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The relationship of food safety culture elements: A serial mediation model

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ABSTRACT

Nowadays, food safety culture (FS-culture) is widely acknowledged as a critical factor influencing food safety outcomes, prompting extensive research in this domain. Although previous studies have explored the elements and benefits of FS-culture, limited attention has been given to the relationship among these elements. This study aims to address this gap by examining the mediating role of communication, management systems and processes, and the work environment in the relationship between leadership and commitment - two key elements of FS-culture. A serial mediation model was tested using data from 471 food handlers across 37 Brazilian food service establishments. FS-culture was assessed using a self-administered questionnaire comprising 31 indicators, which evaluated five core elements: 1) leadership, 2) communication, 3) management systems and processes, 4) environment, and 5) commitment. Mediation analysis was conducted using PROCESS macro. The results suggest that leadership indirectly influences commitment and its effect is mediated through a sequential process involving communication, management systems and processes, and the work environment. Commitment is positively and directly affected by communication, management systems and processes, and the work environment. The serial mediation model illustrates the relationship between the investigated FS-culture elements, underscoring the importance of a holistic approach to fostering a strong FS-culture. Interventions aimed at improving FS-culture should prioritise leadership development, enhance communication strategies, implement robust management systems and processes, and cultivate a supportive work environment. Future research is warranted to explore the generalisability of these findings across diverse cultural and organisational contexts, providing a broader understanding of the mechanisms driving FS-culture in various settings.

1. Introduction

Food safety culture (FS-culture) is a phenomenon defined as a long-term organisational construct that encompasses the deeply rooted beliefs, behaviours, and assumptions shared by all employees, significantly influencing the organisation's food safety performance (Sharman, Wallace, & Jespersen, 2020). A systematic analysis of FS-culture research (Zanin, Stedefeldt, & Luning, 2021) demonstrated that the initial body of research on FS-culture focused on defining the concept and its core elements. They analysed the elements/dimensions used in 47 studies and categorised them into 12 groups, namely people, commitment, pressure, leadership, risk, communication, food safety management systems, work environment, consistency, adaptability,

policy & strategy, and external environment. Although different terms were used across studies, many referred to similar key elements such as commitment, leadership, risk perception, communication, management systems and processes, and environment (Griffith, Livesey, & Clayton, 2010b). Moreover, the role of these elements in shaping the prevailing FS-culture may vary depending on the context of the food business, such as the type of food operation (e.g., food service, manufacturing, retail, hospitality), company size (e.g., small and medium-sized enterprises, large corporations), and geographic location (e.g., different countries or regions) (Zanin, Stedefeldt, & Luning, 2021).

While previous research focused on identifying or defining the elements and dimensions of a proactive FS-culture, more recently there is a trend towards examining the relation between the FS-culture elements

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and its outcomes. Recent research increasingly emphasises the benefits of proactive FS-culture in maintaining safe and appropriate food handling practices (e.g., Zanin, Stedefeldt, da Silva, da Cunha, & Luning, 2021; Cavelius, Goebelbecker, & Morlock, 2023). This emphasis is rooted in the established understanding that standalone traditional training programs have limited efficacy in improving food safety practices (da Cunha, 2021; da Cunha et al., 2022). Empirical studies have demonstrated that a proactive FS-culture linked to fewer non-conformities with food safety regulations (de Andrade, Stedefeldt, Zanin, Zanetta, & da Cunha, 2021), reduced microbiological contamination rates (Wu, Hammons, Silver, Neal, & Oliver, 2020), and resulted in financial savings (Jespersen et al., 2019). To illustrate, a study conducted in 50 retail delis in the United States demonstrated that a proactive FS-culture was associated with a lower contamination rate of *Listeria monocytogenes*. The retail delis with a proactive FS-culture showed greater commitment from managers towards food safety and hygiene measures (Wu et al., 2020). Similarly, a study conducted in Brazil involving 32 restaurants found that fewer violations of food safety legislation were associated with a proactive FS-culture. The restaurants with a proactive FS-culture had managers with high educational levels and extensive food safety training (de Andrade, Stedefeldt, Zanin, & da Cunha, 2020), highlighting managers' vital role in supporting a proactive FS-culture. Also, leadership is increasingly recognised as a crucial factor in FS-culture as it can influence job satisfaction (Natarajan, 2022), organisational climate (Ko & Kang, 2019; Natarajan, 2022), and employee commitment to hygiene practices (Taha, Zanin, & Osaili, 2024).

In the field of safety culture, several studies have analysed the relationships between different factors to understand the underlying mechanisms. Naji, Isha, Alazzani, Saleem, and Alzoraiki (2022) found that safety communication is key in linking safety culture and performance. Noort, Reader, Shorrocks, and Kirwan (2016) similarly demonstrated the positive impact of effective safety communication on safety performance and commitment. In the context of FS-culture, the role of leadership and effective communication to promote work commitment has been suggested by Yiannas (2009) and Griffith, Livesey, and Clayton (2010a). To further our understanding of FS-culture, it is crucial to explore how and why leadership influences food handlers' commitment. This involves examining the intricate relationship between leadership and other key elements of FS-culture, such as communication, management systems and processes, and the work environment. The specific mechanisms connecting the elements shaping a proactive FS-culture have only been explored to a limited extent.

Furthermore, it remains unclear how management systems, processes and the work environment - crucial management factors - mediate the relationship between leadership and employee commitment. For example, De Boeck, Mortier, Jaccsens, Dequidt, and Vlerick (2017) proposed a moderator-mediator model in which knowledge acts as a mediator. Their mediation analysis indicated that knowledge mediates the relationship between food safety climate and compliance, participation and behaviour. Motivation also partially mediates the relationship between food safety climate and compliance and behaviour. Taha et al. (2024) investigated the relationship between leadership styles, job satisfaction, commitment, and hygiene practices among food handlers in Dubai. They found that transactional and transformational leadership positively influenced job satisfaction, commitment, and hygiene practices. Furthermore, job satisfaction and commitment mediated the relationship between leadership styles and hygiene practices. Despite the growing literature in the field, the specific mechanisms connecting the proximal elements (e.g. leadership and communication) and distal elements (e.g. commitment) shaping a proactive FS-culture have only been explored to a limited extent. By understanding the interconnectedness of the elements of FS-culture, from leadership to work commitment, and the mediating role of other elements, we may: 1) advocate the inclusion of these elements as an entire concept; 2) provide a deeper understanding of FS-culture supporting the development of

more effective strategies to promote a proactive FS-culture; and 3) support FS-culture as a phenomenon based theory and not just a management system. Thus, the current study aims to investigate whether the FS-culture elements (communication, management systems and processes, and environment) act as potential mediating variables in the relationship between leadership and commitment.

2. Models and hypotheses

Fig. 1 shows the proposed mediation model. The proposed model posits that leadership indirectly affects commitment through a series of mediating variables. Thus, we propose a serial multiple mediation model grounded in theoretical considerations (Griffith et al., 2010a; Abidin, Arendt, & Strohbehn, 2013; De Boeck, Jaccsens, Bollaerts, & Vlerick, 2015; Zanin, Luning, da Cunha, & Stedefeldt, 2021) and recent empirical research (de Andrade et al., 2020; Zanin, Stedefeldt, et al., 2021; Nyarugwe, Linnemann, & Luning, 2020). Serial mediation appears to be a suitable choice, as in a parallel mediation model, the antecedent variable X is modelled as directly influencing the consequent Y as well as indirectly through two or more mediators, under the condition that no mediator causally influences another (Hayes, 2017). Nevertheless, empirical evidence suggests that elements of FS-culture are not entirely independent (Griffith, Jackson, & Lues, 2017), working synergistically, and may influence commitment through a series of mediating factors. In simpler terms, serial mediation helps us to understand how an initial cause (independent variable X) leads to a final effect (dependent variable Y) through one or more intermediate steps (mediating variables Mi) (Baron & Kenny, 1986). It is assumed that the independent variable, leadership, indirectly influences the dependent variable, commitment, through a series of mediating variables, communication, management systems and processes, and environment. Thus, the serial mediation model encompasses the following hypotheses:

Hypothesis 1. Communication (a_1b_1), management systems and processes (a_2b_2), and environment (a_3b_3) mediate the relationship between leadership and commitment.

Hypothesis 2. There is a positive effect of communication (b_1), management systems and processes (b_2) and environment (b_3) on food handlers' commitment.

Given the assumed importance of communication, management systems and processes, and environment for effective leadership in

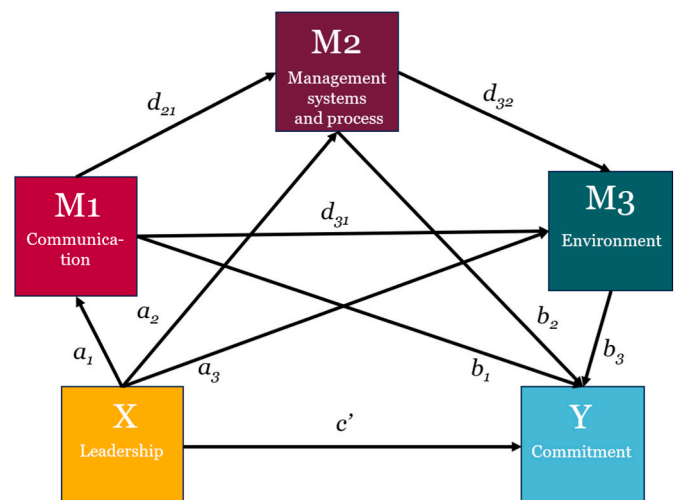


Fig. 1. Hypothesised serial mediation model

X: independent variable; Y: dependent variable; Mi: mediators. Letters and numbers indicate each path.

Note: d_{31} was used to draw the model but was not considered a hypothesis, as it does not affect the outcome.

fostering FS-culture and commitment, we anticipated a serial mediation model. In other words, the indirect effect of strong communication, robust management systems, and a supportive work environment can explain the relationship between leadership (X) and commitment (Y). Otherwise, in serial mediation, the influence of X on Y is transmitted sequentially through multiple intermediary variables (M1, M2, and M3). Thus, our last hypothesis is:

Hypothesis 3. Leadership indirectly influences commitment through a mediated serial process involving communication, management systems and processes, and environment leading to a significant total effect (c).

Leadership was designated as the initial component within the proposed FS-culture framework (Fig. 1), reflecting its pivotal role within organisational contexts. Leadership is considered an important driver in an organisation because it influences employee behaviour, especially transformational leadership (Zheng, LisaGao, Li, & Dang, 2023). To strengthen food safety, top management and leadership support are fundamental, as only safety standards and structured processes are not enough (Demenciano et al., 2024). Authors suggested leadership style as a strong motivator of employees' performance (Kaunda & Yangailo, 2023) and their compliance with food safety and hygiene behaviours, significantly impacting the organisational climate (Basit, 2020; Ko & Kang, 2019). In addition, leadership is the element with the largest effect on the formative constructs of the FS climate (de Andrade et al., 2021).

Commitment was designated as the outcome variable, i.e. the last element in the model. Food handler commitment is an important behavioural outcome. It reflects individual motivations and beliefs, proven as a full mediator between training, employee involvement and food safety performance (Taha et al., 2024) and between knowledge and food hygiene practices (Al Bayari, Taha, Suliman, & Osaili, 2023). Furthermore, commitment has also been shown to mediate the relationship between transformational leadership and food safety behaviour (Liu, Ahmad, Jiang, & Zulqarnain Arshad, 2024). A strong commitment was also identified when leaders perceived a positive safety climate in their work environment (Fruhen, Griffin, & Andrei, 2019). By differentiating between distal (e.g., leadership) and proximal (e.g., commitment) factors influencing food handler behaviour, this study offers a nuanced understanding of the relationship within the FS-culture framework.

Second, another important definition of the model was the exclusion of risk perception, an element defined by Griffith, Jackson, and Lues (2017). Risk perception addresses understanding risks associated with foodborne diseases, their potential lethality, and optimistic bias in employees (Griffith et al., 2010a; Zanin, Luning, et al., 2021). Risk perception is challenging to quantify objectively, and some authors argue that it can change due to continued changes (Zanin, Luning, et al., 2021), which makes the risk perception unclear in the FS-culture context. For instance, de Andrade et al. (2021) excluded risk perception from their conceptualisation of food safety climate, treating it as a separate variable. This approach reflects the ongoing challenge of integrating risk perception into the quantitative FS-culture framework. Additionally, some research suggests that risk perception may decrease even within a proactive FS-culture because it may be related to the fluctuation of risk degree. A study conducted within the army food service demonstrated that transitioning the prevailing FS-culture from reactive-active to active-proactive resulted in a lower risk perception score, moving it from proactive to active (Zanin, Stedefeldt, et al., 2021). However, others explained the phenomenon as a cognitive bias where food handlers compare themselves to perceived higher-risk stereotypes, such as street food vendors when inferring their risk. A study involving 176 food handlers revealed that those working in hospitals, restaurants, and school meal services presented optimistic bias, perceiving the risk of foodborne disease in their establishment types as lower compared to other types of food services, such as beach kiosks (da Cunha, Stedefeldt, & de Rosso, 2014). If food handlers believe that their hygiene practices

are adequate, they may be overly optimistic about the risk of disease outbreaks in their workplace (da Cunha, Braga, Passos, Stedefeldt, & de Rosso, 2015). This highlights the need for further research to better understand the complex relationship between risk perception and FS-culture.

3. Methods

3.1. Participants

We determined the minimum sample size by using the software application developed by Schoemann, Boulton, and Short (2017). Based on prior research by de Andrade et al. (2021) regarding correlations between the variables and the proposed three-mediator model, a minimum of 220 participants was required to achieve a statistical power of 80% with a 95% confidence level. Increasing the sample size to over 400 would further enhance the power to 97%. Four hundred and seventy-one ($n = 471$) food handlers from 37 food service establishments participated in this study and completed the questionnaires.

The study participants were food handlers from various food services, including hotels, restaurants, institutional dining facilities, and cafeterias in São Paulo State - Brazil. All participants were required to be 18 years of age or older. No restrictions were placed on gender, experience level, education, or prior food safety training because we consider that the different characteristics encompass the FS-culture. All participants signed informed consent, following the ethics issues previously approved by the Brazilian ethics committee (Protocols: CAAE 48041715.9.0000.5404; CAAE 65339517.0.0000.5505).

Food handlers completed questionnaires during their work breaks. Individual administration was preferred; however, questionnaires were also administered in small groups at their locations. In these cases, strict measures were taken to ensure no interference from supervisors or colleagues.

3.2. Measures

A self-administered questionnaire developed by Abidin et al. (2013), previously applied in other food service establishment studies in Brazil (de Andrade et al., 2020; de Andrade et al., 2021; Zanin, Luning, et al., 2021; Zanin, Luning, & Stedefeldt, 2022) was used to evaluate the FS-culture elements. The original questionnaire included 35 indicators assessing the six elements of FS-culture. However, the current study included five: 1) leadership, 2) communication, 3) management systems and processes, 4) environment, and 5) commitment, hereafter referred to as FS-culture elements. The risk perception element was measured but not considered in this study because of its complexity and conflicting results in previous studies.

These elements were selected in our study as they have been reported in many studies as being important for FS-culture (Griffith et al., 2010a; Abidin et al., 2013; De Boeck et al., 2015; de Andrade et al., 2020; Zanin, Luning, et al., 2021). Leadership refers to managers' efforts to engage employees in adequate food handling practices (Griffith et al., 2010a; Yiannas, 2009). Commitment includes job satisfaction and employees' attitudes towards food safety (Griffith et al., 2010a; Abidin et al., 2013). Communication involves food safety information dissemination within the organisation and the willingness of employees to discuss inappropriate food safety practices (Griffith et al., 2010a; Abidin et al., 2013). Management systems and processes refer to management styles, planning, organisation, control, and compliance with hygiene regulations and prerequisite programs (Griffith et al., 2010a). The environment relates to the availability and accessibility of adequate infrastructure and the sufficiency of employees to carry out necessary safety measures (Griffith et al., 2010a; Zanin, Luning, et al., 2021); it refers to the supportiveness of the (working) environment. All responses were measured on a five-point Likert scale: '1 strongly disagree'; '2 partially disagree'; '3 neither agree or disagree'; '4 partially agree' and '5 strongly agree'.

3.3. Data analysis

Serial mediation analysis was conducted using the PROCESS Macro described by Hayes (2017) and implemented within SmartPLS v.4 software (SmartPLS GmbH, Bönningstedt, Germany). PROCESS utilises ordinary least squares and logistic regression to analyse path models with observed variables. The PROCESS approach was chosen due to its superior power compared to the Sobel test, and its ability to accommodate data that may not adhere strictly to normal distribution (Hayes, 2018). All variables were entered as latent constructs. The outer model, which represents the relationships between latent variables and their indicators, was evaluated using the criteria outlined by Henseler, Ringle, and Sinkovics (2009). Factor loadings for each item should exceed 0.50, indicating a strong relationship with the corresponding latent variable.

Additionally, the Average Variance Extracted (AVE) should be greater than 0.50, suggesting adequate convergent validity. A higher AVE indicates that the indicators are strongly related to the latent variable (Henseler, Ringle, & Sarstedt, 2009). Discriminant validity was measured using Fornell-Larcker criteria, i.e., the square root of the AVE of a construct should be greater than the correlation between that construct and any other construct in the model (Fornell & Larcker, 1981). Finally, internal consistency was assessed using composite reliability (CR), with a value greater than 0.70 demonstrating acceptable reliability. Multicollinearity was checked with variance inflation factors (VIF) below 5.0. Multicollinearity occurs when predictor variables are highly correlated, which may lead to unstable estimates and inflated standard errors in the regression model (Montgomery, Peck, & Vining, 2012). Bootstrapping procedures with 10,000 resamples were employed to estimate direct and indirect effects. Direct, indirect and total effects were analysed using bias-corrected confidence intervals (without zero) at the 97.5% level. To estimate the magnitude of the direct effects, f^2 effect sizes were calculated and classified as small ($f^2 = 0.02$), medium ($f^2 = 0.15$) or large ($f^2 = 0.35$) (Cohen, 1988).

4. Results

4.1. Descriptive statistics and outer model

The sample population skewed slightly toward males (66%). The average age of the participants was 30.6 years. Encouragingly, approximately 74% of respondents reported attending one or more food safety training sessions. Participants reported an average of 6.15 years of experience in food handling. Approximately 17% possessed over a decade of experience within the food service industry.

Table 1 presents the means and factor loadings for all FS-culture element indicators. Each element comprises at least three indicators, all of which demonstrate factor loadings exceeding 0.500.

Table 2 presents the mean values, correlations, CR, VIF, and AVE for the FS-culture elements. The correlation coefficients between elements range from small ($r = 0.29$) to moderate ($r = 0.58$). All correlations were lower than AVE's square root, suggesting good discriminant validity. All elements demonstrate adequate reliability, with CR values exceeding 0.70. Multicollinearity is not a concern, as evidenced by the very low VIF values ($VIF < 1.90$). Furthermore, the AVE values are greater than 0.50, indicating that the constructs capture more variance than the measurement error.

4.2. Hypotheses testing

All hypothesised mediation paths (indirect effects) were significant, confirming hypothesis 1. Specifically, communication served as a positive mediator in the relationships between leadership and both management systems and processes (a_1d_{21} ; path coefficient = 0.196), and commitment (a_1b_1 ; path coefficient = 0.056). Additionally, the combined influence of communication and management systems and processes significantly mediated the relationship between leadership and

Table 1

Food safety culture indicators, factor loadings, mean, and standard deviation.

Elements/ Indicators	Factor loading	Mean ^a ; SD
<i>1 Leadership</i>	–	–
My manager is actively involved in making sure safe food handling is practised	0.820	4.57; 0.78
My manager always watches to see if employees are practising safe food handling	0.829	4.27; 0.99
Employees are disciplined or reprimanded when they fail to follow food safety practices	0.630	3.66; 1.49
My leader gives correct instructions on how to handle food safely.	0.828	4.29; 1.07
<i>2 Communication</i>	–	–
I can freely speak up if I see something that may affect food safety	0.559	4.67; 0.72
Management provides adequate and timely information about current food safety rules and regulations	0.863	4.32; 1.01
I am encouraged to provide suggestions for improving food safety practices	0.893	4.40; 0.94
My leader gives correct instructions on how to handle food safely.	0.543	4.15; 1.00
<i>3 Management systems and process</i>	–	–
Management inspires me to follow safe food handling practices	0.617	4.29; 0.98
There is good cooperation among departments to ensure that customers receive safely prepared food	0.812	4.41; 0.86
New employees and experienced employees work together to ensure food safety practices are in place	0.813	4.30; 0.95
When lots of work needs to be done quickly, employees work together as a team to get the tasks completed safely	0.753	4.24; 1.05
My coworkers are always supportive of each other regarding food safety	0.750	4.11; 1.10
<i>4 Environment</i>	–	–
Equipment items needed to prepare food safely (e.g., handwashing sinks) are readily available and accessible	0.894	4.12; 1.18
Adequate supplies are readily available to perform safe food handling practices	0.864	4.00; 1.21
Facilities are of adequate quality to follow safe food handling practices	0.892	4.15; 1.13
<i>5 Commitment</i>	–	–
I follow food safety rules because it is my responsibility to do so	0.571	4.81; 0.53
Food safety is a high priority to me	0.653	4.78; 0.54
I follow food safety rules because I think they are important	0.844	4.85; 0.44
I am committed to following all food safety rules	0.828	4.83; 0.43

^a Five-point Likert scale (1: strongly disagree to 5: strongly agree); SD = Standard deviation.

environment ($a_1d_{21}d_{32}$; path coefficient = 0.062) and between leadership and commitment ($a_1d_{21}b_2$; path coefficient = 0.012) (Table 3 - indirect effects).

The model confirms hypothesis 2 (Table 3 - path coefficients). There is a positive effect of communication (b_1 ; path coefficient = 0.132; $f^2 = 0.05$), management systems and process (b_2 ; path coefficient = 0.059; $f^2 = 0.01$) and environment (b_3 ; path coefficient = 0.072; $f^2 = 0.04$) on food handlers' commitment.

The results indicate a mediation model, as evidenced by the significant total effect (c) when accounting for the serial influence of the mediating FS-culture elements (Table 3 - total effects). This suggests that leadership's impact on commitment is channelled through the sequential effects of communication, management systems and processes, and environment. Thus, hypothesis 3 was confirmed.

The path coefficients and effect sizes of paths b_{21} (path coefficient = 0.457; $f^2 = 0.18$), d_{31} (path coefficient = 0.405; $f^2 = 0.06$) support the sequential nature of the model. Given their values, it is evident that these paths mutually influence each other, making a parallel model inappropriate.

Table 2

Food safety culture elements, correlations, and multicollinearity check.

Elements	Mean	SD	Correlation coefficient (r)					CR	VIF	AVE
			1	2	3	4	5			
1. Leadership	4.16	0.83	1.00	–	–	–	–	0.807	1.747	0.585
2. Communication	4.41	0.69	0.51	1.00	–	–	–	0.815	1.808	0.537
3. Management systems and processes	4.26	0.77	0.58	0.60	1.00	–	–	0.863	1.874	0.613
4. Environment	4.08	0.83	0.50	0.51	0.45	1.00	–	0.914	1.532	0.780
5. Commitment	4.81	0.36	0.29	0.43	0.36	0.38	1.00	0.819	–	0.538

SD = standard deviation; CR = composite reliability; VIF = variance inflation factor; AVE = average variance extracted.

Table 3

Direct effects, path coefficients, specific indirect effects and total effects of the model.

Path identification	Path	Effects	CI (97.5%) Lower	CI (97.5%) Upper
<i>Direct effect</i>				
Leadership - > Commitment	c'	−0.007	−0.091	0.026
<i>Path coefficients</i>				
Leadership - > Communication	a ₁	0.428	0.479	0.636
Leadership - > Management systems and processes	a ₂	0.352	0.304	0.482
Leadership - > Environment	a ₃	0.456	0.403	0.740
Communication - > Commitment	b ₁	0.132	0.059	0.212
Management systems and processes - > Commitment	b ₂	0.059	0.023	0.155
Environment - > Commitment	b ₃	0.072	0.037	0.113
Communication - > Management systems and processes	d ₂₁	0.457	0.286	0.469
Communication - > Environment	d ₃₁	0.405	0.215	0.587
Management systems and processes - > Environment	d ₃₂	0.140	−0.061	0.359
<i>Indirect effects</i>				
Leadership - > Communication - > Commitment	a ₁ b ₁	0.074	0.032	0.122
Leadership - > Management systems and processes - > Commitment	a ₂ b ₂	0.033	0.009	0.061
Leadership - > Environment - > Commitment	a ₃ b ₃	0.033	0.020	0.069
Leadership - > Management systems and processes - > Environment - > Commitment	a ₂ d ₃₂ b ₃	0.004	0.002	0.010
Leadership - > Communication - > Environment - > Commitment	a ₁ d ₂₃ b ₃	0.017	0.006	0.031
Leadership - > Communication - > Management systems and processes - > Commitment	a ₁ d ₂₁ b ₂	0.018	0.005	0.035
Leadership - > Communication - > Management systems and processes - > Environment - > Commitment	a ₁ d ₂₁ d ₃₂ b ₃	0.002	0.001	0.006
<i>Total effect</i>				
Leadership - > Commitment	c	0.147	0.099	0.206

5. Discussion

5.1. Theoretical implications

This study elucidates the intricate relationship among the FS-culture key elements including leadership, commitment, communication,

management systems and processes, and environment. Our findings suggest that the influence of leadership on food safety commitment is mediated by a sequential process involving communication, systems and management, and environment (path: c). The current serial mediation model includes elements frequently used in FS-culture assessment. Although the construct can be extended to include additional relevant elements according to the food business context (Zanin, Stedefeldt, & Luning, 2021), omitting any of the current five elements will compromise the model. For example, a systematic review by Zanin, Stedefeldt, and Luning (2021) distinguished twelve groups of FS-culture elements across existing studies, but there is not yet an acknowledged assessment framework. Additional empirical data are necessary to expand the model; a complete and accurate picture of FS-culture cannot be obtained by simply removing the core elements from the used framework (leadership, commitment, communication, management systems and processes, and environment). Our findings also support that FS-culture is a formative construct, meaning that the individual elements collectively "form" the overall construct (de Andrade et al., 2021). This stands in contrast to reflective constructs, where a latent variable is believed to cause (or reflect) the measured indicators (Hair, Hult, Ringle, & Sarstedt, 2017). So, although elements and dimensions support FS-culture, it is generally considered a unique phenomenon, representing a single underlying concept.

The results indicate that leadership is a foundational element in cultivating a proactive FS-culture, corroborating with the literature (Griffith et al., 2010a; Schein, 2016; Yiannas, 2009). By fostering a positive and proactive approach to food safety, leadership can positively influence communication, management systems, the work environment, and ultimately employee commitment. Inadequate leadership and management practices can contribute to a reactive FS-culture, hindering improvements in food safety outcomes (Griffith et al., 2010a). Beyond the primary serial mediation path, our analysis identified several alternative pathways of influence. For instance, we found indirect relationships between leadership and commitment through communication alone (a₁b₁). Additionally, the elements 'management systems and processes' (a₂b₂) and 'environment' (a₃b₃) were also single mediators, suggesting multiple routes through which these factors can impact the outcome variable. These findings underscore the interconnected nature of the FS-culture elements (Nyarugwe, Linnemann, Hofstede, Fogliano, & Luning, 2016; Taylor, 2011), suggesting causal relationships beyond mere correlation. Such results may explain the often subtle improvements observed in FS-culture elements scores across intervention or comparative studies (de Andrade et al., 2020; Nyarugwe et al., 2020; Tomasevic et al., 2020), underscoring their critical role in mediating each other. While these changes may appear incremental, their collective impact on the work environment and minimising the risk of food-borne diseases can be substantial.

The five elements used in this research are based on the safety culture concept, grounded and dependent on organisational factors. Yiannas (2009) and Griffith et al. (2010b) discussed the link between safety culture and organisational culture, positioning FS-culture as a distinct yet interrelated construct. Their work highlighted the influence of organisational context on both safety and FS-culture, suggesting potential impacts on safety behaviours and overall organisational

performance (Nyarugwe et al., 2016). Thus, we also may expand the element's interaction to safety and organisational culture as a new hypothesis for further research.

5.2. Practical implications

Although this research is primarily theoretical, it offers valuable practical implications. Our findings show that leadership could be the starting point for fostering a proactive FS-culture. Effective leadership is critical to cultivating a shared commitment to food safety by enhancing open communication, developing robust management systems, and creating a supportive work environment (Yu, Guchait, Achyldurdyeva, & Pasamehmetoglu, 2023). Leadership acts as an antecedent and moderator of employee behaviour (Yu et al., 2023), shaping individuals' beliefs, opinions, and values related to food safety practices. Consequently, leaders who actively promote FS-culture within food services, must take responsibility for guiding beliefs, opinions, and values and set an example for their team. Therefore, it is important to prioritise leadership development (Habibi, 2023).

Our analysis shows that communication has a stronger indirect influence on the relationship between leadership and commitment than management systems and processes, and the work environment. Communication also showed a stronger direct influence on commitment when compared with other elements. So, it is suggested in decision making that leaders must focus first on effective communication, before addressing management systems, processes or the work environment. Effective communication needs to consider different resources for communication, for digital channels (e.g., webpage, social media, games) and traditional communication channels (e.g., leaflets, newsletters oral communication etc) (Griffith, Jackson, & Lues, 2017; Kasza, 2024), aiming to reach all employees. It is also important to recognise that it can be difficult for employees to communicate with their managers because they fear upsetting them due to cultural differences or language barriers (DiPrete, Garza, & Spinrad, 2023). Moreover, numerous studies consistently show a positive correlation between transformational and charismatic leadership and employee engagement (e.g., Jackson, Meyer, & Wang, 2013). To overcome communication barriers, managers should establish open and two-way communication channels in the workplace (Yiannas, 2009) and be open to suggestions and receive information about mistakes without punishment. Establishing and sustaining a robust management system, along with a supportive work environment, necessitates adequate financial investment (Zanin, Stedefeldt, et al., 2021). This financial commitment must be reinforced by strong managerial dedication and strategically prioritised to align with the overarching mission, vision, and values of the food business (Jespersen et al., 2019).

5.3. Limitations and future research

In our study, we used the FS-culture elements framework described by Griffith et al. (2017) but excluded risk perception based on recent literature (Zanin, Stedefeldt, et al., 2021; de Andrade et al., 2021). Adding this FS-culture element to the mediation model may affect the identified relationship between leadership and commitment through the sequential processes. Risk perception is complex and ambivalent (Slovic, 1987) and further research is needed to investigate its role and relationship with other FS-culture elements affecting the FS-culture dynamics. The current study focused on a specific serial mediation model, but the complex interrelationships among FS-culture elements suggest the potential for alternative relationship pathways. Future research could explore these additional models to gain a more comprehensive understanding of the phenomenon. This study used quantitative FS-culture measures due to the statistical model choice, although the literature emphasises the need for a mixed-methods approach to assess FS-culture comprehensively. Future research could explore novel models while adhering to established methodological best practices.

Finally, another limitation of this study is the absence of food safety outcome measures, such as failure rates or violations. Relying on self-reported data can introduce biases (da Cunha, De Rosso, Pereira, & Stedefeldt, 2019) and limit the ability to draw definitive conclusions about the relationship between FS-culture and actual food safety performance. Therefore, we base our discussion on the premise that the food handler's commitment (among other elements) could shape adequate food safety behaviour.

6. Conclusion

The serial mediation model illustrates the relationship of the investigated FS-culture elements and supports that interventions should prioritise leadership development, effective communication, robust management systems and processes and a supportive work environment. Furthermore, the results indicate a mediated model, whereby leadership's influence on commitment is channelled through the sequential effects of communication, management systems and processes, and environment. Our results underpin FS-culture as a phenomenon-based theory rather than just a management system. Future research could examine the generalisability of these findings across different cultural and organisational contexts.

CRediT authorship contribution statement

Diogo Thimoteo da Cunha: Writing – original draft, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Carolina Bottini Prates:** Writing – original draft, Methodology, Investigation. **Isabela Gomes Canuto:** Writing – original draft, Investigation. **Elke Stedefeldt:** Writing – review & editing, Investigation. **Pieterneel Arianne Luning:** Writing – review & editing, Investigation. **Laís Mariano Zanin:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare to no conflict of interest.

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Data availability

Data will be made available on request.

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