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Original article

Food safety culture and climate prevailing in micro and small food manufacturing enterprises in Mauritius and Rodrigues

Aishah B. Z. Joomun,¹ Carol A. Wallace,^{2*}  Badroonesha Aumjaud^{1†} & Deena Ramful-Baboolall¹ 

¹ Department of Agricultural and Food Science, Faculty of Agriculture, University of Mauritius, Réduit, Mauritius

² Centre for Global Development, School of Health, Social Work and Sport, University of Central Lancashire, Lancashire, UK

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Summary Food safety culture and climate are strong elements of food safety performance. This study describes a mixed-methods approach to assess prevailing food safety knowledge, attitudes, practices, culture and climate in micro and small food manufacturing businesses in Mauritius. The approach included participant observation, questionnaire-based surveys and checklists, and was adopted to collect data from six managers/owners and thirty-six employees in six businesses. Results showed that food handlers had satisfactory knowledge in some aspects of food hygiene and safety. Mean scores of specific food safety climate indicators for employees diverged from the corresponding values for managers. Inconsistencies were observed in food safety culture maturity scores computed from survey data (quantitative), which were higher than related scores obtained from participatory observation (qualitative). This discrepancy underlines the importance of triangulation methods and the necessity to establish appropriate weightings for data obtained from different methods to gain an overall assessment of food safety culture. The results provide concrete input to develop tailor-made interventions to improve knowledge, attitudes and practices of employees and managers, and promote positive food safety cultures. Further research is needed to design theory-based interventions to improve food safety culture and interpretation grids to analyse and triangulate prevailing food safety culture data.

Keywords food handler knowledge, food manufacturing, food safety behaviour, food safety culture and climate, Mauritius, micro and small enterprises, mixed-methods approach, Rodrigues.

Introduction

Background

Food safety is a global challenge and of great concern to food businesses. According to the World Health Organisation (WHO), contaminated food is still causing foodborne diseases affecting consumers' health (WHO, 2022, 2023b). Food poisoning cases showed an overall increase in Mauritius and Rodrigues during the last decade (Ministry of Health and Wellness, 2022). According to press and scientific reports, food poisoning outbreaks have been mainly associated with small food businesses including street food vendors and school canteens (Yashvin, 2011a, 2011b; Business-Mega, 2013; Gaungoo & Ajlouni, 2018; Inside News, 2021). Globally, small food businesses contribute significantly to food security, economic growth and social development, including employment (Herbel

et al., 2013), and are linked to countries' export potential (Arshad *et al.*, 2023). In Mauritius, Micro, Small and Medium Enterprises (MSMEs), including food enterprises, are eyed as the engine of socio-economic growth since they contribute to a Gross Domestic Product of about 40% and represent about 55% of the total number of employed people (Ministry of Business, Enterprise and Cooperatives, 2017). The importance of support for Small and Medium Enterprises (SMEs) to strengthen food safety in Low- and Middle-income Countries (LMICs) has been highlighted. Spiess *et al.* (2013) describe the importance of aspects such as hygiene and food safety when training (women) entrepreneurs in Tanzania while government intervention regarding sponsored training, publicity and food safety awareness creation for SME and food handlers was recommended to ensure supply chain food safety in Ghana (Ababio and Lovatt, 2015). Indeed, pathogen contamination risks, particularly *Listeria monocytogenes* risks, due to increasing complexity and length of African food supply chains whilst remaining relatively informal, have recently been highlighted (Sibanda

*Correspondent: E-mail: cawallace@uclan.ac.uk

†Retired.

et al., 2023) and this has relevance to SME food businesses in Mauritius.

Food contamination can occur if unhygienic conditions are favoured, (WHO, 2023a). Food safety standards, such as good hygienic practices and food safety management systems (FSMS), are applied in the global food supply chain, but the continued occurrence of food poisoning cases together with inconsistencies in food safety system application show weaknesses in the fulfilment of current food safety standards (FAO, 2008, 2015, 2023; WHO, 2015, 2022; Food Standards Agency, 2023). This raises questions on whether the application of systems is sufficient to guarantee food safety, and whether small businesses have the capacity and capability to apply standards (Yapp and Fairman, 2006). These shortcomings could be overcome by developing and using practical and simplified food safety tools and approaches which are more adapted to the context of MSMEs (FAO, 2008, 2023; Nyarugwe *et al.*, 2016; Gilmour & Traka, 2022). One example is Safer Food Better Business (SFBB), which is a simplified food safety management system for small catering and retail businesses in the UK (FSA, 2020).

Effective implementation of FSMS helps organisations to identify and control food safety hazards through application of hazard analysis and critical control point (HACCP) principles and foundational good hygienic practices. In Mauritius, there are provisions regarding food hygiene and safety in the Mauritius Food Act (2022) and Mauritius Food Regulations (1999). No general provisions have been made for HACCP in the Mauritius Food Regulations (1999); however, the Fisheries and Marine Resources (Export of Fish and Fish Products) (Amendment) Regulations (2012), requires the implementation of HACCP by exporting fish business operators and this is expected to be extended to other selected food processing categories, such as milk processing, meat processing, fish processing and water bottling (Budget speech, 2022/23). Previous studies report that proper food safety practices and prerequisite programmes for HACCP are not followed in many food businesses, in Türkiye (Bas *et al.*, 2006), in Mauritius (Ramnauth *et al.*, 2008) and in Poland (Dzwolak, 2014, 2019). Increasing food safety knowledge in food businesses is an important step towards changing prevailing attitude and behaviour in order to strengthen food safety management and promote adoption of HACCP (Eves & Dervisi, 2005; Bas *et al.*, 2006; Ramnauth *et al.*, 2008; Dzwolak, 2019). Human behaviour, which is heavily influenced by culture, is strongly related to how rules are put into practice. Therefore, it is crucial to comprehend the human aspects of food safety by looking into the company's overall culture and more particularly its food safety culture (GFSI, 2018; Zanin, Luning, Stedefeldt 2021).

Food safety culture and climate

Food safety culture and climate have been recognised as major factors in ensuring food safety and represent strong elements of the food safety performance of an enterprise (Yiannas, 2009). A first classification of food safety culture was given by Griffith *et al.* (2010b) who classified food safety culture as being positive/negative and strong/weak for six culture elements: communication, commitment, risk perception, environment, styles and process, and leadership and management systems. Since Griffith's first publication (2010), with the increase in knowledge, literature and expertise in the field of food safety culture, several food safety culture and climate definitions have been put forward (Yiannas, 2009; Griffith *et al.*, 2010a; Powell *et al.*, 2011; De Boeck *et al.*, 2015; De Boeck, 2018; GFSI, 2018; Sharman *et al.*, 2020; Zanin, Luning, Thimoteo da Cunha *et al.*, 2021). The food safety culture definition published by the GFSI (2018) and the food safety climate definition given by De Boeck *et al.* (2015) were used in this study. The GFSI defines food safety culture as shared values, beliefs and norms that affect mindset and behaviour towards food safety throughout an organisation (GFSI, 2018). Five dimensions (values and mission, people system, adaptability, consistency, and risk awareness) were extracted from a review of culture measurement approaches (Jespersen, Griffiths, Wallace, 2017), and further developed by GFSI (2018) to provide critical components for each dimension as well as a food safety culture guidance for stakeholders (GFSI, 2018). De Boeck *et al.* (2015) interpreted food safety climate as individual/shared perceptions of leadership, communication, commitment, resources and risk awareness concerning food safety and hygiene in the workplace. Thus, culture exists at a deeper level and is more difficult to change than climate but can evolve with time and situation.

Culture is a complex phenomenon (Schein, 2004); and food handlers' attitudes, behaviours, values and beliefs impact the enterprises' prevailing culture, making food safety culture and climate assessment more challenging. Nevertheless, the human dimension *via* the workforce is not only the source of current culture understanding but can also provide innovative ideas for development in food systems (Martindale *et al.*, 2023); therefore, it is crucial to involve the workforce in both measuring and efforts to improve food safety culture. Several determinants have been proposed to assess food safety culture from multiple perspectives while applying method triangulation (Nyarugwe *et al.*, 2016; Jespersen & Wallace, 2017; Zanin, Luning, Thimoteo da Cunha *et al.*, 2021). Researchers have recommended the use of a combination of methods (interviews, observations, focus group, document review, survey questionnaires) for data collection and method triangulation to analyse

data so as to obtain a true and holistic picture of the food safety management, culture and climate of an organisation (Abidin, 2013; Jespersen & Wallace, 2017; Nyarugwe *et al.*, 2018; De Boeck *et al.*, 2019; Zanin, Luning, Thimoteo da Cunha *et al.*, 2021; Zanin, Luning, Stedefeldt, 2021; Alrobaish *et al.*, 2022). Several tools have also been developed to assess food safety culture in an organisational context (Ungku Fatimah *et al.*, 2014; De Boeck *et al.*, 2015; Jespersen *et al.*, 2016, 2019; Jespersen & Wallace, 2017; Nyarugwe *et al.*, 2018; Zanin, Luning, Thimoteo da Cunha *et al.*, 2021). Classification levels of safety and food safety culture have been proposed ranging from simple (good/bad, negative/positive) to a five-stage classification (Jespersen *et al.*, 2016; Nyarugwe *et al.*, 2016) to evaluate prevailing culture of an organisation. Nyarugwe *et al.* (2018) and Zanin *et al.* (2022) classified food safety culture as reactive, active and proactive taking into consideration the importance of food safety and safe hygienic practices (Nyarugwe *et al.*, 2018, 2020; Zanin, Luning, Thimoteo da Cunha *et al.*, 2021, 2022). It is important to include an appropriate classification method based on the measurement approaches being used (*e.g.*, survey interview, observation, *etc.*) to enable evaluation of the organisation's overall food safety culture in order to implement specific interventions aiming to mature the culture.

Food safety culture and climate evaluation can also be influenced by employees (human factors) who have a tendency to respond in a socially desirable manner by either over-reporting good behaviour or under-reporting undesirable behaviour. Social desirability responding can be assessed by using a valid scale so that its impact on the food safety culture maturity starting point can be taken into account in the design of improvement strategies (Jespersen, Maclaurin, Vlerick, *et al.*, 2017). Studies also revealed strategies which can be implemented to strengthen food safety culture to promote a proactive food safety culture (Da Cunha, 2021; Zanin, Stedefeldt, Maria da Silva *et al.*, 2021, 2022).

Concepts and theories

Different behavioural theories have been used in trying to increase food hygiene and safety knowledge and practices. These include Health Belief Model, the knowledge, attitudes, and practice (KAP) model, and the theory of planned behaviour (TPB) (Insfran-Rivarola *et al.*, 2020). The KAP model is a health behaviour change theory which was used as the theoretical basis behind the development of hypothesised relationships. The theory presents the knowledge, attitudes and behaviour's progressive relationship as follows: knowledge is the foundation of behaviour change, and belief and attitudes are the driving force of behaviour change; the model is supported by the idea that knowledge can be translated into attitudes and practices. However,

literature has concluded that knowledge is not always translated into practice (Zanin *et al.*, 2017). As behaviour is influenced by several factors, including training strategy, business structure and organisational culture aspects such as leadership, communication, commitment and risk perception, the actual relationships between knowledge, attitudes and practices are more complex than a linear application of the KAP model (Griffith *et al.*, 2010b; Zanin *et al.*, 2017). Nevertheless, food safety knowledge of food handlers plays a significant role in determining their attitudes and eventually their practices of personal and kitchen hygiene as well as disease control measures (Bas *et al.*, 2006; Al-Shabib *et al.*, 2015; Hinsz and Nickell, 2015; Stedefeldt *et al.*, 2015; Zanin *et al.*, 2017; Young *et al.*, 2019; Insfran-Rivarola *et al.*, 2020; Kwol *et al.*, 2020; Da Cunha, 2021).

Research problem and significance

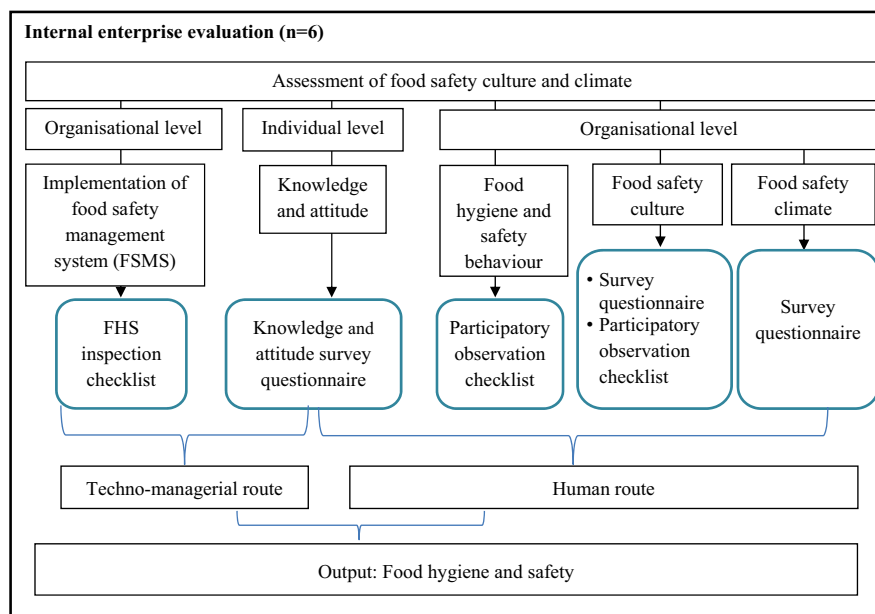
Much food safety culture research has focussed on theory development and assessment approaches and there are few empirical studies investigating culture in MSMEs world-wide. In Mauritius, there is a lack of information relative to food hygiene and safety, food safety culture and climate in MSMEs, which represents a research gap that this study aims to address. An understanding of the barriers to an effective implementation of basic food hygiene and safety principles and the prevailing food safety culture and climate of the enterprises can assist the development of intervention strategies to overcome these problems. This is the first empirical study in this context and aims to provide an insight into current food safety knowledge, attitudes and practices, culture and climate in food enterprises in Mauritius and Rodrigues to enable development of tailor-made interventions to improve the food safety behaviour, culture and climate as well as business food safety performance.

Objectives and scope

The objective of this study is to establish the baseline knowledge, attitudes, practices, culture and climate within food MSMEs in Mauritius and Rodrigues as a basis for food safety culture improvement. Research questions included how a mixed methods research design involving established and developed methods could be applied in the MSME context. The study was performed in six MSMEs to obtain quantitative and qualitative assessment of food safety culture components.

Outline of the paper

The introduction reviews the background literature related to the topic being investigated as well as providing a framework for establishing the importance of the



(FSMS: Food Safety Management System; FHS: Food Hygiene and Safety)

Figure 1 Research framework for measurement of food safety culture and climate in MSMEs in Mauritius and Rodrigues. FHS, food hygiene and safety; FSMS, Food Safety Management System.

research. The methodology describes the mixed method approach developed and/or adopted to assess prevailing food safety culture and climate at different MSMEs in Mauritius and Rodrigues, the scoring system, and approach to interpreting the data to assess the food safety culture. The results and discussion present the findings obtained and statistical analysis performed using the different instruments developed and/or adopted, and discuss the main research findings.

Methodology

Study design

This research was part of a larger longitudinal study of food safety behaviour (knowledge, attitudes and practices), culture and climate in MSMEs in Mauritius and Rodrigues. The research followed a mixed-method design (Fig. 1) to assess the prevailing food safety culture and climate in selected MSMEs. The research methodology involved the use of different methods to enhance the research validity (Hussein, 2009; Nyarugwe *et al.*, 2016; Jespersen & Wallace, 2017). The research framework builds on the food safety culture conceptual model of De Boeck *et al.* (2019), which is made up at the organisational level of the techno-managerial (food hygiene and safety system and practices) and the human route (food safety culture and climate) and includes the

mediating effect of individual knowledge and attitude in motivating food safety behaviour. As in Fig. 1, the knowledge overlaps with both techno-managerial and human route: organisational level knowledge about the business and food safety systems and individual knowledge about food safety, which links with the human route. Food handlers' attitude is also human route.

Selection of enterprises

Market surveys were performed to identify operating local businesses. The businesses were contacted to discuss the research and all enterprises who agreed to be part of the research were chosen for initial evaluation. Due to the wide range of research activities (Fig. 1) and associated time commitment, purposive convenience sampling was then used to identify a manageable group of manufacturing MSMEs who were willing to participate in all activities and six food manufacturing enterprises were recruited yielding a total of forty-two participants. The range of food products included: dried cassava soups and cereal mixes; dumplings; frozen snacks; dried and ground spices; production and processing of dried and ground turmeric; retorted (ready-to-eat) octopus products.

Design of empirical study and trustworthiness

The empirical study design consisted of assessing food safety management systems, knowledge, attitude,

practices, culture and climate elements using the mixed method approach outlined in Fig. 1. All participants gave informed consent and the data were collected during 1 week research placement in each enterprise during October to December 2019.

(Jespersen, Maclaurin, Vlerick, *et al.*, 2017) reported that research behind a culture evaluation system should optimise quality, trustworthiness, and cover the broadest possible content to inform the food enterprise correctly. In this research, trustworthiness was achieved through several approaches. Methods included previously validated approaches, including the De Boeck *et al.* (2015) food safety climate scale, the maturity model of Jespersen *et al.* (2016, 2019) and the social desirability measurement statements of (Jespersen, Maclaurin, Vlerick, *et al.*, 2017). With respect to the developed methods (questionnaire assessing knowledge, attitudes and practices, food safety inspection checklist, and food safety participatory observation checklist) validity was ensured through literature review, expert consultation and pilot testing.

Quantitative data collection

Assessment of enterprise's work environment

A food hygiene and safety inspection checklist (FHS) was developed based on the Mauritius Food Regulations, 1999. It covered the features relating to premises, equipment, facilities, personnel, visitors, training, production and monitoring. A score of one was given when an element was present and zero if the element was absent. If an element from the checklist was not applicable for one enterprise, the requirement was not taken into consideration when calculating the overall score. The mean percentage scores of all sections were calculated to find the extent of compliance with elements in the checklist. Classification of compliance level was adapted from Monney *et al.*, 2014 and Auad *et al.*, 2018 (Table 1).

Assessment of knowledge and attitude

A nominal-polytomous survey questionnaire was designed based on the literature to measure knowledge and attitude on specific food hygiene and safety issues. Thirty-three multiple-choice questions, assessing

knowledge, were formulated which consisted of four response options, with one correct answer, two incorrect answers and one 'I don't know' option. Twenty-five attitude statements were developed and provided for a 3-point Likert scale. The questionnaire was translated into the local language and administered through face-to-face interview.

Quantitative assessment of food safety culture and climate

A survey questionnaire was designed consisting of two sections, namely background demographic information on participants and food safety culture and climate statements. The validated food safety climate statements of De Boeck *et al.* (2016) were included. This consisted of twenty-eight indicators from the following five dimensions: leadership, communication, commitment, resources and risk awareness. The statements were reworded to adapt to the Mauritian context whilst retaining their original intended meaning. Fifty-eight positive and negative food safety culture statements were developed based on the position paper from the GFSI (2018) using the five dimensions: Vision and mission, People, Consistency, Adaptability, and Hazard and Risk awareness; and the critical components in each dimension. The questionnaire also contained eleven statements from the validated food safety desirability response scale (FSDRS) of Jespersen, Maclaurin, Vlerick, *et al.* (2017) to explore potential social desirability bias among food handlers through three subscales: "Self-deception – Assertion of positives (SD1)" (six statements), "Image management (IM)" (two statements) and "Self-deception – Denial of negatives (SD2)" (three statements). The statements pertaining to food safety culture and food safety climate were randomly organised in the questionnaire to further avoid biased socially desirable responses.

A 5-point smiley Likert response scale was used (1: Strongly disagree; 2: Disagree; 3: Neither agree nor disagree; 4: Agree; 5: Strongly agree) to measure opinions of employees on each statement. The smiley was added to the scale design to help the participants understand the Likert responses as local researchers felt that participants might have difficulty discriminating between the levels of a 5-point scale. The use of smileys in Likert scales has been reported as being useful to help with understanding the scales (Toepoel *et al.*, 2019; Watson *et al.*, 2022).

Translation of survey questionnaire

The statements were translated into the local language (Kreol Morisien) to facilitate administering the questionnaire to all employees. All the translated statements were validated by two experienced Mauritian food safety academics to eliminate any discrepancies in the translation process while ensuring cultural equivalence. Translation and cultural adaptation of questionnaires

Table 1 Classification of level of compliance to work environment hygiene and safety

Range of mean % compliance score	Level of compliance
0–20	Very poor
21–40	Poor
41–60	Fair
61–80	Good
81–100	Very good

bring about valuable input (Zidan *et al.*, 2016) and was necessary in this research to ensure effective communication, promote better participation and accuracy of the data.

Data analysis. Data were analysed using the statistical software: SPSS version 20.0 and Microsoft Office Excel. One-way ANOVA at 5% level was done to find any significant differences between mean percentage correct answers of the six enterprises to the knowledge questions. The mean food safety culture score was calculated to indicate the overall maturity of each enterprise and its corresponding maturity level for each dimension. The enterprises were then located on the food safety maturity model of Jespersen *et al.* (2019); www.cultivatefoodsafety.com/our-models. Social desirability data were analysed qualitatively for managers and employees. Higher scores indicated higher social desirability responding and closer to zero indicated that answers are independent of others' views of them. The distribution of responses of managers and employees were tabulated for each response scale. The mean food safety climate scores were calculated for the different enterprises, managers and employees. Web diagrams with mean responses of managers and employees for the different indicators of the food safety climate tool were also made. Kruskal–Wallis test was done to find if there were any significant differences ($P < 0.05$) within the mean food safety climate scores of the different enterprises.

Qualitative assessment of food safety culture and climate

Participatory observation was used to have a broader understanding of food safety culture maturity (Jespersen & Wallace, 2017; Nyarugwe *et al.*, 2018; Zanin, Luning, Thimoteo da Cunha *et al.*, 2021). A checklist was developed and used as a guide to observe food handler's daily activities in their working environment. It consisted of three sections: (i) Company details; (ii) Observation checklist (people behavioural items) to verify behaviour in practice; and (iii) Food Safety Culture and Climate checklist, which used the food safety culture and climate statements from the survey questionnaire aiming to verify the results people gave during the survey. The researcher immersed naturally into the enterprise setting to mitigate the Hawthorne effect, which could influence behaviour and practices of employees (Oswald *et al.*, 2014). This included carrying out the same tasks as the employees, adhering to the starting/finish/break time, and having break and lunchtime with the employees. While ensuring interpersonal relationships/trust with the employees to elicit natural behaviours of employees, the actual employees' behaviour during the working hours, was observed and the number of times an event occurred was

recorded using tally mark(s). The frequency of complying/non-complying food hygiene practices within a specific time frame was noted for each enterprise. With this framework (Fig. 1), behaviour is the totality of human activity in the working environment, while practices are repetitions of routines and/or activities of each individual. The observed food safety culture findings collected were recorded, that is comments were written for each enterprise under the five dimensions (GFSL, 2018) and their expected cultural content and were analysed qualitatively. The corresponding maturity stages and interpretation of the food safety culture data were carried out by identifying the level based on best fit of the observed situation to the statements at the five levels of the food safety maturity model of Jespersen *et al.* (2019) (www.cultivatefoodsafety.com/our-models).

Ethical approval

The University of Mauritius Research Ethics Committee approved the study (Project Code: UoM-REC/2021/P28). All participants agreed to participate and signed an informed consent.

Results and discussion

Level of food hygiene in enterprises

Enterprises E1, E4, E5 and E6 achieved a 'fair' level of food hygiene compliance compared to E2 and E3 which were rated as "good" (Table 2). The common non-compliances in E2, E3 and E4 related to one-way flow of process operations to reduce cross-contamination; in E1 and E4, the preparation area was not separated from storage areas of either raw materials or finished products; in some enterprises, the working surfaces were not cleaned and disinfected before and after use and were not in good conditions. In all enterprises, there was a separate storage system for potable and non-potable water, and toilet

Table 2 Level of food hygiene compliance in food manufacturing enterprises

Enterprises	Mean % food hygiene compliance score	Level of food hygiene compliance
E1	49.14	Fair
E2	63.56	Good
E3	67.50	Good
E4	48.56	Fair
E5	49.36	Fair
E6	55.86	Fair

0%–20%: Very poor; 21%–40%: Poor; 41%–60%: Fair; 61%–80%: Good; 81%–100%: Very good.

facilities were not in direct contact with the preparation area. Utensils and equipment used were cleaned but not disinfected before and after use in any enterprises. Some food handlers in E1 used uncleaned utensils and equipment. These observed conditions are likely to increase risk of hazards and cross-contamination. Contamination and cross-contamination reduction are crucial along a food chain as they are key factors in preventing foodborne diseases as a simple act of using uncleaned or inappropriate equipment can lead to cross-contamination (Rammutla, 2016) and inappropriate practices can result in foodborne outbreaks (Taylor *et al.*, 2015; Taha *et al.*, 2021). One way to control the spread of food safety hazards is to ensure good hygienic practices as well as implementation of appropriate design and facilities principles, including linear flow of process operations (Codex, 2020). Cleaning and disinfection, if effective, through good housekeeping, control the risk of hazards (microorganism, allergens and foreign materials) and food product contamination with the food premises, while maintaining a safe working environment for the food handlers (Holah, 2014). Construction and design of the food premises and equipment, maintaining hygienic conditions, improving cleanliness and pest control are important factors in eliminating potential hazards as well as risks (Sprenger, 2017; Baş *et al.*, 2007). In a study by Baş *et al.* (2007), it was found that the Turkish enterprises faced difficulties in implementing food safety management systems due to inadequate physical conditions of the premises and equipment.

Food handlers' food hygiene and safety knowledge

As shown in Table 3, 61.9% of the respondents were female food handlers, 28.6% were more than 51 years old and 35.7% had between 1 and 5 years of working experience in a food manufacturing enterprise. The majority (64.3%) of food handlers surveyed stated that they had been trained in food hygiene and safety, mainly by the Ministry of Health and Wellness for the award of the food handler's certificate. Sociodemographic parameters, such as educational level attained and prior training in food safety can also influence food safety knowledge. A study in Turkey showed that the total food safety knowledge score was higher in trained food handlers of food businesses (45.8 + 17.6) than in untrained ones (40.8 + 14.3) ($P < 0.05$) (Bas *et al.*, 2006). It is logical that no prior food hygiene training could influence food safety knowledge levels: in the present study 37.5% of the respondents reported that they had no prior food hygiene and safety training. Effective training and refresher training can improve the employee's knowledge on food safety, increase their positive attitudes towards food safety and influence

Table 3 Demographic profile of the food handlers surveyed in the six enterprises

Respondents ($n = 42$)	Male	38.1%
	Female	61.9%
Age group (years)	15–20	11.9%
	21–25	16.7%
	26–30	16.7%
	31–35	11.9%
	36–40	4.8%
	41–50	9.5%
	>51	28.5%
Level of education	Certificate of Primary Education	19.0%
	Secondary School Form IV or less	38.1%
	Secondary School Certificate	28.6%
Working experience	Tertiary	14.3%
	<1 year	28.6%
	1–5 years	35.7%
	5–10 years	16.7%
Prior food hygiene training	>10 years	19.0%
	Yes	64.3%
	No	35.7%

their food safety behaviours (Cohen *et al.*, 2001; Adesokan *et al.*, 2015; Dora-Liyana *et al.*, 2018).

Regarding individual participants knowledge, all the respondents answered correctly the question relating to the importance of using hand sanitisers at work (Table 4). It is important to know that handwashing using sanitisers being one of the best techniques to remove pathogens present on food handlers' hands, preventing the multiplication and transmission of pathogens from hand to hand or from hand to the food, preventing the individual from getting sick and reducing the risk of diseases due to cross contamination of microbiological food safety hazards *via* human hands (CDC, 2015). More than 80% of respondents gave correct answers to questions addressing issues such as definition of food safety, FSMS and expiry date, how to prevent hair from contaminating food, type of professional clothing worn in the kitchen and its importance, storage conditions of cooked food, importance of stock rotation and regular removal of waste from the work station. However, a very low percentage of correct answers were noted for the question on the best option for hand drying. Sixty-nine percent of respondents did not know which microorganisms are often present on a food handler's hands indicating their poor knowledge about microbes.

Moreover, only 45%, 61% and 26% respondents were able to correctly identify three examples of physical, chemical and microbiological food safety hazards respectively. A lack of knowledge of microbiological food safety hazards was also observed in a study conducted among food handlers from Owerri Metropolis of Imo State Nigeria (Onyeaka *et al.*, 2021). Literature

Table 4 Percentage food handlers according to responses to knowledge questions

Knowledge questions	CA % Food handlers	IA	DK
A. Food Hygiene and Food Safety			
What best defines 'Food Hygiene'?	78.57	4.76	16.67
What does Food Safety mean to you?	92.86	2.38	4.76
What do you understand by Food safety Management System?	80.95	11.90	7.14
Why is it important to wash hands using sanitizer at work?	100.00	0.00	0.00
What is the best option to dry your hands after washing?	19.05	76.19	4.76
How to prevent hair from contaminating food?	83.33	16.67	0.00
Which microorganism is often present on a food handler's hand	21.43	9.52	69.05
Which certificate does an employee need to have to handle food?	71.43	21.43	7.14
Which one of these foods is likely to contain <i>Salmonella</i> ?	52.38	30.95	16.67
What professional clothing is worn in the kitchen?	92.86	4.76	2.38
Importance of wearing professional clothing in the kitchen	92.86	2.38	4.76
Which of the following is a case of cross contamination?	61.90	28.57	9.52
The most appropriate method to defrost meat	57.14	40.48	2.38
The minimum core cooking temperature for poultry	33.33	30.95	35.71
What is the temperature range in which most food poisoning microorganisms multiply rapidly?	35.71	33.33	30.95
Why is it important to wash fruits and vegetables before using?	76.19	23.81	0.00
What is the correct temperature of a refrigerator?	45.24	40.48	14.29
What happens to microorganisms when food is placed in the refrigerator?	38.10	52.38	9.52
How would you keep cooked food to be used later?	90.48	9.52	0.00
What do you understand by the term 'Expiry date'?	90.48	9.52	0.00
Why is it important to have stock rotation?	83.33	11.90	4.76
Why should waste be removed regularly from your work station?	90.48	9.52	0.00
What would you do if you saw a rat in the kitchen?	97.62	2.38	0.00
What is the food hygiene reason to control cockroaches?	69.05	30.95	0.00
B. HACCP			
What does HACCP stand for?	26.19	38.10	35.71
What is the purpose of HACCP?	69.05	11.90	19.05
What is the link between food safety and HACCP?	69.05	14.29	16.67
What does CCP stand for?	16.67	54.76	28.57
What do you understand by risk assessment?	61.90	16.67	21.43
Why is record keeping important as part of the HACCP process?	30.95	59.52	9.52

CA, correct answer; DK, do not know; IA, incorrect answer.

reports that food safety knowledge contributes to food handlers' attitudes and adequate knowledge could promote good behaviour, personal and food hygiene practices in the kitchen, as well as disease control measures (Motarjemi *et al.*, 2014; Kwol *et al.*, 2020). According to Rahman *et al.* (2012) and Pepple (2017), food handlers' educational level and lack of food safety knowledge could lead to improper food handling practices and increased risk of foodborne illnesses. A relationship has been identified between knowledge, attitude and practice (KAP) by using the KAP model. The KAP model assumes that the behaviour of an individual is dependent upon his/her knowledge which will positively lead to a change in attitude and then in practices (Kwol *et al.*, 2020). Food handlers' food safety knowledge will determine their attitudes, which could eventually contribute to good behaviour, good personal and food hygiene practices in the kitchen, and disease control measures (Motarjemi *et al.*, 2014; Kwol *et al.*, 2020). Food safety knowledge has an influence on food safety practices (Rahman *et al.*, 2012) and there is a direct relationship between level of education and food pathogens, hygiene and safety knowledge, and lack of knowledge indicates an increased risk of food poisoning (Pepple, 2017). In this study, lack of knowledge about hand-drying and of food safety hazards gives some cause for concern but knowledge of other good hygienic practices was generally good.

As shown in Table 4, low % correct answers were obtained for questions on the meaning of the acronyms HACCP and CCP, as well as the importance of record keeping. However, more than half of respondents gave correct responses to questions on the purpose of HACCP, its link to food safety and their understanding of risk assessment. Interestingly, Ramnauth *et al.* (2008) revealed that the respondents of fish producing and processing companies in Mauritius had heard about HACCP but only a few of them could tell what the abbreviation of HACCP stood for. HACCP is not currently a legal requirement in Mauritius except for fish processing industries. The mixed understanding of HACCP concepts found here suggests that further work is needed to fully progress the application of HACCP-based food safety management systems as recommended in international guidelines (Codex, 2020).

One-way ANOVA at 5% level indicated that there was a significant difference among the mean percentage correct answers of the six enterprises, $P\text{-value} = 7.22\text{E-}05$ ($P < 0.05$), indicating that the enterprises' mean answers are substantially different from one another, *i.e.*, that different levels of food safety knowledge exist in different enterprises. E5 obtained the highest mean percentage correct answer (75.8 ± 18.80) followed by E6 (74.3 ± 24.56) ($P < 0.05$). E1 obtained the lowest mean percentage correct answer (53.6 ± 17.33).

Table 5 Percentage food handlers according to Likert scale responses to attitude statements

Attitude statements	% Food handlers		
	Agree	Neither agree nor disagree	Disagree
D1 Food served to the client should be safe	97.62	2.38	0.00
D2 Food handlers have a responsibility towards safety of the food	92.86	7.14	0.00
D3 Food production and food service staff have sole responsibility to ensure food safety	69.05	7.14	23.81
D4 Food safety is more important than quality of food	78.60	11.90	9.50
D5 It is important to sensitise people about Good Hygienic Practices (GHP)	95.24	2.38	2.38
D6 Good Hygienic Practices is a burden to staff	11.90	16.7	71.43
D7 Food safety is important to protect consumers' health	97.62	2.38	0.0
D8 Learning more about food safety is a waste of time	4.76	0.0	95.24
D9 Food safety is costly and time consuming	26.19	21.43	52.38
D10 HACCP implementation is a long process	42.86	50.0	7.14
D11 It is difficult to follow the HACCP plan	14.29	57.14	28.57
D12 Filling forms for records is a tedious work	21.43	23.81	54.76
D13 HACCP is a good system to ensure food safety	83.33	16.67	0.0
D14 Audits disturb the routine work	4.76	30.95	64.29
D15 During service, rapidity is more important than food safety	9.52	9.52	80.95
D16 Training for food hygiene, food safety and HACCP is not important	4.76	4.76	90.48
D17 The high amount of dishes that have to be prepared do not affect the safe food handling practices	73.81	11.90	14.29
D18 To save cost when preparing food and to work faster, shortcuts with food safety can be taken	7.14	9.52	83.33
D19 Even during rush hour, the food prepared and served is safe.	88.10	7.14	4.76
D20 My tasks of preparing dishes do not affect my capacity to follow food safety principles	88.10	2.38	9.52
D21 Measuring temperature of a product is a waste of time	9.52	7.14	83.33
D22 It is important to learn about food hygiene and food safety	100.0	0.0	0.0
D23 Ensuring food safety is costly and a waste of time	4.76	9.52	85.71
D24 It is a stress on the staff to ensure food hygiene and food safety	28.57	16.67	54.76
D25 Good food hygiene practices reduce incidence of food poisoning	97.62	2.38	0.00

Food handlers' attitude towards food hygiene and safety

According to Ajzen (2001), behaviour can be predicted by measuring food safety attitude and people's reactions based on their intentions which are influenced by attitudes. Table 5 shows that the food handlers unanimously agreed to the statement on the importance of learning about food hygiene and safety. More than 80% of respondents agreed with attitude statements D1, D2, D4, D5, D7, D13, D19, D20 and D25 indicating that they were conscious of the responsibility for and importance of food safety practices, including HACCP and GHPs, and felt they had capacity to follow requirements even during busy times. About 50% respondents expressed uncertainty about length of HACCP process and difficulty to follow a HACCP plan. Results on "serving safe food to consumers" and "training on food hygiene and safety is essential" were similar to that obtained by Faour-Klingbeil *et al.* (2015) in the foodservice sector in Lebanon, where all food handlers believed that they serve safe food to consumers and it is important to follow training in food safety and hygiene which is essential to their work. Attitude is also a crucial factor, besides

knowledge, that may influence food safety behaviour and practices, reducing the occurrence of foodborne diseases (Akabanda *et al.*, 2017; Da Vitória *et al.*, 2021). More than 90% food handlers expressed disagreement to the negatively worded questions, suggesting strong agreement on the need for food safety training and education and of the cost-benefits of food safety practices. Food handlers' attitudes are known to be important in knowledge application which has a significant impact on individuals' behaviour and practices (Lee *et al.*, 2017; Da Vitória *et al.*, 2021). It has been highlighted that the link of positive behaviour, attitudes and continued education of food handlers is necessary towards the sustainability of safe food handling practices (Bas *et al.*, 2006).

Observed food handlers' food hygiene and safety behaviour and practices

The data presented in Table 6 indicate the food safety practices of food handlers of six enterprises. Positive behaviours were somewhat rarely observed and a high number of negative behaviours were observed among the food handlers, which does not tie in with the good

Table 6 Observed food handlers' positive and negative food hygiene and safety behaviour and practices

	E1		E2		E3		E4		E5		E6	
	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Total number of times an event occurred												
Positive practices/behaviours												
People behavioural items	19	36	18	22	49	46	23	16	16	19	22	20
Cleaning and disinfection	2	0	15	4	18	14	11	4	26	14	18	9
Cuts and wounds	0	0	0	0	2	2	0	0	0	0	0	0
Gloves worn when required	0	8	0	15	2	13	0	4	2	16	0	7
Washing hands at the right time	9	188	7	105	38	144	26	89	9	118	7	131
Adequate hand washing	5	11	0	17	13	32	0	20	0	22	0	28
Waste disposal	2	2	0	3	10	0	8	0	7	0	15	0
Negative practices/behaviours												
People behavioural items	51	0	32	30	38	28	29	12	11	23	18	29
Cleaning and disinfection	5	–	11	–	–	–	–	8	–	8	8	0

‘–’, Not seen on the day of observation.

knowledge and positive attitude of food handlers. In most cases, cleaned utensils/equipment were used but some employees used the same utensils/equipment for two different tasks. Raw foods (raw/cooked chicken/fish) were handled without wearing gloves and handwashing was poorly carried out among food handlers during the day, with proper handwashing procedures not followed. The majority of the food handlers were working with their jewellery on, hairnets were not worn and the protective clothing was worn outside the manufacturing plant. These issues give cause for concern about potential for contamination of food products being handled. In a study conducted among food handlers in Brazil, 48.2% of participants incorrectly followed sanitisation procedures and knowledge scores were not correlated to self-reported practices scores (Da Vitória *et al.*, 2021) supporting these results. More emphasis needs to be laid upon handwashing and disinfection, as it has been found that proper handwashing and using an appropriate alcohol-based sanitiser can help to prevent the spread of viruses and harmful bacteria (Metrex, 2014; CDC, 2020; Mayurnikova *et al.*, 2020). Sharif *et al.* (2013) pointed out that improper practices and lack of knowledge of food handlers can be one of the reasons

for the spread of foodborne outbreaks. Facilities, infrastructures, knowledge, time, work pressure, resources available, management, among others, are factors that could affect safe food practices and need to be understood to resolve the problems (Azanaw *et al.*, 2019; CDC, 2022).

Prevailing food safety culture

Based on the survey results, the mean maturity scores of the enterprises ranged from 3.71 to 4.32 on the self-assessment food safety culture scale (Table 7). This implies a positive and mature food safety culture. However, the food safety culture maturity scores obtained from the survey data were much higher when compared to those of the participatory observation of food safety culture which ranged from 1 to 1.6 (Table 7). The participatory observation results indicated that the enterprises were still at stage 1 (Doubt) or stage 2 (React) of the food safety culture maturity scale. This could be explained by the fact that, in the survey, high scores were obtained for the social desirability statements pointing towards higher social desirability responding and a wish to portray a more favourable view of the enterprise than actually exists.

Table 7 Food safety culture maturity score measured using survey method and participatory observation

Dimensions	Survey scores						Participatory observation scores					
	E1	E2	E3	E4	E5	E6	E1	E2	E3	E4	E5	E6
Values and mission	4.48	3.42	4.37	4.80	4.63	4.16	1	1	2	2	2	1
People	3.84	3.60	3.84	4.00	4.02	3.79	1	1	1	2	2	1
Consistency	3.96	3.78	3.72	4.08	3.95	3.75	1	1	1	1	1	1
Adaptability	4.14	3.85	4.26	4.58	4.6	4.05	1	1	2	1	1	1
Hazard and risk awareness	4.01	3.89	4.17	4.11	4.4	4.03	1	1	2	1	1	1
Mean maturity score (1–5)	4.08	3.71	4.07	4.31	4.32	3.95	1	1	1.6	1.4	1.4	1

This result highlights the need for a mixed-methods approach and triangulation of data so as to obtain a true picture of the prevailing food safety maturity level of the enterprises (Jespersen & Wallace, 2017).

Prevailing food safety climate

The mean food safety climate scores ranged from 3.22 to 4.26 (Table 8). Mean food safety climate scores close to 4 implied that the overall perception was at a good level (the most frequent response was 4: Agree on the Likert scale). E2 obtained the lowest score close to 3 which could be due to a neutral perception of the food safety climate components by the employees (mean is 3.02), as the mean food safety climate score of the manager was quite high (mean is 4.21). This difference can be due to the lack of trust, motivation and cooperation issues between the employees and manager and is similar to the findings of De Boeck *et al.* (2016) in Belgium butcheries. Based on Kruskal–Wallis test, there were no significant differences ($P > 0.05$) within the mean food safety climate scores of the different enterprises, again similar to the results obtained by De Boeck *et al.* (2016) in different butcheries assessed, where the modes from different butcheries were between 4 and 5, corresponding to a level of perception of food safety climate ranging from good to very good.

Managers perceived some of the indicators differently from the employees (Fig. 2). The employees were convinced that the managers laid down simple and clear objectives (L1) and the managers showed the ability to encourage them to work in a hygienic manner (L3). For communication, a larger difference can be observed for indicators C1 and C4. The employees were less convinced that the manager talked with them about food hygiene and safety regularly. Despite being micro and small enterprises, communication is a problem between managers and employees and among employees. Likewise, De Boeck *et al.* (2016) found that communication among employees is also a problem, as the author expected that people are more communicative when working among a small number of personnel.

Managers perceived indicators (Commitment) D1, D2 and D5 slighter better than the employees, showing that the managers considered food hygiene and safety to be of great importance for the company’s success and it was recognised by the colleagues. The indicator R1 ‘employees have sufficient time to do the work in a hygienic and food safe way’ was scored higher by the managers than by the employees. Employees claimed that they do not have sufficient time to complete their work. Managers gave higher scores for indicator R3 ‘there is adequate space and lighting to work in a hygienic and safe manner’ and R4 ‘there is adequate investments to ensure that food hygiene and safety is maintained’. In this study, employees mistook food

Table 8 Food safety climate data expressed as percentage and means scores on a five-point Likert scale (1: totally disagree → 5: totally agree)

	E1 (n = 10)					E2 (n = 6)					E3 (n = 12)					E4 (n = 5)					E5 (n = 5)					E6 (n = 4)				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Total food safety climate (%)	1.43	9.29	8.21	47.86	33.21	15.48	24.40	4.76	33.33	22.02	0.80	6.25	10.72	55.65	26.79	0.71	3.56	2.86	40.00	52.86	5.00	10.71	0.71	26.43	57.14	4.46	3.57	10.71	60.71	20.54
Mean food safety climate score	4.02					3.22					4.02					4.26					4.20					3.89				

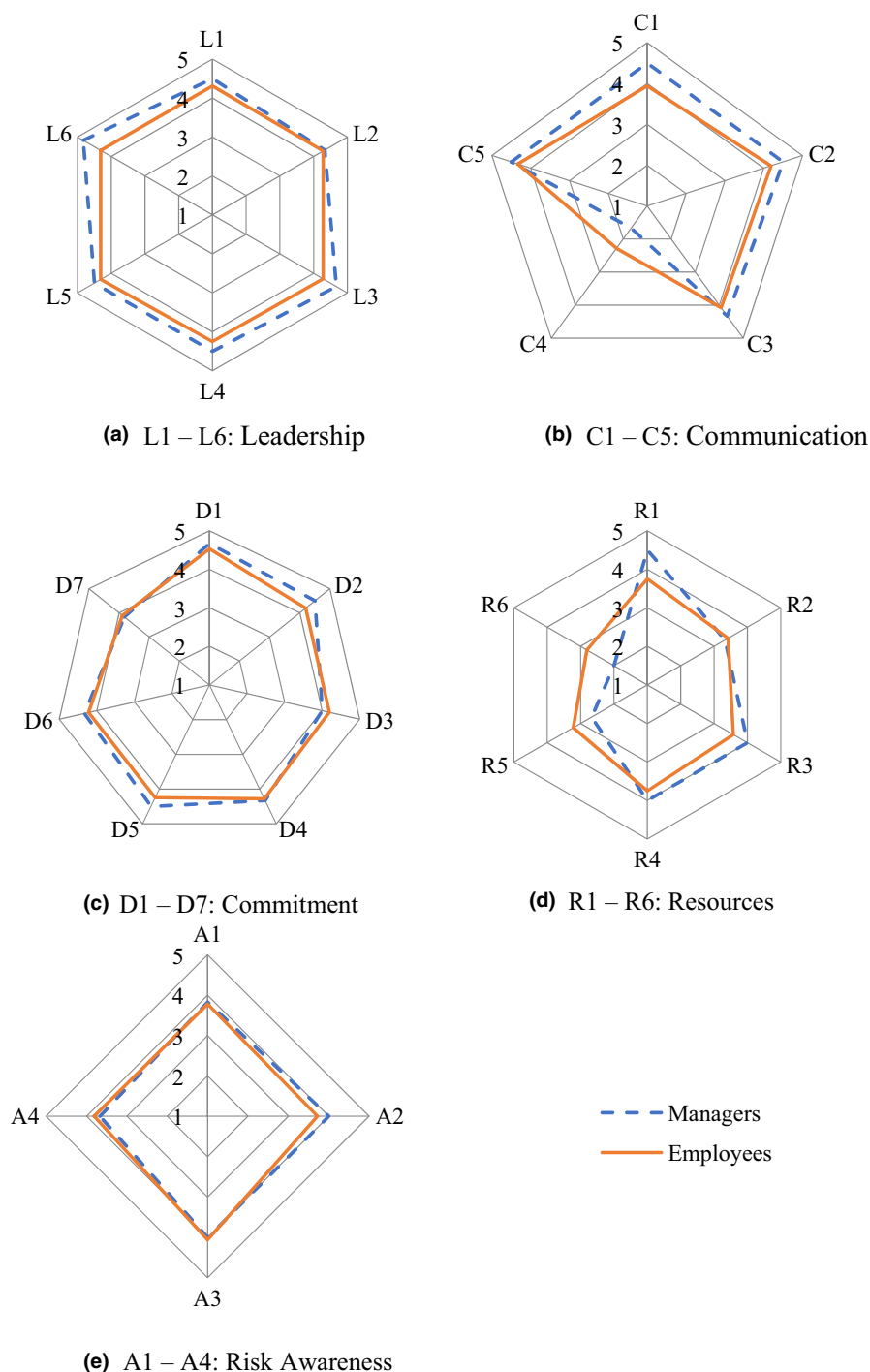


Figure 2 Web diagrams with mean responses (5-point Likert scale) of managers ($n = 6$) and employees ($n = 36$) for the different food safety climate indicators.

hygiene and safety posters with posters on instructions for work and managers were less convinced that posters and/signs on the importance of food hygiene and

safety were present in their enterprise. Indicator R5 was poorly scored by both managers and employees, showing a need for the importance of regular training

Table 9 Food safety management, culture and climate scores using different methods

		Results for six case study enterprises					
	Methods	1	2	3	4	5	6
Techno-managerial route	Overall food hygiene and safety audit score (%)	49.14 (Fair)	63.56 (Good)	67.50 (Good)	48.56 (Fair)	49.36 (Fair)	55.86 (Fair)
Human route	Attitude scores	Positive	Positive	Positive	Positive	Positive	Positive
	Knowledge scores	53.64 ± 17.33	54.04 ± 13.20	61.11 ± 18.58	70.91 ± 12.42	75.76 ± 18.80	74.24 ± 24.56
	Mean food safety culture score using survey questionnaire	4.08	3.71	4.07	4.31	4.32	3.95
	Food safety culture stage using participatory observation	1.00	1.00	2.00	1.00	1.00	1.00
	Mean food safety climate score	4.02	3.22	4.02	4.26	4.20	3.89

in the enterprises. Conversely, posters, signs or icons on the importance of hygiene and food safety were always present in the butcherries surveyed (De Boeck *et al.*, 2016). It is highlighted similarly by De Boeck *et al.* (2016) that regular training is equally important as regular repetition on similar topics on food hygiene and safety.

For indicators A1, A3 and A4 for risk awareness, the scores of the managers and the employees were quite similar. Indicator A2 ‘employees are alert and attentive to potential difficulties and risk associated with hygiene and food safety’ was scored slightly higher by the managers than the employees. Employees perceived indicators communication and resources lower than the managers as the latter were more convinced that they communicate on food hygiene and safety in the enterprise and ensure enough resources are available. Alternatively, similar trends were observed for indicators leadership, commitment and risk awareness for both managers and employees.

Triangulation of data on food safety management, culture and climate

Table 9 summarises the assessment of the food safety management, culture and climate in the six enterprises using different approaches. The scores obtained for food safety culture were higher when survey questionnaire was used as compared to the participatory observation. The food hygiene and safety audit score obtained using a designed checklist revealed the work environment of the enterprises, hence giving an evaluation of compliance with established legal requirements (Mauritius Food Regulations, 1999) and the level of food hygiene and safety performance of the enterprises.

Generally, the poor work environment, lack of proper flow of process operations poor hygienic practices, poor cleaning and sanitation procedures together

with underestimation of the risks and lack of knowledge may favour inadequate hygienic practices increasing food safety risks. Deficiencies in the conditions of the work environment may demotivate food handlers while enabling conditions provide incentives for them to work (Nyarugwe *et al.*, 2018; Zanin, Stedefeldt, Maria da Silva *et al.*, 2021; Zanin, Luning, Stedefeldt 2021).

A higher food safety culture score (Table 8) was obtained from the survey data, showing a more positive food safety culture as compared to that of the participatory observation. Similar results were obtained in a study carried out in Brazil where the quantitative analysis revealed an overestimation of the food safety culture elements and underestimation was obtained in the qualitative analysis (Zanin, Stedefeldt, Maria da Silva *et al.*, 2021). From this study, the inclusion of items that test social desirability in survey responding provided additional results that suggested the high food safety culture scores obtained from the survey indicate the participants had a tendency to respond in a socially desirable manner. This could also be due to the food handlers not feeling comfortable in answering the questions in the enterprises due to fear of the managers or that they might be judged by the researcher or because of normative beliefs they had. Personality factors (anxiety, motivation, self-esteem) have been linked with self-deception, and impression management can result in automatically indulging in socially desirable behaviour (Graeff, 2005; Andersen & Mayerl, 2019). Findings support those of previous studies by (Zanin, Stedefeldt, Maria da Silva *et al.*, 2021), Jespersen and Wallace (2017) and Ungku Fatimah *et al.* (2014), where divergence was noted between different food safety culture data collection methods used.

The research findings revealed that the overall perception of food safety climate of the enterprises for the ‘human route’ is at a good level but that a lower

food hygiene and safety inspection score (Techno-managerial route) was noted. Similar trends were observed by previous researchers (De Boeck *et al.*, 2019; Zanin, Stedefeldt, Maria da Silva *et al.*, 2021), explaining a difficult situation to improve food safety, due to lack of awareness of food hygiene issues of food handlers. De Boeck *et al.*, 2019 highlight this as a risky situation where system and product related methods score low but human route methods score high and food handlers might overestimate their climate through optimistic bias or complacency. Optimistic bias, or optimism bias, is a psychological phenomenon in which people believe they are more likely to experience positive events and less likely to experience adverse events than others (Kress & Aue, 2017). Optimistic bias can negatively influence food safety, for example, optimistic food handlers may be complacent about their ability to manage risk and overlook operating procedures leading to potential food contamination (Rossi *et al.*, 2017). To overcome this potential challenge, more tailored and location-specific strategies for improvement of food safety management and/or food safety culture can be put in place (De Boeck *et al.*, 2019). Results from this research on both climate and culture *via* survey compared with culture observation results seem to match this situation (De Boeck *et al.*, 2019), suggesting a potentially risky situation for food safety in these enterprises in Mauritius and Rodrigues. However, the overall knowledge and attitude scores in this research were generally good, suggesting that food handlers understand the importance of food safety and have a positive attitude and this may help to reduce the risk of optimistic bias and complacency. Indeed, the addition of the (Jespersen, Maclaurin, Vlerick, *et al.*, 2017) social desirability items to the culture and climate survey in this research reveal a high likelihood of socially desirable responding impacting the high climate and culture scores observed from the survey method. As mentioned by previous researchers (Hussein, 2009; Jespersen & Wallace, 2017; Nyarugwe *et al.*, 2018; De Boeck *et al.*, 2019; Zanin, Luning, Stedefeldt, 2021), the use of results from only one method could be inappropriate and lead to wrong conclusions and a more complete food safety culture evaluation can be obtained by using method triangulation. This is the first research study to evaluate both culture and climate alongside food safety management status and food safety knowledge and attitude. The use of combined results from different methods can increase the chance of neutralising the limitations of one method and strengthen the benefits of the other to obtain results which are more reliable. Nevertheless, to be able to analyse and interpret the qualitative and quantitative data, there is a need for further work on interpretation approaches to evaluate the overall

picture of food safety management, culture and climate. This is important to support the interpretation of the prevailing food safety culture and strength of food safety management, both in MSMEs locally in Mauritius and Rodrigues and internationally.

Study limitations

The approach used in this research study has some limitations. This study was relatively small as it covered only six enterprises in Mauritius and Rodrigues and the sample sizes of food handlers and managers were small. Regarding social desirability measurement, only eleven or the eighteen items described by (Jespersen, Maclaurin, Vlerick, *et al.*, 2017) were used in this research due to some of the items being highly similar when translated. This meant that the social desirability items could not be used to adjust the food safety culture results in line with the validated scale of (Jespersen, Maclaurin, Vlerick, *et al.*, 2017) but the tendency for socially desirable reporting could be seen from the results. Multiple methods were used together with their different scales; although this made comparison and interpretation of the data more challenging, this research highlighted the need for further work on interpretation of mixed methods food safety culture and management.

Conclusion and recommendations

The current study and the use of developed mixed methods approach and method triangulation enabled a comprehensive and realistic assessment of the baseline knowledge, attitudes, practices, prevailing food safety culture and climate within MSMEs in Mauritius and Rodrigues, highlighting the inconsistencies that may be obtained in food safety culture assessment. The knowledge and attitude survey findings together with the data obtained from the inspection checklist stress the need for the enterprises to improve their food hygiene and safety level to ensure food safety and safeguard consumers' health. The food handlers' lack of knowledge in some areas, training and failure to follow food hygiene rules could be one of the problems, which is supported by other investigations carried out worldwide. This research indicated that the use of survey questionnaires alone could have produced a biased result as food handlers may have responded in a socially desirable manner as compared to the observed data, and the use of single method could lead to wrong conclusions. The combination of results obtained from different methods used can increase the likelihood of neutralising the shortcomings of one method and can strengthen the benefits of the other, thus obtaining a more reliable outcome. Moreover, it is important to consider employees, environment and

their practices in the assessment of food safety culture. By addressing all the research questions and objectives, the research findings have provided insights into the food safety culture and climate prevailing in selected food enterprises which will help to develop tailor-made interventions, including educational actions to address current gaps at each enterprise. The methodology and the gap analysis can be used as the starting point for the development of food safety culture interventions. Hence, further research and the use of theoretical models is imperative to enhance sustainability of food safety assurance as well as aiming to mature food safety culture of the selected MSMEs, and other enterprises. Support to improve food safety practices and culture in this setting is essential for consumer health protection.

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Conflicts of interest

The authors have no conflicts of interest to declare regarding this work.

Author contributions

Aishah B. Z. Joomun: Conceptualization (equal); formal analysis (lead); funding acquisition (lead); investigation (lead); methodology (equal); visualization (lead); writing – original draft (lead); writing – review and editing (equal). **Carol A. Wallace:** Conceptualization (supporting); methodology (equal); supervision (lead); writing – review and editing (equal). **Deena Ramful-Baboolall:** Conceptualization (equal); methodology (equal); supervision (supporting); writing – review and editing (equal). **Badroonesha Aumjaud:** Conceptualization (supporting); methodology (equal); supervision (supporting); writing – review and editing (equal).

Peer review

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Data availability statement

Copies of all checklists and tools used in the research can be obtained on request from the corresponding author.

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