consortium's global food safety standard (BRC), the International Food Standard (IFS), the Safe Quality Food (SQF), and the ISO 22000:2005. The harmonious objective of these standards is to protect consumer health through an integrated process-based food safety management based on the basic minimum requirements acceptable for food safety, and third-party audits (Mensah and Julien, 2011). Previously, these standards were considered voluntary for food operators to apply and there is a stream in the literature discussing how these stringent standards impact food producers, especially SMEs and family businesses in developing countries (e.g. Henson and Reardon, 2005; Henson and Humphrey, 2010; Schuster and Maertens, 2013). Currently, the global recognition of these standards is performing the task of a framework for uniformity in requirements, mutual acceptance of audit procedures and audits, and reassurance in the capability and competence of suppliers. Some of them have become commonly mandatory in most countries such as the case of HACCP.

In addition, end-product testing is not an efficient approach to ensure food safety due to unable to determine safety risks before consumption and potentially devastating effects on human life. Food safety should be based on scientific evidence and assessment of the risk to the population, and this risk assessment should be quantitative where feasible (FAO/WHO, 1997). The risk-based preventive approach is implied in FSMS by specifying the necessary minimum requirements acceptable for food safety. Based on these requirements, food manufacturers proactively prevent food safety incidents from occurring in any food chain stages that can cause end-product to be unsafe, rather than just reacting to the incidents. Thus, there are different approaches to assess food safety risks such as the work of Gkogka *et al.*, (2013) shows two different risk assessment approaches to derive the potential appropriate level of protection (ALOP) for Salmonella in chicken meat in the Netherlands. One is a “top-down” approach, based on epidemiological data, and the second is a “bottom-up” approach, based on food supply chain data. Wang, Li and Shi (2012) and Chan and Wang (2013) also propose integrated risk assessment approaches to perform structured analysis of aggregative food safety risk in the food supply chain by using the concepts of fuzzy set theory and analytical hierarchy process. They provide structured risk assessment and establish aggregative food safety risk indicators as a practical tool that can be effectively employed in incorporating the safety objectives into operations planning. Furthermore, food safety assurance is based on the establishment of appropriate control measures and operational food safety management throughout the food supply chain, which form a comprehensive system fully explained or understood by understanding how each part or component interacts and influences other components (Yiannas, 2009).

It is proven that none of FSMS is perfect even it had been certificated, well-audited, and inspected. Cormier *et al.* (2007) argue that audits which include a visit to the facility and review of records can only confirm that the procedures and processes of the manufacturing system are being implemented as planned. Powell *et al.*, (2013) express some criticism on (third party) audits and inspections and claim that they are not enough to guarantee food safety since they reflect only a snapshot in time and cannot guarantee future implementation. They also give many foodborne illness outbreaks from commercial food operators that had high scores of audits or inspections. The existing research on FSMS suggests that fundamentally fulfilling the minimal requirements of regulation and standards are not sufficient (Kafetzopoulos *et al.*, 2013; Kok, 2009). It is essential to strengthening FSMS and ongoing compliance with regulations and standards by continuous improvement approach that enables companies to achieve and sustain operational and business objectives. FSMS is an integrated process management system including a variety of procedures based on Deming’s cycle from planning of the steps (Plan), implementation day-to-day operations (Do), verification (Check) of PRPs, control measures and system implementation, and improvement (Act) by reviewing the overall system implementation (ISO, 2005). Thus, FSMS is underpinned by the continual improvement that is an integrative management philosophy means “is a recurring activity to increase the ability to fulfil requirements” (ISO/FDIS 9000, 2000).

Specifically, this paradigm seeks continual improvement of machinery, materials, labour utilisation, product quality and safety, and production methods through the application of suggestions and ideas of team members.

3.2 Measurement of FSMS implementation

Certifying an FSMS is a must but it does not guarantee the optimum level of managing food safety hazards and consequently absolute food safety and the quality of the end products (Fotopoulos *et al.*, 2009; Kafetzopoulos *et al.*, 2013; Kok, 2009). In the past, many authors (Fotopoulos, Kafetzopoulos and Psomas, 2009; Luning *et al.*, 2008) indicated that the availability of a diagnostic instrument to assess the implementation of the FSMS was rather restricted. As a result, Luning *et al.*, (2008) and Jacxsens *et al.* (2010) were the first pioneers in building the implementation measurement system of FSMS based on the diagnostic instrument (FSMS-DI) and microbial assessment scheme (MAS) to assess a company's FSMS including control, preventative and core assurance activities as well as their contributions to the system outputs under the impact of the riskiness of contextual factors. The measurement gives insight into the level of implementation of the different FSMS activities, the actual microbial implementation, and the food safety output that can be used by food business operators in firms' internal auditing process and provides evidence about major factors affecting the status of FSMS. It is designed to identify the bottlenecks in the current practice and where improvements are necessary.

Within a decade, these approaches have been widely adopted by many researchers for various kinds of food supply chains, namely fresh produce (Kirezieva *et al.*, 2013; Luning *et al.*, 2008; Nanyunja *et al.*, 2015; Sawe *et al.*, 2014), animal-based processing (Jacxsens *et al.*, 2010; Luning *et al.*, 2015), meat and dairy (Jacxsens *et al.*, 2011; Njage *et al.*, 2018), lamb (Osés *et al.*, 2012), fish processing (Kusaga *et al.*, 2014), raspberries chain (Rajkovic *et al.*, 2017) to assess the status of FSMS based on measuring the system output and the insight a company has on its performance (e.g. results of external inspections or audits, results of sampling). However, most of them focus on those activities that specifically aim at controlling and assuring microbiological food safety, leaving chemical and physical hazards out of the scope (Jacxsens *et al.*, 2010; Luning *et al.*, 2011). Also, this diagnostic tool is not applied widely due to the requirement of experts' or researchers' participation in organising workshops to explain and train managers to fill out what level of all indicators and some parts of the assessments demand microbiological sampling (Kirezieva, Jacxsens, *et al.*, 2015). Therefore, food firm managers cannot use this tool daily to continuously assess and improve their current practices.

Using a different approach, Kafetzopoulos, Psomas and Kafetzopoulos (2013) develop an instrument for measuring FSMS by the effectiveness of the HACCP-based FSMS and its critical objectives including identification, assessment, and control of foodborne hazards. They affirm the effectiveness of FSMS in connection to which its prescribed safety targets are met and the validation of this instrument in the food manufacturing sector. The simple instrument of this study contributes to encourage, facilitate, and improve food companies' self-assessment process, guiding them in adopting the proper manufacturing practices concerning food safety. Though this study does not consider determinant factors that could influence FSMS implementation. A much more systematic approach would identify how FSMS interacts with other variables such as human resources, organisational attributes, and external factors that are believed to be linked to FSMS implementation as mentioned in the above section. To fill this gap, Kafetzopoulos and Gotzamani (2014) develop this approach to propose a model for measuring the effectiveness of quality (ISO 9001) and HACCP-based FSMS thanks to their stated objectives when these systems are jointly implemented in a food company. They also investigate the critical factors for effective implementation of the ISO 9001 and HACCP systems and examine the degree to which the combined application of ISO 9001 and HACCP influences the overall implementation of the certified firms.

3.3 Managing FSMS implementation in global food supply chains

Once an FSMS has been developed, its implementation could be influenced by many factors because of a large number of stakeholders with an enormous variety of structures, logistics, and chain participants changing rapidly and continuously. When analysing the management of FSMS, the role of the critical success factor (CSF) in enabling food businesses to focus on the most crucial factors that lead to the successful achievement of their desired food-safety goals has emerged, such as Fotopoulos, Kafetzopoulos, and Psomas (2009), van Asselt et al. (2010), and Kafetzopoulos and Gotzamani (2014). CSF theory was first introduced by John Rockart (Rockart, 1979) and later, the universal definition of CSFs was given by

Boynton and Zmud (1984). We also use the view of this theory to review and identify what we already know about FSMS management.

According to ISO 22000 (2005), to fulfil food safety objectives, “the organisation should provide adequate resources for the establishment, implementation, maintenance, and update FSMS”. These resources include human resources, infrastructure, and work environment. A great deal of previous research has focused on the impact of organisational factors on FSMS implementation. For example, human resource is considered as the topmost challenge in implementing FSMS, and it could attribute as determinant factors of quality and food safety effectiveness (Fotopoulos *et al.*, 2009; Kafetzopoulos and Gotzamani, 2014). The level of the FSMS implementation could be impacted by the degree of employee involvement (Fotopoulos *et al.*, 2011, 2009; Kafetzopoulos and Gotzamani, 2014; Kirezieva, Luning, *et al.*, 2015; Luning *et al.*, 2008), their efficient knowledge and skills to ensure food safety (Kafetzopoulos and Gotzamani, 2014), awareness of the relevance and importance of their activities in contributing to food safety (ISO, 2005), training programs for employees to improve the current level of the above requirements related to food safety. Sharman *et al.*, (2020) also suggest an increased focus is needed on culture, climate, and behaviour in food businesses by assessing different types of culture, climate, and employees, and conclude that different employee behaviours impact the culture and climate of an organisation. Together, these studies indicate that these critical factors from organisations highly interact with FSMS implementation and affect its success.

It is interesting to see how innovative and smart technologies impact FSMS through the high citation literature emphasising the role of blockchain, Internet of Things, artificial intelligence, machine learning, augmented reality (AR), visual reality (VR) and so on. These technologies can help food companies to achieve better transparency, traceability, and integrity to enhance food safety and consumer trust in global food supply chains (Aung and Chang, 2014; Feng Tian, 2017; Kamble *et al.*, 2020; Nguyen and Doan, 2019; Saberi *et al.*, 2019; Wang *et al.*, 2019). The collaboration between Walmart and IBM for pork in China and sliced mango imported to America from Latin America are mentioned as an innovative application in the food industry. Advanced technologies deeply change manufacturing and operating processes by establishing smart design architectures as well as enhance food safety mechanisms, provide quality assurances, and smooth supply chain disruptions from food wastage and spoilage (Kamath, 2018). The use of computer-aided design and manufacturing software, immersive and non-invasive hybrid prototyping technologies, and the ability to interact within the cyber-physical systems eliminate the need for post-process quality inspections and enables a self-optimization control system (Kamble *et al.*, 2020). The deployment of new technologies combined with data analytics and existing industry standards support the entire supply ecosystem to benefit from such a comprehensive data snapshot. However, there are several challenges accompanied with these technologies in terms of technological obstacles, interoperability, standardisation, lack of trust issues among stakeholders as well as legal and regulatory challenges (Chang *et al.*, 2020).

In addition, Kirezieva, Jacxsens, et al., (2015) confirm the structure of the market and supply chain, interactive relationship between organisations within the food chain that affect FSMS implementation. To support this, the study of Kirezieva, Luning, *et al.* (2015) confirm that collaborative/supportive supply chains contribute to more advanced FSMS and good system output as firms demonstrated advanced knowledge and expertise about safety and quality management. These factors are adopted as chain characteristics in the group of the context factors (product, production, organisational and chain characteristics) affecting the design and operation of FSMS activities from several studies (Luning and Marcelis, 2007, 2009; Luning et al., 2011; Kirezieva et al., 2013; Kirezieva, Luning, *et al.*, 2015; Lu *et al.*, 2020). They emphasise that the conditions and relationships with other organizations in the chains may have impacts on the status of FSMS. Also, many authors point out that implementing FSMS requires regulatory and market opportunities information, technical and financial support from these parties other parties such as non-profit organisations (NGOs), business associations, and financial institutes are significant on firm's FSMS implementation (Kirezieva, Luning, *et al.*, 2015; Qijun and Batt, 2016; Abebe *et al.*, 2020). Additionally, Qijun and Batt (2016), Chaoniruthisai *et al.*, (2018); Rincon-Ballesteros *et al.*, (2019) confirm that difficulty in obtaining external funds is perceived as a significant financial barrier to adopting a certificated FSMS.

4 Gaps and future research agenda

The study presents the systematic literature review derived from the urgent need for strengthening FSMS in global food supply chains produces an elaborate picture of the current knowledge showing how food operators measure and manage FSMS implementation. Using the method of systematic literature review, the paper has presented those mandatory and voluntary regulations and standards are the most critical part of international requirements to assure integrated, proactive, risk-based approaches as well as continuous improvement in FSMS in global food chains. To measure FSMS, it is interesting that previous researchers have successfully created and verified several assessment tools using different approaches, namely the diagnostic instrument, microbial assessment scheme, and achievement level of critical objectives of FSMS. Also, many studies provide evidence about several external and internal factors affecting the management of FSMS implementation including organisational resources, food safety culture, climate, and behaviour. Industry 4.0 technology adoption significantly impact the management of FSMS in global supply chains by smart design architectures to eliminate the need for quality inspections and to enable a self-optimization control system. In terms of external factors, the structure of the market and supply chain, interactive relationships between organisations within the food chain affect FSMS implementation. With the aim of guiding future research, some limitations/gaps which were observed during our content analysis are presented in this section, along with potential future research questions as seen in **Error! Reference source not found.**.

Concerning requirements for FSMS, the harmonious objective of regulations and standards compliance is a must to protect consumer health even though significant variations in food safety governance across countries and among value chains increase the burden of auditing costs and certifications on food manufacturers. It is required that food manufacturers proactively prevent food safety incidents from occurring in any food chain stages, rather than just reacting to the incidents. Given the importance of maintaining a robust FSMS and there is no such thing as a free safe lunch due to the increasing cost of FSMS development and implementation in the food industry (Macheka *et al.*, 2013; Qijun and Batt, 2016). Very little is currently known about how to form a uniformity in global recognition of regulations and standards to reduce food safety costs. Also, what factors motivate and encourage firms to create common requirements, mutual acceptance of audit procedures and audits, and reassurance in the capability and competence of suppliers.

The analysis of measurement produced some evidence of various tools for assessing FSMS implementation that has been adopted within food firms around the world (e.g. Luning *et al.*, 2008; Kirezieva *et al.*, 2013; Kafetzopoulos and Gotzamani, 2014; Kirezieva, Luning, *et al.*, 2015; Nanyunja *et al.*, 2015; Njage *et al.*, 2018). Although HACCP-based assessment emphasises that hazard analysis is the key to an effective FSMS (ISO 22000, 2005), its major drawback is that does not give sufficient consideration to other vital elements such as prerequisite programmes, communication and system management as requirements of many standards and regulations (i.e. ISO 22000, BRC, SFQ, IFS). As Mortimore and Wallace (2013) affirm, HACCP by itself cannot control food safety because a risk-based program requires hazard analysis and risk evaluation skills along with many prerequisites and other management support activities. These instruments are required not only to be easy-to-use for managers and food safety teams as daily basis tools but also included the objective of hazard analysis along with manufacturing optimisation.

Additionally, little is known about how the complexity of manufacturing behaviours and optimisation influence FSMS. For example, current expositions have not considered the key dimensions of manufacturing optimisation consisting of time and flexibility besides safety and cost. This limitation leads to the question that what are possible trade-offs between these key dimensions concerning cost, time, and flexibility when food firms decide to improve their FSMS practices. There would be many fruitful areas for further work on how to build measurement metrics that must be highly customised based on the unique characteristics of each company's production, and surrounding market under compliance with regulation and standards. Moreover, the outcomes of these measurements should lead to clear improvement opportunities for the current practices. Research to date has not yet determined mechanisms on how to encourage firms to seek continual improvement in FSMS. Assessing the degree to which the implementation of FSMS impacts business performance through available data at their firms such as financial performance, operational performance and food safety output would be more practical to motivate firms to review and update their systems continuously. The research question is what the relationship between FSMS and business performance is.

Critical factors play vital roles in managing FSMS implementation. There are highly interactions between organisational factors and FSMS implementation consisting of sufficient resources in each firm including human resources, infrastructure, and work environment (Kafetzopoulos and Gotzamani, 2014; Nyarugwe *et al.*, 2018; Sharman *et al.*, 2020). However, each firm is unique in production, organisation, and the context in which it is operating. The previous studies have not dealt with these dynamics and differences of each enterprise such as firm size, culture, ownership structure. Hence, what is the impact of organizational factors on the management of FSMS implementation contingent on the firm's characteristics? Moreover, although smart technologies contribute to strengthening FSMS implementation, large companies successfully apply new technologies while small and medium enterprises (SMEs) still deal with a lot of difficulties (Kamble *et al.*, 2020). So how firms overcome the challenges associated with new technologies, especially in the case of SMEs, remains unknown.

Concerning external factors, previous studies confirm that collaborative and supportive supply chains contribute to more advanced FSMS, and chain characteristics affect the design and operation of FSMS. However, researchers have not treated the definition of a collaborative/supportive supply chain in much detail as they cannot reflect what kind of relationships in the chains as well as how organisations collaborate with others. Much uncertainty still exists about the relationship and collaboration in the value chains to create higher impacts on FSMS implementation. Additionally, there are many pieces of research concerning the abilities of a firm to obtain supports for information, finance, technology and knowledge to improve FSMS (Abebe *et al.*, 2020; Chaoniruthisai *et al.*, 2018; Qijun and Batt, 2016; Rincon-Ballesteros *et al.*, 2020). From these studies, what is not yet clear is the impacts of the organisations such as non-profit organisations (NGOs), business associations, and financial institutes on FSMS implementation of the firm.

Table II. Summary of gaps and research questions

Theme	**Gaps**	**Future research questions (RQ)**
Requirements for FSMS in global supply chains	• Mechanism to uniform regulations and standards • Lack of common requirements, mutual acceptance of audit procedures and audits, and reassurance in the capability and competence of suppliers among firms in global supply chains.	**RQ1:** How to form a uniformity in global recognition of regulations and standards to reduce costs in fulfilling FSMS requirements? **RQ2:** What and how to motivate firms to establish common requirements, mutual acceptance of audit procedures and audits, and reassurance in the capability and competence of suppliers across firms in global supply chains?

Measurement of FSMS implementation	• The complexity of manufacturing behaviours influenced FSMS remains unknown. • Possible trade-offs between key dimensions of manufacture optimisation concerning cost, time, and flexibility when food firms decide to improve their FSMS practices. • The relationship between FSMS and business performance.	**RQ3:** How to build measurement metrics that must be highly customised based on the unique characteristics of each company's production, and surrounding market under compliance with regulation and standards? **RQ4:** How to encourage firms to seek continual improvement in FSMS? **RQ5:** What is the relationship between FSMS and business performance?
Managing FSMS implementation in global food supply chains	• Impact of organisational factors regarding the dynamics and differences of each enterprise. • SMEs cannot apply smart technologies to strengthen FSMS implementation due to many challenges. • Lack of information about collaborative/supportive supply chains which impact FSMS. • The impact of external parties such as non-profit organisations (NGOs), business associations, and financial institutes on FSMS implementation of the firm.	**RQ6:** What is the impact of organizational factors on the management of FSMS implementation contingent on the firm's characteristics? **RQ7:** How do firms overcome the challenges associated with new technologies applying for FSMS? **RQ8:** In the case of SMEs, whether there are more obstacles in dealing with challenges associated with new technologies for FSMS? **RQ9:** The degree to which the organisations collaborate, and support others could create higher impacts on FSMS implementation? **RQ10:** Whether the impact of other parties such as non-profit organisations (NGOs), business associations, and financial institutes are significant on FSMS implementation?

5 Concluding remarks

5.1 Theoretical and managerial implications

The current study contributes several key implications for researchers in this field. First, it is the first to our knowledge to examine measurement and management of FSMS in the context of global supply chains applying systematic literature review combined with biological mapping analysis on 81 peer-reviewed papers published from 2005 to 2020. We thus encourage future studies to discuss several uncovered gaps emerging from this study which is summarised in **Error! Reference source not found.**. This study also makes ten unique research questions concerning further theoretical developments and managerial implementations to strengthen FSMS in global food trading. Second, our systematic analysis shows that only a limited number of measurement tools for FSMS have been identified. There are many dimensions related to manufacturing behaviours and tradeoffs remaining unclear. This would be a fruitful area for further work. Finally, the research analysis underpinned by CSF theory reviewing both internal and external factors for managing FSMS can also be used for future research to strengthen the effectiveness of FSMS. These CSFs are from organisational resources, the relationship and collaboration within food supply chains as well as from the support of external parties.

Besides the theoretical implications for researchers, several managerial implications are recommended for food businesses. There is a systematised list of published practices that have been studied and reported in this research. Food firms that are seeking improvement opportunities for FSMS would be served well by this review. In particular, international requirements on FSMS are provided and summarised for food businesses. Regarding measurement, practitioners should pay more attention to the current measurement tools, especially in balancing manufacturing dimensions, namely food safety, cost, time, and flexibility. This work has been one of the first attempts to thoroughly examine critical factors of FSMS implementation from the organisation and the supply chains. An implication of this is that these practices could be considered as a useful reference point for practitioners.

5.2 Limitations

The purpose of the current review was to analyze and synthesize the extant literature on FSMS in global supply chains. The study is guided by the main research question using CIMO logic during this process. Mandatory and voluntary regulations and standards are the most critical part of international requirements to assure integrated, proactive, risk-based approaches as well as continuous improvement in FSMS in global food chains. To measure FSMS, several assessment tools using different approaches have been successfully created and verified, namely the diagnostic instrument, microbial assessment scheme, and achievement level of critical objectives. Also, several external, internal factors, Industry 4.0 technology adoption that significantly impact the management of FSMS implementation are presented in the paper.

However, the study has two limitations. First, the reader should bear in mind that the study is based on a strict review protocol which might not include relevant literature and non-English articles in other sources of the field. Second, despite the rigour of the protocol combined with biological mapping analysis software, some inadvertent errors may still have crept into our analysis. Notwithstanding these limitations, the study suggests that several interesting avenues for future research. First, among three identified themes related to FSMS, the first one seems to be well developed while the other two need more future works. We hope this study will stimulate future research aimed at developing more measurement tools and identifying the impacts of critical factors on FSMS since food safety cannot be compromised at any stage of supply chains. Second, the identified research questions are offered for researchers and food manufacturers potential opportunities to further investigate two aspects of FSMS, including measurement and management.

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