



Allergen safety among Brazilian restaurant food business operators: guilt, rather than regret or shame, links cognitive responsibility to intentions

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ABSTRACT

Consumers with food allergies and intolerances face significant risks when eating out, especially in countries lacking specific legislation on allergen communication. In such contexts, they depend heavily on the information and practices adopted by food business operators (FBOs). This study investigated key aspects of allergen management among FBOs, focusing on (i) knowledge and decision-making in situations involving allergic reactions; (ii) cognitive, moral, and emotional determinants influencing the management of allergenic foods; and (iii) potential allergen contamination in food preparation utensils used by establishments claiming to have implemented control measures. An intentionally stratified sample of 310 FBOs from 19 cities across all five Brazilian regions participated in the survey. The questionnaire consisted of 11 knowledge questions and an extended version of the Norm Activation Model (NAM), including constructs of responsibility attribution, awareness of consequences, personal norms, and behavioural intentions towards allergen management. Environmental assessments were conducted using rapid tests for allergen residues on shared utensils from 10 selected establishments. Knowledge gaps were evident, particularly in distinguishing lactose intolerance from cow's milk allergy—only 28.0% answered correctly. The NAM analysis indicated that knowledge predicts awareness of consequences, which, together with responsibility attribution, shapes personal norms and behavioural intentions. Guilt emerged as a moral emotion mediating this relationship, further reinforcing the intention to prevent allergic incidents. In the environmental assessment, 88% of samples tested negative; however, four blenders showed contamination with egg or gluten. Despite positive intentions among participants, observed knowledge gaps and the limited scope of existing regulations suggest that standardised national legislation and evidence-based training programmes may be necessary to strengthen allergen safety in Brazilian foodservice.

1. Introduction

Food allergy is a major public health concern and can be defined as

an adverse condition in which ingestion of, or contact with, specific foods trigger an abnormal immune response (Solé et al., 2018). Over recent decades, the topic has attracted increasing attention, partly

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because multiple sources suggest that prevalence has been rising worldwide. A global meta-analysis estimated an overall prevalence of 4.3%, with regional values of 4.2% in Asia, 3.2% in the Americas, 4.8% in Europe, 1.6% in Africa, and 7.5% in Oceania (Feng et al., 2023). However, prevalence estimates vary substantially depending on how food allergy is measured. Evidence from Brazil highlights this challenge: in a community-based study of adults in Central Brazil, 10.8% of participants initially self-reported food allergy in a screening questionnaire, but this estimate fell to 1.0% after a second, more specific instrument administered by trained researchers to identify probable IgE-mediated immediate food allergy (Silva et al., 2016). These discrepancies indicate that differences observed across settings may reflect not only true heterogeneity, related to age, cultural context, dietary patterns, immunological mechanisms, food type, and geography, but also methodological variation in diagnostic strategies and study instruments (Solé et al., 2018). The available evidence indicates that these and other factors—such as the absence of comprehensive surveillance systems, reliance on self-reported or administrative data, methodological variability across studies, and the underdiagnosis of cases managed outside specialised healthcare settings—may lead to underestimation of food allergy prevalence overall (Ruzante et al., 2025; Turner et al., 2024).

Beyond prevalence, food allergy entails continuous risk management in everyday eating, particularly when meals are obtained outside the home. In these contexts, safety cannot depend solely on individual vigilance; effective protection also requires accessible consumer information and shared responsibility across healthcare, governance and regulatory systems, scientific communities, and the food sector (FAO & WHO, 2024). Yet, in food service environments, such safeguards are often less robust than for packaged foods. Dominguez et al. (2024) noted that although many industrialised countries mandate allergen declaration within regulatory frameworks, primarily for pre-packaged foods, ingredient information is frequently limited for foods prepared and served in restaurants and other food service establishments, leaving food-allergic consumers uncertain when dining out. Correspondingly, Stankovich et al. (2023) argue that regulatory gaps in restaurant contexts can contribute to adverse physical and psychosocial outcomes for people affected by food allergy and advocate a risk-based approach to policy development that strengthens monitoring and regulatory action. Although comprehensive allergen management frameworks have been identified as best practice, recent evidence indicates that most jurisdictions address only limited dimensions of allergen safety, particularly in food service settings (Vicentini et al., 2026).

In Brazil, the interplay between regulatory framework and everyday practice in food service may be especially consequential. As an upper-middle-income, emerging economy, the country offers a distinctive setting in which local jurisdictions have adopted heterogeneous rules for allergen communication in food service, creating a patchwork of cities and states with, and without, specific allergen regulations. In the absence of overarching guidance from national health authorities for allergen management in food service, consumer protection may depend disproportionately on the motivations of food business operators (FBOs), as well as on organisational norms and culture within establishments. This logic aligns with broader arguments in the hospitality literature that food safety culture functions as a phenomenon through which motivated staff and organisations prioritise and operationalise safety-related practices, including internal communication about allergen risks, systematic prevention of allergen cross-contact, and ongoing staff training on allergen management (Da Cunha et al., 2025; Dominguez et al., 2024).

This study aims to investigate how Brazilian FBOs manage food allergy risks in restaurant settings, with a particular focus on the interplay between cognitive, moral, and emotional determinants of allergen safety. Specifically, we examine three complementary domains: (i) food allergy knowledge and decision-making in situations involving suspected allergic reactions; (ii) objective evidence of potential allergen contamination on routinely cleaned utensils in establishments that

report being prepared to serve food-allergic customers; and (iii) the role of cognitive and moral-psychological determinants – including awareness of consequences, responsibility attribution, and anticipated moral emotions – in shaping intentions to adopt allergen management and communication practices. By extending the Norm Activation Model to incorporate anticipated guilt, regret, and shame in a heterogeneous regulatory landscape, the study explores whether guilt, more than regret or shame, functions as a key pathway linking cognitive appraisals of consequences and responsibility to food business operators' intentions to protect consumers with food allergies, and examines whether these associations differ across jurisdictions with distinct regulatory requirements.

2. Theoretical framework

2.1. Food allergy regulations in Brazil

In Brazil, the description of allergenic foods is regulated at the national level for the category of prepackaged foods (Brazil, 2022). Consequently, non-prepackaged foods commercialised in food service establishments are not covered by specific nationwide legislation regulating this issue. In order to ensure consumer safety beyond packaged foods, several local jurisdictions have implemented specific regulations addressing allergenic ingredients in food service settings. Such initiatives can be observed in the states of Ceará, Piauí, Pará, and Bahia, as well as in the cities of Rio Grande, Belo Horizonte, Rio de Janeiro, and Serra Negra (Bahia, 2025; Belo Horizonte, 2018; Ceará, 2022; Pará, 2024; Piauí (Government of the State), 2023; Piauí, 2024; Rio de Janeiro, 2017; Rio Grande, 2017; Serra Negra, 2025). These initiatives are local and that there is no regulatory guidance from the Brazilian Ministry of Health or the National Health Surveillance Agency (ANVISA in Portuguese).

Most of these jurisdictions require the disclosure of specific allergenic ingredients on menus, as observed in Ceará, Pará, Bahia, Rio de Janeiro, Belo Horizonte, and Rio Grande (Bahia, 2025; Belo Horizonte, 2018; Ceará, 2022; Pará, 2024; Rio de Janeiro, 2017; Rio Grande, 2017; Serra Negra, 2025). However, the scope of the required allergens varies across legislation. For instance, the city of Rio de Janeiro mandates only the disclosure of gluten and its derivatives, whereas the state of Ceará requires the presentation of ten allergenic ingredients using standardised icons (Ceará, 2022; Rio de Janeiro, 2017). Some jurisdictions also specify that allergen information must be provided in both physical and digital menus, as established in the states of Pará and Bahia (Bahia, 2025; Pará, 2024). Table 1 presents a summary of local legislation concerning allergen disclosure for non-prepackaged foods in Brazil.

The local regulations summarised in Table 1 are primarily focused on ingredient disclosure requirements, such as listing allergens on menus or using standardised icons. None of these regulations mandate staff training, allergen management processes, or verification procedures typically found in more comprehensive allergen safety frameworks, as observed in the US Food Code (US Food and Drug, 2024), regulation (EU) 852/2004 for European Union (European Union, 2011), and the GSO Codex Standard 80:2023, (2023) for the Gulf Cooperation Council. A recent global scoping review of allergen management regulations identified five core dimensions of comprehensive allergen control in foodservice: ingredient disclosure, consumer notification prompts, staff training, anaphylaxis emergency plans, and formal allergen management systems (Vicentini et al., 2026). The Brazilian local regulations identified in the present study align primarily with the first dimension—ingredient disclosure—while lacking requirements across the other four domains, particularly those related to training and systematic allergen control processes. Nevertheless, even disclosure-focused regulations may influence FBOs' awareness and sense of responsibility by signaling policy attention to allergen safety and consumer protection.

Based on these regulatory differences, and despite the limited scope

Table 1

Brazilian legislation on allergenic ingredients in non-prepackaged foods in food service establishments.

Regulation	Locale	Description
Law No. 17899, of January 11, 2022 (Ceará, 2022)	State of Ceará	Food service establishments are required to disclose, on menus, the presence of gluten, lactose, milk, fish, almonds, colorants, tree nuts, soy, eggs, and crustaceans, using standardised icons.
Law No. 10654 of July 4, 2024 (Pará, 2024)	State of Pará	Food service establishments are required to disclose, on physical and digital menus, the presence of foods containing lactose, gluten, and seafood.
Law No. 14863, of February 12, 2025 (Bahia, 2025)	State of Bahia	Food service establishments must inform customers on menus or buffet displays about the presence of wheat, rye, barley, oats, crustaceans, eggs, fish, peanuts, soy, milk, almonds, hazelnuts, cashew nuts, Brazil nuts, macadamia nuts, walnuts, pecans, pistachios, pine nuts, chestnuts, and natural latex.
Law No. 6159 of May 4, 2017 (Rio de Janeiro, 2017)	City of Rio de Janeiro	Food service establishments are required to disclose the presence of gluten and its derivatives, specifically in buffet-style or self-service establishments.
Law No. 11116, of June 21, 2018 (Belo Horizonte, 2018)	City of Belo Horizonte	Food service establishments are required to disclose the presence of gluten, lactose, sugar, and whether products are classified as dietetic or light.
Law No. 8067 of January 2, 2017 (Rio Grande, 2017)	City of Rio Grande	Food service establishments are required to disclose the presence or absence of gluten, sugars, shellfish, oilseeds (including peanuts, nuts, walnuts, almonds, and hazelnuts), and eggs in the composition of their products.
Law No. 4775, of May 27, 2025 (Serra Negra, 2025)	City of Serra Negra	Food service establishments, including restaurants, bars, snack bars, hotels and self-service or buffet-by-weight establishments, are required to disclose the presence of lactose, milk protein, gluten and their derivatives in foods prepared and/or served to customers.

of existing requirements, it is reasonable to expect that FBOs in jurisdictions with specific requirements for food allergen communication and management will demonstrate higher levels of knowledge, ascription of responsibility, and awareness of consequences related to food allergy. Accordingly, the following hypothesis is proposed:

Hypothesis 1. (H1): Food business operators from the States of Ceará, Pará, and Bahia, and from the cities of Rio de Janeiro, Belo Horizonte, Rio Grande, and Serra Negra will show higher levels of knowledge, ascription of responsibility, and awareness of consequences related to food allergy.

2.2. The norm activation model

The Norm Activation Model (NAM) was developed to explain altruistic behaviour grounded in individuals' moral obligations (Schwartz, 1977). In its traditional form, the NAM proposes a sequential process in which awareness of consequences – the recognition of potential negative outcomes for others – precedes the ascription of responsibility, that is, the perception of personal accountability for preventing those outcomes (Kim & Hwang, 2020; Onwezen et al., 2013). Together, these cognitive appraisals activate personal norms, defined as an individual's perceived moral obligation to engage in prosocial or socially responsible

behaviours (Song et al., 2023), which in turn shape behavioural intentions (Govaerts & Olsen, 2022; Han, 2014). Awareness of consequences enhances personal norms by clarifying the harms that may result from inaction (Moghavvemi et al., 2020; Song et al., 2023), whereas responsibility attribution strengthens the sense of personal duty to avoid such harms (Han, 2014; Onwezen et al., 2013).

Beyond its original configuration, the NAM has been extended to include additional determinants such as knowledge (Kim & Hwang, 2020) and anticipated emotions, including guilt (Govaerts & Olsen, 2022; Han, 2014; Radic et al., 2021), regret (Brewer et al., 2016), and shame (Rosenthal & Ho, 2020a). Individuals with higher levels of knowledge often experience stronger moral obligations and more positive behavioural intentions, while anticipated moral emotions further strengthen the link between cognitive appraisals and prosocial actions (Kim & Hwang, 2020). This extended NAM framework has been applied to a range of pro-environmental and food-related behaviours, from pesticide reduction to food waste prevention and food safety practices in food services (Meira et al., 2025; Kim et al., 2022; Mahasuweerachai, 2024). Here, we draw on this extended framework to examine how knowledge and anticipated moral emotions interact with awareness of consequences and responsibility attribution to shape food business operators' intentions regarding allergen management and communication (H2–H7).

Hypothesis 2. (H2): Awareness of consequences is a driver of the ascription of responsibility for preventing food allergy incidents.

Hypothesis 3. (H3): Awareness of consequences is a driver of personal norms related to food safety practices and communication to prevent allergic reactions.

Hypothesis 4. (H4): Ascription of responsibility for the prevention of food allergy reactions is a driver of personal norms.

Hypothesis 5. (H5): Personal norm regarding food safety and communication is a driver of the intention to implement preventive practices and improve communication about food allergens.

Hypothesis 6. (H6): Knowledge about food allergies is a driver of awareness of consequences.

Hypothesis 7. (H7): Knowledge about food allergies is a driver of the ascription of responsibility for prevention of food allergy incidents within food service establishments.

2.3. Guilt, regret and shame as drivers of intention

Affective processes are central to human decision-making, complementing rational evaluations and drawing on prior experiences. Within the NAM framework, negative emotions such as regret, guilt, and shame help explain how moral evaluations translate into personal norms and behavioural intentions. These emotions arise when individuals recognise the negative consequences of their (in)actions and assume responsibility, thereby strengthening moral obligation and intention (Coricelli et al., 2007; Onwezen et al., 2013).

Anticipated regret is a central emotion in decision-making because it reflects individuals' evaluations of their choices relative to better alternative outcomes and has been associated with intentions and behaviours that promote healthier and risk-reducing actions (Brewer et al., 2016). In health-related contexts, regret linked to negative outcomes can be particularly strong, and emphasising the negative consequences of inaction may increase anticipated regret and promote preventive behaviours (Brewer et al., 2016; Feldman & Albarracín, 2017). In food allergy management, FBOs may anticipate regret if they imagine a customer experiencing an allergic reaction caused by poor safety procedures or unclear allergen communication, and such anticipated regret can translate awareness of consequences and ascription of responsibility into stronger personal norms and intentions to act preventively.

Anticipated guilt emerges when individuals foresee acting, or failing

to act, in ways that conflict with their moral standards, and has been consistently linked to stronger personal norms and prosocial intentions in moral domains (Han, 2014; Onwezen et al., 2013; Radic et al., 2021). Although its role within the NAM has not yet been fully formalised theoretically, empirical evidence suggests that anticipated guilt can act as a key mechanism through which moral evaluations are translated into behavioural intentions. In the context of food allergy management, FBOs may anticipate guilt if they imagine a customer having an allergic reaction because appropriate allergen control and communication practices were not implemented or enforced, which can strengthen their perceived obligation to prevent such incidents.

Shame is a powerful social emotion that directly affects individuals' moral self-concept and is therefore highly relevant in the study of moral behaviour (Gilbert, 2003; Wang et al., 2025). Because shame is closely tied to concerns about social evaluation and relationship disruption, individuals are strongly motivated to avoid situations that could elicit it, and observing shame in others can also shape behaviour, as people may avoid reproducing actions that led to another person's public embarrassment, thereby supporting social cohesion and norm adherence (Gilbert, 2003; Schaumberg & Skowronek, 2022). In food service settings, FBOs may anticipate shame if they imagine being publicly blamed by customers, staff, or authorities for an allergic reaction caused by inadequate food allergen management, suggesting that anticipated shame can operate alongside regret and guilt as an affective pathway through which awareness of consequences and ascription of responsibility enhance personal norms and intentions to implement and maintain robust food safety and allergen communication practices.

Consistent with the extended NAM and the documented role of anticipated regret, guilt, and shame, this study conceptualises these emotions as mediators linking key cognitive variables in the NAM framework – awareness of consequences and ascription of responsibility – to personal norms and, ultimately, to behavioural intentions regarding food allergy prevention in restaurant settings. Accordingly, the following hypotheses are proposed:

Hypothesis 8. (H8): Anticipated regret mediates the relationships between awareness of consequences and personal norms, and between awareness of consequences and behavioural intention regarding the implementation of food safety and allergen communication practices.

Hypothesis 9. (H9): Anticipated guilt mediates the relationships between awareness of consequences and personal norms, and between awareness of consequences and behavioural intention regarding the implementation of food safety and allergen communication practices.

Hypothesis 10. (H10): Anticipated shame mediates the relationships between awareness of consequences and personal norms, and between awareness of consequences and behavioural intention regarding the implementation of food safety and allergen communication practices.

3. Methods

3.1. Sample

A total of 310 FBOs participated in this study. Participants were recruited from 19 cities across all five regions of Brazil: Belém (North), Palmas (North), Fortaleza (Northeast), Salvador (Northeast), Natal (Northeast), Brasília (Central-West), Cuiabá (Central-West), Belo Horizonte (Southeast), Campinas (Southeast), Limeira (Southeast), Piracicaba (Southeast), Ribeirão Preto (Southeast), Serra Negra (Southeast), Santos (Southeast), Rio de Janeiro (Southeast), Curitiba (South), Porto Alegre (South), and Rio Grande (South). The selection of cities was based on the classification of urban centres according to REGIC (Regions of Influence of Cities), prioritising major metropolises from each geographic zone (Fig. 1). Additionally, data collection included cities with specific local food service legislation - namely Belém, Belo Horizonte, Fortaleza, Rio de Janeiro, Rio Grande, and Salvador - in order to

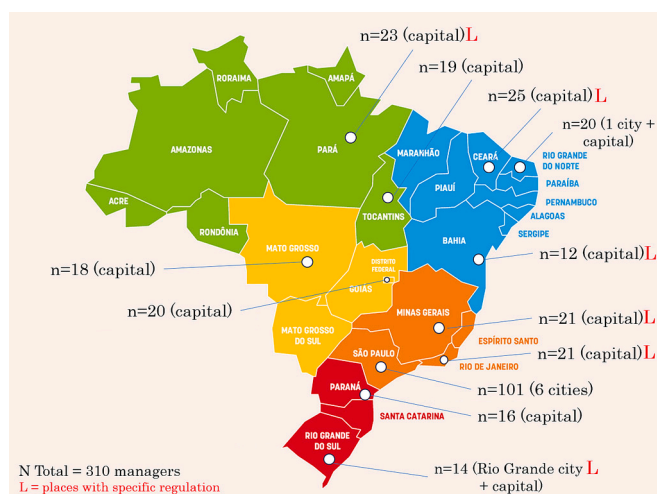


Fig. 1. Sample distribution across Brazilian regions and states.

capture a diversity of regulatory contexts. The minimum required sample size was calculated using the inverse square root method (Kock & Hadaya, 2018), considering a 5% significance level and a minimum path coefficient of 0.20. This resulted in an estimated minimum of 160 FBOs (approximately 32 per region), a threshold exceeded in the present study, ensuring adequate statistical power for multivariate analyses.

Recruitment of establishments began from each city's central area or established gastronomic hub, where a preliminary online search confirmed the presence of relevant businesses within the predefined zone. After defining the starting location, a buffer of up to 5 km was demarcated to map all food service establishments, compile an operational list, and design a visitation route. This list was then used for in-person invitations, and establishments not identified online but within the set boundaries were also included, as additional venues were systematically identified during on-foot canvassing of the area. In cities with high acceptance or broad culinary districts, up to three independent starting points were employed to maximize coverage. The sampling frame targeted businesses classified according to the National Classification of Economic Activities, focusing on a) restaurants and other food and beverage service activities and b) catering, buffet services, and other prepared food services. Establishments specialised for coeliac consumers or those with specific food allergies were excluded from the sample, to maintain focus on the general population. Aside from these, there were no restrictions regarding cuisine type or specialty - thus, the sample encompasses a wide variety of commercial establishments. The distribution of sampled establishments aimed to reflect the national proportions of foodservice types reported in Brazil: 40% restaurants, 22% bars, 20% fast-food chains, and 18% snack bars (Statista, 2018). Although the sample was not probabilistic, it was intentionally stratified to ensure coverage of different Brazilian regions and food service typologies. The broad geographic scope, inclusion of diverse commercial models, and representation of distinct regulatory environments enhance the potential for external validity and analytical depth, which, while not establishing strict representativeness, offers substantial insight into the sectoral and regional realities of Brazilian food services.

All participants were over 18 years of age and agreed to participate in the study by signing an informed consent form, previously approved by University of Campinas on November 22, 2024 in accordance with Brazilian ethical standards (CAAE Protocol No. 83116524.6.0000.5404).

3.2. Measures

The research participants completed a questionnaire consisting of items on demographic data, food allergy knowledge and an extended

NAM. The demographic section included questions on gender, race/ethnicity, educational level, and length of work experience in food services.

In this context, 16 indicators were used to assess four constructs involved in the NAM: ascription of responsibility (4), awareness of consequences (4), personal norms (4), and behavioural intention (4). The responses were assessed using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Three latent variables were included to measure anticipated guilt (3 items), anticipated shame (3 items), and anticipated regret (3 items). Consistent with evidence that anticipated regret is a distinct, future-oriented emotion and a powerful motivator of health and risk behaviours, anticipated regret, shame, and guilt were assessed as a separate latent construct (Brewer et al., 2016). Each construct was assessed using a 5-point Likert scale ranging from 1 (“not at all”) to 5 (“extremely”). Respondents indicated the intensity of anticipated guilt, shame, and regret they would experience in response to three hypothetical scenarios involving failures in food allergen management in food service settings, designed to capture three core aspects of food allergen control widely required by national regulations in different countries – management, communication, and staff training (Vicentini et al., 2026). In each scenario, FBOs were asked to imagine a customer experiencing a severe allergic reaction due, respectively, to the absence of allergen-related safety practices, unclear communication of ingredients, or an employee's failure to properly prepare a safe dish for a food-allergic customer, and then to rate how guilty, ashamed, and regretful they would feel. The use of hypothetical scenarios to assess anticipated moral emotions is consistent with prior research showing that individuals can reliably predict how much guilt, shame, or regret they would feel when imagining moral norm violations or harmful outcomes (Pletti et al., 2016), and scenario-based instruments commonly ask respondents to rate the intensity of guilt- and shame-related feelings in response to standardised vignettes, supporting this approach as a valid way to capture proneness or anticipated intensity of these emotions.

The assessment of knowledge was based on the study by Soon (2018) and consisted of 11 questions, one of which was multiple-choice, and the others were judgment-based, where the participant could choose between “true”, “false” or “not sure” to evaluate the statements presented.

All questionnaires were administered in person during a visit to the restaurant. A tablet was used to facilitate administration via the SurveyMonkey interface.

3.3. Environmental allergen detection

In a subsample of 10 restaurants, environmental allergen testing was conducted to objectively assess the presence of allergen residues on utensils that had undergone routine cleaning and sanitation. Establishments were selected at random (simple draw) among those whose owner or manager responded affirmatively to the question “Are you and your staff prepared to serve customers with food allergies?”, in order to focus on businesses that perceived themselves as capable of managing allergic consumers. Due to the need for refrigerated storage and the time required to perform the tests after removal from refrigeration (30 min), the subsample was limited to establishments located in the cities of Limeira and Campinas. It is important to note that the environmental allergen testing was designed as an exploratory component and was not intended to be statistically representative of the full sample nor analytically integrated into the structural equation modelling. Instead, it provides complementary, objective insight into real-world allergen control practices among a small subset of establishments that reported being prepared to manage food-allergic consumers. Given the limited sample size and geographic scope, these findings should not be generalised to Brazilian foodservice as a whole. The survey component ($n = 310$) provides the primary evidence base for the behavioural model, while the environmental testing ($n = 10$) offers illustrative context regarding actual practices.

Within each selected restaurant, a single general-use food-contact utensil was chosen using a predefined decision map that ranked items according to their a priori likelihood of allergen contamination, while including only utensils commonly used across different production areas. The priority order was: cutting boards, blenders, food processors, mixers, spoons, baking trays, knives, and pots. If a given utensil was not available, or if it was dedicated exclusively to specific ingredients (e.g., a blender used only for fruit juices), the next item in the sequence was selected. This procedure resulted in the sampling of 10 utensils, one per establishment, all collected from equipment that staff reported as cleaned and ready for use, without prior notice that these specific items would be sampled.

Surface samples were collected using sterile swabs on approximately 10×10 cm areas of each utensil, applying a crosshatch swabbing technique recommended for environmental allergen monitoring (Neogen, 2020). Swabs were transferred to tubes containing the manufacturer's extraction buffer, shaken for 1 min, and the extracts were then analyzed using Reveal® 3-D lateral flow immunoassays (Neogen Corp., Lansing, MI, USA) for five priority food allergens: egg (Neogen, 2021a), total milk (Neogen, 2021b), gluten (Neogen, 2020), soy (Neogen, 2021c), and peanut (Neogen, 2023). A total of 50 tests were performed ($5 \text{ allergens} \times 1 \text{ utensil per establishment} \times 10 \text{ establishments}$). The Reveal® 3-D devices are qualitative, single-use lateral flow tests designed for rapid screening of low levels of allergen residues on environmental swabs and clean-in-place rinses, providing visually readable results in approximately 5 min. According to the manufacturer's specifications, the Total Milk kit screens samples at around 2 ppm milk protein (corresponding to approximately 5 ppm total milk) or $7 \mu\text{g}/100 \text{ cm}^2$ of protein on surfaces (Westlab, 2023), and similar sensitivity ranges (low ppm and low $\mu\text{g}/100 \text{ cm}^2$ levels) have been reported for the Reveal® 3-D kits (Neogen, 2020).

Test outcomes were interpreted visually as recommended by the manufacturer and recorded in four categories: negative (no detectable allergen, below the screening limit), positive (visible test line indicating allergen at or above the limit of detection), high positive/overload (pattern consistent with heavy contamination and potential line saturation), and invalid (absence of control line).

3.4. Analysis

The measurement model was evaluated prior to structural analysis using Confirmatory Factor Analysis (CFA) using Diagonally Weighted Least Squares (DWLS). Standardised item loadings above 0.50 were considered acceptable, indicating strong associations between indicators and their respective latent constructs. McDonald's omega (ω) was calculated for each construct, with values greater than 0.70 reflecting satisfactory internal consistency. Convergent validity was assessed through the Average Variance Extracted (AVE), with values above 0.50 taken as evidence that latent constructs captured sufficient variance from their indicators. Model fit was assessed using multiple criteria: relative chi-square ($\chi^2/\text{df} < 5$), Comparative Fit Index (CFI; preferably >0.95 , acceptable >0.90), Tucker–Lewis Index (TLI; preferably >0.95 , acceptable >0.90), Root Mean Square Error of Approximation (RMSEA <0.10 , with 90% confidence interval), and Standardised Root Mean Square Residual (SRMR <0.08).

Two structural models were estimated using the Covariance-based Structural Equation Model (CB-SEM) approach. The first validated the traditional NAM, examining classical paths between latent NAM variables. The second model extended NAM by introducing anticipated feelings of guilt, shame, and regret as parallel mediators of the relationship between ascription of responsibility and personal norms. CFI, TLI, χ^2/df , RMSEA, and SRMR were again applied to confirm robust model fit. Structural path coefficients were estimated and their significance assessed. Model explanatory power was evaluated using the coefficient of determination (R^2) for endogenous variables. Indirect effects (mediation) were analyzed using PROCESS technique, using

bootstrapped confidence intervals to determine the significance of mediating pathways. CB-SEM and mediation analysis were made in SmartPLS 4.1.1.6 (Ringle et al., 2024).

Two-way ANOVA was used to compare anticipated guilt, shame, and regret among them and among the three scenarios. The Bonferroni post hoc test was used for paired comparisons. CFA and two-way ANOVA was performed using JASP 0.18.2 (University of Amsterdam).

4. Results

This section presents the main findings of the study, organised around the regulatory context (H1), the extended NAM model linking knowledge, cognitive appraisals, personal norms, and behavioural intentions (H2–H7), and the mediating role of anticipated moral emotions (H8–H10).

4.1. Sample characteristics

The sample of 310 FBOs covered all five Brazilian regions and a broad range of food service formats, supporting the analytical scope of the study across diverse organisational and regulatory contexts. The mean age was 36 years. Professional experience in the food sector was predominantly 1–10 years (54.9%), with a further 22.7% reporting more than 15 years' experience. Just over half of participants identified as women (51.6%), and 48.4% as men. Most identified as white (56.5%), followed by black (20.7%). In terms of education, 43.8% had completed or partially completed secondary education, and 39.1% had completed or partially completed higher education. Most establishments were chains or franchises (63.7%), with the remainder operating independently. The most common service format was à la carte restaurants (28.15%), followed by snack bars (17.0%), and themed restaurants (15.4%).

4.2. Food allergy knowledge and decisions in anaphylaxis scenarios

FBOs showed good understanding of some key aspects of food allergy, but important knowledge gaps and suboptimal decisions in hypothetical anaphylaxis scenarios indicated substantial room for improvement in practice (Table 2). In particular, confusion between food allergy and intolerance and uncertainty about appropriate emergency responses were relatively common. Participants were first asked how they would respond if a customer experienced an anaphylactic reaction in the establishment: 77.3% indicated that they would respond appropriately by seeking immediate medical assistance, whereas 9.9% reported that they would attempt to identify which food the customer was allergic to, 7.2% stated that they would tell the customer that they should have informed staff about their allergy, and 5.6% indicated that they would investigate the possible cause of the reaction.

Regarding knowledge of allergenic ingredients, FBOs, on average, answered 70.9% of items correctly. For example, most participants correctly recognised that exposure to even small quantities of an allergen may trigger an allergic reaction (87.5%), that separate frying oils should be used for gluten-containing and gluten-free foods (83.6%), and that strict allergen avoidance is the most effective preventive strategy (82.2%). However, notable gaps remained: just over half of participants (53.3%) believed that lactose intolerance is similar to milk allergy, whereas only 28.0% correctly distinguished between these conditions, and only 61.5% were aware that allergens can be transferred via hands.

4.3. Regulatory context

Overall, FBOs operating in jurisdictions with specific allergen regulations did not consistently report higher levels of knowledge, ascription of responsibility, or awareness of consequences than those in jurisdictions without such regulations, and H1 was therefore not supported.

Table 2

Number and percentage of correct and incorrect responses on food allergy knowledge among food business operators in Brazil (n = 310).

Description	True n (%)	False n (%)	Uncertain n (%)
Ingesting a small amount of food allergen will cause an allergic reaction	271 (87.4%)	6 (1.9%)	33 (10.6%)
High temperature cooking such as roasting, baking, deep frying can reduce or destroy food allergen	37 (11.9%)	216 (69.7%)	57 (18.4%)
If someone has an allergic reaction, offer water to dilute the allergen and stop the reaction	37 (11.9%)	176 (56.8%)	97 (31.3%)
Lactose intolerance is similar to milk allergy	169 (54.5%)	85 (28.0%)	56 (18.1%)
Removing peanuts from a final dish will prevent an allergic reaction	24 (7.7%)	266 (85.8%)	20 (6.5%)
I can use the same hot oil to cook regular chips or gluten-free chips as the hot oil will destroy the allergen	15 (4.8%)	258 (83.2%)	37 (11.9%)
Allergens can be transferred by hands	188 (60.6%)	60 (19.4%)	62 (20.0%)
If there are limited utensils to prepare allergen and non-allergen meals separately, it should be OK to use the utensils for both types of food.	35 (11.3%)	243 (78.4%)	32 (10.3%)
If kitchen appliances are cleaned efficiently, this can prevent cross contamination of allergens	230 (74.2%)	56 (18.1%)	24 (7.7%)
The best way to prevent allergic reaction is to avoid the allergen	256 (82.6%)	22 (7.1%)	32 (10.3%)

Note: Bold values represent the correct answer for the sentence.

Although some descriptive differences emerged between locations, these patterns were small and did not translate into systematic advantages for regulated settings. FBOs from cities with local regulations on food allergy and those from cities or states without any regulation showed similar levels of ascription of responsibility (3.71 vs. 3.74; $p = 0.83$), awareness of consequences (4.01 vs. 3.93; $p = 0.39$), personal norm (4.05 vs. 3.97; $p = 0.45$), and intention (4.14 vs. 4.09; $p = 0.70$). Interestingly, food allergy knowledge was higher among FBOs from cities without any regulation (7.32 vs. 6.64; $p = 0.005$; $d = 0.35$), and knowledge levels did not differ significantly across regions ($F(4, 299) = 1.08, p = 0.36$).

4.4. Extended NAM model

The extended NAM showed good fit and largely supported the hypothesised cognitive pathways linking knowledge, awareness of consequences, responsibility attribution, personal norms, and behavioural intentions. Knowledge was positively associated with awareness of consequences and ascription of responsibility, and awareness of consequences and personal norms emerged as key drivers of FBOs' intentions to adopt allergen management and communication practices, whereas the path from responsibility to personal norms was weaker than expected.

CFA indicated that the measurement model was adequate: all standardised factor loadings exceeded 0.60 (Table 3), values for Omega were consistently above 0.76 (Table 4), and the AVE was above 0.50 for most factors, supporting reliability and convergent validity. Model-fit indices also met recommended thresholds ($\chi^2/df = 4.15$; CFI and TLI = 0.97; RMSEA = 0.054 [90% CI: 0.04–0.06]; SRMR = 0.039), underscoring the robustness of the specification and the adequacy of the latent constructs.

The CB-SEM showed an acceptable model fit, with all indices within recommended thresholds ($\chi^2/df = 2.44$; CFI = 0.94; TLI = 0.93; SRMR = 0.042; RMSEA = 0.068; 90% CI [0.059, 0.078]). In the structural model (Fig. 2). Awareness of consequences strongly predicted ascription of responsibility ($\beta = 0.817$; $R^2 = 0.68$) and personal norm ($\beta = 0.717$;

Table 3

Factor loadings, means, and standard deviations of the indicators of the Norm Activation Model applied to food allergy incidents in food service settings.

Code	Indicators	Standard loadings	Mean*	SD
Res1	I feel responsible for food allergy incidents that occur in the establishment where I am a manager or owner.	0.600	3.32	1.21
Res2	I can help prevent possible allergic reactions in customers with food allergies if I take the appropriate preventive measures.	0.821	4.07	0.88
Res3	I believe that food service food business operators should take responsibility for adopting practices to reduce the chances of customers experiencing any type of allergic reaction.	0.800	3.83	1.08
Res4	I cause harm to the health of customers with food allergies if there are no people with knowledge of the subject in my establishment	0.777	3.66	1.13
Con1	Serving food without properly considering food allergies can cause serious reactions in customers, including death.	0.813	4.01	0.94
Con2	Failure to communicate about allergenic ingredients in the food served can have a negative impact on the health of customers with food allergies.	0.882	4.10	0.78
Con3	Customers with food allergies may experience a reduced quality of life if they consume meals containing allergenic ingredients.	0.625	3.74	1.00
Con4	Adopting appropriate practices to communicate with customers with food allergies and following procedures to prevent allergen contamination can help create a fairer society.	0.826	4.09	0.82
PN1	I feel it is my moral duty to ensure that the food served in my establishment is safe for customers with food allergies, whether through good practices or accurate information provided to customers.	0.871	4.05	0.84
PN2	Regardless of what others do, because of my moral principles, values, and beliefs, I feel I should implement strict practices to prevent allergic reactions in my establishment.	0.853	3.88	0.92
PN3	I believe it is important that all food business operators take steps to prevent customers from being exposed to food allergens.	0.879	3.95	0.91
PN4	If I can contribute to making food safe for customers with allergies in my establishment, I feel I will be a better professional.	0.879	4.21	0.78
Int1	I intend to implement strict food safety practices in the future to prevent allergic reactions in my establishment.	0.814	3.93	0.85
Int2	I like the idea of ensuring that all my staff are well trained and informed about food allergies in order to provide safe food.	0.927	4.24	0.69
Int3	I have a positive attitude towards implementing food safety practices to prevent allergic reactions.	0.929	4.12	0.75
Int4	Implementing an effective communication system would be beneficial to prevent allergic reactions in customers.	0.891	4.24	0.75

Notes: Res: ascription of responsibility; Con = awareness of consequences; PN: Personal norms; Int: Behavioural intention. *Scale from 1 to 5; SD = Standard deviation.

Table 4

Mean values, standard deviations, and reliability indices (McDonald's omega and average variance extracted) of the constructs.

Factors	Mean*	SD	ω	AVE
Ascription of responsibility	3.72	0.82	0.767	0.637
Awareness of consequences	3.99	0.69	0.788	0.626
Personal norms	4.03	0.73	0.870	0.756
Behavioural intention	4.12	0.65	0.899	0.759
Anticipated guilt	3.96	1.08	0.779	0.560
Anticipated shame	3.88	1.14	0.811	0.580
Anticipated regret	3.95	1.15	0.798	0.617

* Scale from 1 to 5; SD = Standard deviation; ω = McDonald's Omega; AVE = Average variance extracted.

$R^2 = 0.77$), whereas the path from ascription of responsibility to personal norm was not significant ($\beta = 0.188$, n.s.). Thus, hypotheses 2 and 3 were supported and H4 was rejected. Personal norms strongly predicted behavioural intention ($\beta = 0.953$; $R^2 = 0.91$), indicating a high explanatory power of the model for intention and confirming hypothesis 5. Extending the model, knowledge positively predicted awareness of consequences ($\beta = 0.330$; $R^2 = 0.12$), but did not significantly predict ascription of responsibility ($\beta = 0.027$, n.s.), thereby confirming H6 and rejecting H7.

4.5. Anticipated moral emotions

Anticipated moral emotions contributed differentially to the extended NAM, with guilt emerging as the most robust mediator between cognitive appraisals, personal norms, and behavioural intentions, whereas anticipated regret and shame showed weaker or non-significant mediation effects, providing only partial support for H8–H10 and highlighting guilt as the main emotional pathway in this context. Fig. 3 displays the mean levels of guilt, shame, and regret across the three scenarios. The two-way ANOVA indicated significant main effects for both emotion and scenario: regret was lower than guilt ($p = 0.013$) and shame ($p = 0.005$), whereas guilt and shame did not differ significantly. In Scenario 1 (management), negative emotions were lower than in Scenario 2 (communication; $p = 0.022$) and Scenario 3 (training; $p = 0.001$), with Scenarios 2 and 3 showing similar mean levels of negative emotions.

The mediation results provided partial support for the proposed hypotheses (Table 5). The cognitive mediation paths of the NAM were broadly confirmed: ascription of responsibility significantly mediated the relationship between awareness of consequences and personal norms (Con → Res → PN), and personal norms mediated the relationship between awareness of consequences and behavioural intention (Con → PN → Int), as well as between ascription of responsibility and behavioural intention (Res → PN → Int). Thus, the mediation hypotheses based solely on the core NAM variables were supported. Regarding moral emotions, anticipated guilt showed consistent mediation effects, whereas regret and shame were not supported, indicating that only H9 was confirmed. The mediation of guilt between awareness of consequences and personal norms was significant (Con → Guilt → PN), as was the sequential mediation via personal norms in relation to behavioural intention (Guilt → PN → Int), and the composite indirect path (Con → Guilt → PN → Int), indicating that guilt operates as an additional mediator between the cognitive components of the model and intentions to implement preventive practices. In contrast, the confidence intervals for all effects involving regret and shame included zero, indicating no significant mediation.

4.6. Environmental allergen detection

Environmental testing of routinely cleaned utensils in establishments that reported being prepared to serve food-allergic customers revealed mostly negative results, but detectable contamination with egg or gluten

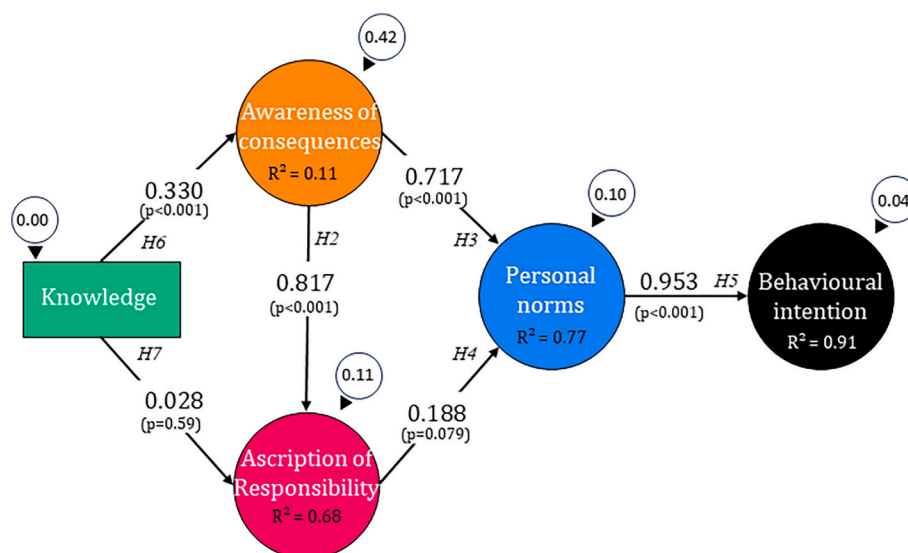


Fig. 2. Covariance-based structural equation model with standardised path coefficients, p -values, hypotheses (H) and explanatory power (R^2).

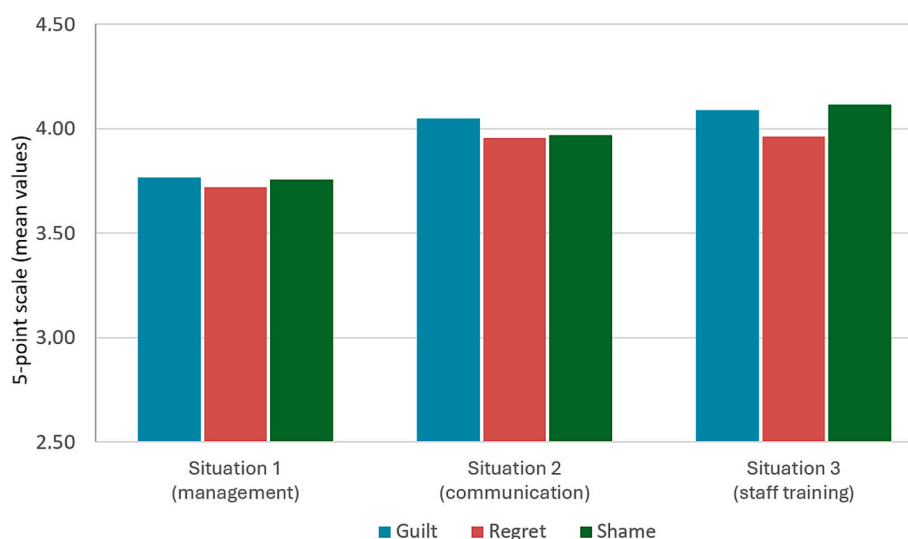


Fig. 3. Mean values of emotional variables (guilt, regret, and shame) reported by food business operators across three hypothetical situations in food service settings.

in four blenders. Table 6 presents the results of the surface tests for food allergens carried out in food service establishments that reported being prepared to serve customers with food allergies. In line with the pre-defined decision map, blenders were tested in seven establishments, cutting boards in two, and a pot in one, totalling 50 tests. Most samples (88%) were negative for the allergens assessed. Of the 50 surface tests conducted, 8.0% ($n = 4$) returned a positive result for food allergens: three for egg and one for gluten, all detected on blenders shared within the food service operations. Two additional tests (one for egg and one for gluten) were classified as invalid.

5. Discussion

This study investigated how Brazilian food business operators perform in three domains: (i) knowledge and decision-making in anaphylaxis/allergic reaction scenarios, (ii) environmental control of allergens on food-contact surfaces, and (iii) cognitive and emotional determinants of intentions to act towards allergen-safe practices, modelled through an extended NAM.

Overall, the findings provided mixed support for the proposed

hypotheses. H1 was not supported, as FBOs in jurisdictions with specific allergen regulations did not consistently show higher levels of knowledge, ascription of responsibility, or awareness of consequences than those in jurisdictions without such regulations. H2, H3, H5, and H6 were confirmed, indicating that awareness of consequences and personal norms act as key cognitive drivers of FBOs' intentions, and that knowledge primarily operates through awareness of consequences rather than directly through responsibility attribution. In contrast, H4 and H7 were not supported, suggesting that ascription of responsibility plays a more limited role in shaping personal norms than originally anticipated. Regarding moral emotions, only H9 was confirmed, as anticipated guilt – but not regret or shame – significantly mediated the relationships between awareness of consequences, personal norms, and behavioural intentions, whereas anticipated regret and shame did not show significant mediation effects, leading to the rejection of H8 and H10.

5.1. Preparedness, knowledge gaps, and practice

Although establishments stated that they were prepared to serve customers with food allergies, responses to scenario-based items showed

Table 5

Indirect effects and mediation results for cognitive and emotional pathways in the norm activation model.

Path identification	Path	Sample mean	97.5% CI (lower bound)	97.5% CI (upper bound)
Con -> Res -> PN	a ₁ b ₁	0.193	0.103	0.287
Con -> Guilty -> PN	a ₂ b ₂	0.059	0.008	0.131
Con -> Regret -> PN	a ₃ b ₃	-0.017	-0.087	0.055
Con -> Shame -> PN	a ₄ b ₄	0.017	-0.048	0.083
Con -> PN -> Int	a ₅ d	0.385	0.202	0.564
Res -> PN -> Int	b ₁ d	0.194	0.098	0.303
Guilty -> PN -> Int	b ₂ d	0.097	0.014	0.192
Regret -> PN -> Int	b ₃ d	-0.029	-0.140	0.078
Shame -> PN -> Int	b ₄ d	0.026	-0.069	0.125
Con -> Res -> PN -> Int	a ₁ b ₁ d	0.151	0.079	0.224
Con -> Guilty -> PN -> Int	a ₂ b ₂ d	0.045	0.006	0.098
Con -> Regret -> PN -> Int	a ₃ b ₃ d	-0.013	-0.068	0.043
Con -> Shame -> PN -> Int	a ₄ b ₄ d	0.013	-0.037	0.064

CI = confidence interval; Con = awareness of consequences; Res: ascription of responsibility; PN: Personal norms; Int: Behavioural intention; Bold values indicate significant mediation.

Table 6

Qualitative results of environmental allergen detection in food business (n = 10).

Food allergen	Negative	Positive	High positive	Invalid
Egg	6	3	0	1
Total milk	10	0	0	0
Gluten	8	1	0	1
Soy	10	0	0	0
Peanut	10	0	0	0

n = 50 surface tests (5 allergens × 1 utensil per establishment × 10 establishments).

that not all FBOs would act appropriately in an anaphylactic reaction. Key misconceptions persisted, such as confusion between lactose intolerance and milk allergy or limited awareness of hand-mediated allergen transfer. The prevalence of doubt and uncertainty across nearly all items was particularly notable. Previous studies have shown that many food service establishments report being confident in their ability to provide safe meals for customers with food allergies (Ahuja & Sicherer, 2007; Bailey et al., 2011; Dupuis et al., 2016; McAdams et al., 2018a). However, substantial knowledge gaps have been widely reported, even in settings where allergen information for non-prepacked foods is mandatory, such as in the United Kingdom (European Union, 2011; Soon, 2018). When high confidence coexists with limited knowledge, unsafe practices may result (Dupuis et al., 2016).

Considering that food service establishments are the second most common setting for allergic reactions (Oriel et al., 2021), adequate knowledge is essential to prevent tragic outcomes, as illustrated by the death of 18-year-old Owen Carey after consuming a dish marinated in buttermilk despite having informed staff of his milk allergy (Soon, 2020). Knowledge levels have been associated with previous training (Elsahoryi et al., 2021; Jianu & Goleţ, 2019; Lee & Sozen, 2016a), higher educational attainment (Ajala et al., 2010; Elsahoryi et al., 2021; Jianu & Goleţ, 2019), and longer professional experience in food service operations (Nasseredine et al., 2021b; Radke et al., 2016), factors that may help explain the heterogeneity observed in the present study.

Notably, FBOs in locations with specific regulations did not exhibit higher levels of attitudes and showed significantly lower knowledge scores than those in several large cities without allergen regulations (e.g. Ribeirão Preto, Piracicaba, Natal), possibly reflecting greater exposure to food-allergic consumers and accumulated experience in dealing with them, consistent with evidence that well-informed experience enhances

food safety knowledge (Brannon et al., 2009). This pattern also reflects the limited scope of existing Brazilian regulations (Table 1), which mandate ingredient disclosure but do not require staff training, allergen management systems, or cleaning verification—elements consistently identified as essential in comprehensive allergen safety frameworks (Vicentini et al., 2026). Disclosure requirements alone do not inherently build staff competency or operational capacity, particularly in the absence of enforcement mechanisms or technical support for implementation. Overall, these findings emphasise the multidimensional nature of knowledge about food allergy—shaped by formal education, prior training, practical experience, and heuristic judgements formed in everyday practice—while also suggesting that a national, standardised regulation could strengthen coherence and support the consistent dissemination of food safety practices.

Surface testing in the present study revealed predominantly negative results (i.e., traces of allergens were undetected), yet residual allergens were detected on four shared blenders in the sample, suggesting that even in establishments reporting readiness to serve allergic consumers, critical points of cross-contact may not always be adequately controlled. Although limited in scale, these findings provide preliminary evidence that perceived preparedness may not always align with effective allergen control in practice. This observation should be interpreted cautiously and not generalised, but it highlights potential areas of concern that warrant further investigation in larger and more representative studies.

Unlike microbial contamination, which can be eliminated with sanitising agents, allergenic residues result from food proteins that must be physically removed (Eisenberg & Delaney, 2018). Their effective removal depends on factors such as the type and quantity of food, cooking methods, surface characteristics, and cleaning methods used. In particular, complex equipment such as blenders can be difficult to clean thoroughly, with residues accumulating in crevices and around blades, thereby increasing the likelihood that allergens persist despite routine cleaning. Standard cleaning procedures (washing, rinsing, sanitising, and air drying) can be effective (Bedford et al., 2020), but any deviation—often due to gaps in knowledge or inconsistent practices—may leave traces of allergens. Even basic operations, including ingredient verification or handwashing, can become sources of risk when inadequately executed (Carter et al., 2020; Dupuis et al., 2016). The fatal anaphylactic reaction of 12-year-old Mia-Shay St Hilaire in a London café in 2023, attributed to a milkshake prepared in an uncleaned blender contaminated with tree nut residues and accompanied by multiple documented failures in allergen communication and control, exemplifies how inadequate equipment hygiene and allergen management can have catastrophic consequences for allergic consumers (Southwark Council, 2025).

Allergen traces have also been reported in areas designated for allergen-free preparation (Ortiz et al., 2018), illustrating how cross-contact can occur despite good intentions and policies. The presence of residual allergens alongside relatively high levels of knowledge suggests that knowing what to do does not always translate into consistently safe practice. Allergen management thus appears to be a behavioural and organisational challenge rather than merely an informational one, reinforcing the utility of frameworks such as the NAM for understanding how safety intentions are translated – or fail to be translated – into action. Although the environmental testing was not statistically linked to the behavioural model, it provides complementary context to the self-reported data. While the structural model captures intentions, norms, and perceived responsibility, the exploratory environmental results offer an objective glimpse into actual practices. Together, these components illustrate a potential gap between perceived preparedness and real-world implementation, a phenomenon widely discussed in food safety literature.

5.2. About the norm activation model and guilt

The traditional cognitive structure of the NAM was supported: awareness of consequences and ascription of responsibility predicted personal norms, which in turn shaped intentions to implement food safety and communication practices aimed at preventing allergic reactions. Among the moral emotions only anticipated guilt – but not regret or shame – emerged as a significant mediator between cognitive appraisals (consequences and responsibility) and personal norms or intentions. This finding underscores guilt as the central emotional mechanism linking “knowing and feeling responsible” to “feeling morally obliged to act.”

The prominence of guilt suggests that FBOs interpret failures in allergen management primarily as moral transgressions against consumers – violations of what they perceive they ought to do – rather than as social exposure (shame) or counterfactual evaluation (regret). Anticipated feelings of guilt align individuals' behaviours with their moral self-concept (Onwezen et al., 2013), as guilt is inherently bound to one's sense of morality. As people typically avoid negative emotions such as guilt (Onwezen et al., 2013; Pletti et al., 2016), their anticipation can motivate preventive behaviour. Guilt entails self-condemnation for perceived harm to others (Tangney et al., 1996), often accompanied by self-directed anger or disgust, thereby activating a heightened sense of responsibility and a desire for reparation. Similarly, in Sheikh and Janoff-Bulman (2010), their study revealed that guilt influences moral obligations more than shame due to its prescriptive nature or its focus on what ought to be done to improve the situation. Consequently, individuals who experience guilt are more inclined to correct their mistakes and to engage cooperatively with others (Rosenthal & Yu, 2022). When moral dilemmas arise, people tend to choose actions that minimise potential experiences of guilt (Pletti et al., 2016).

The centrality of guilt in this study may also reflect its socially embedded nature. Guilt operates not only as an individual moral regulator but also as a socially embedded emotion linked to empathy and community attachment (Rosenthal & Ho, 2020b; Rosenthal & Yu, 2022; Tangney et al., 1996). It can be conceptualised as a psychological response to failing to meet another person's expectations (Chang et al., 2011). Anticipating guilt from failing consumer expectations can motivate cooperative and preventive action, particularly in decisions that affect others (Chang et al., 2011; Pletti et al., 2016), thereby prompting FBOs to act consistently with their personal and moral norms.

Overall, this pattern contributes to the theoretical application of the NAM in the food safety domain by suggesting that not all negative emotions are equally associated with behavioural intentions. Focusing on guilt as a salient moral emotion may offer a useful conceptual refinement for understanding how moral responsibility relates to intentions in allergen management. However, because the SEM analysis was based on cross-sectional, self-reported data and assessed intentions rather than observed behaviour, causal inferences should be made cautiously. Future studies, particularly intervention trials and longitudinal observational research, are needed to determine whether strategies aimed at strengthening moral responsibility and anticipated guilt translate into observable improvements in allergen-management practices.

5.3. Implications for practice

Previous research consistently highlights training as fundamental for improving food allergy management in food service settings (Ahuja & Sicherer, 2007; Radke et al., 2016; Soon, 2018). Effective programmes enhance both knowledge and attitudes among staff (Lee & Sozen, 2016b; McAdams et al., 2018b; Radke et al., 2016). Building on this evidence, training for allergy-prepared establishments could go beyond factual instruction and emergency procedures to cultivate moral awareness, emphasising consequences, personal responsibility, and the anticipated guilt associated with preventable allergic incidents. Scenario-based and

simulation activities can make these moral stakes explicit and reinforce personal norms that drive safer behaviour. From an operational standpoint, interventions could prioritise equipment identified as high risk for cross-contact (e.g. shared blenders) and implement clear segregation, cleaning, and verification routines to ensure consistent control of food allergen residues.

5.4. Implications for policy and inspection

Current food safety legislation in Brazil does not explicitly recognise food allergens as hazards, meaning that failures increasing the risk of allergic reactions may go unnoticed by both food handlers and EHOs. The present findings indicate that FBOs generally show strong intentions to protect consumers with food allergies; however, observed knowledge gaps and, in limited exploratory testing, instances of residual allergen contamination suggest that technical weaknesses in allergen control may exist in some establishments. These could be mitigated through targeted policy measures, training programmes, and EHO guidance. The findings regarding H1 underscore that ingredient disclosure regulations, while well-intentioned, do not by themselves ensure allergen safety. The absence of differences—or in some cases, paradoxically lower knowledge—in regulated jurisdictions suggests that the nature of regulation matters as much as its existence. Effective allergen management requires not only consumer-facing communication but also behind-the-scenes operational controls, staff competency, and organisational accountability. This distinction is critical: the present study does not suggest that regulation is ineffective; rather, it indicates that regulation focused solely on disclosure may be insufficient. A first step could be the creation of standardised national legislation on allergen management in food service, reducing the current fragmentation of local requirements and ensuring consistent expectations for the sector. Beyond pre-packed food labelling, legislation could define minimum standards for restaurants that claim to be allergy-prepared, including procedures for menu communication, equipment segregation, cleaning verification, and emergency management, thereby strengthening consumer protection and enabling EHOs to promote more consistent enforcement and education across jurisdictions.

5.5. Limitations and future research

The cross-sectional, self-reported nature of the NAM component limits causal inference and may overestimate actual behaviour; longitudinal or observational studies conducted in real-time service situations would provide stronger evidence. Given Brazil's size and heterogeneity, the non-probabilistic sample, although intentionally stratified across regions and food service formats, may not fully capture local specificities, and the findings should therefore be generalised with caution. In addition, allergen surface testing was restricted to a small number of establishments and to selected utensils identified by the decision map, potentially underestimating contamination in other equipment or kitchen areas. In addition, allergen surface testing was restricted to 10 establishments in two cities (Limeira and Campinas) and to selected utensils identified by the decision map, potentially underestimating contamination in other equipment or kitchen areas. These findings should therefore be interpreted as exploratory, given the limited and geographically restricted subsample, and should not be generalised to the broader Brazilian food service sector.

The use of hypothetical scenarios to measure anticipated guilt, shame, and regret also means that emotional responses were inferred rather than observed in real events, and future research could complement this approach with qualitative or observational methods. Finally, FBOs' reported intentions and perceived preparedness were not systematically compared with direct observations of routine practices, highlighting a gap between reported intentions and observed practice that should be addressed in future studies. Additionally, the study assessed behavioural intentions rather than observed behaviour, and

although intentions are strong predictors of action, they do not guarantee implementation. Finally, the study did not experimentally test the effects of specific interventions (e.g., training programmes, regulatory enforcement, or moral-emotion appeals), limiting direct policy recommendations.

6. Conclusion

This study shows that Brazilian FBOs generally express strong intentions to protect consumers with food allergies, yet important knowledge gaps remain, and exploratory environmental testing identified residual allergen contamination in some establishments reporting readiness to serve allergic consumers. The extended NAM results indicate that awareness of consequences and personal norms are key cognitive drivers of behavioural intentions, and that anticipated guilt, rather than regret or shame, functions as the main moral-emotional pathway linking cognitive appraisals to intentions regarding allergen management and communication. The lack of systematic advantages in jurisdictions with specific local regulations and the detection of residual allergens on shared equipment suggest that national, standardised guidance may be needed that integrates technical requirements with interventions targeting moral awareness, training, and everyday organisational practices in food service settings.

CRedit authorship contribution statement

Mariana Scudeller Vicentini: Writing – review & editing, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Mirela Nielsen Estigarribia:** Writing – original draft, Investigation. **Giovana Boni Cardoso:** Writing – original draft, Investigation. **Carolina Neves Freiria:** Writing – original draft, Investigation, Formal analysis. **Fabiana Magnabosco Vargas:** Writing – original draft, Investigation. **Raísa Dardaque Mucinhato:** Writing – original draft, Investigation. **Elke Stedefeldt:** Writing – original draft, Methodology, Investigation, Conceptualization. **Lais Mariano Zanin:** Writing – review & editing, Investigation, Funding acquisition, Conceptualization. **Caroline Opolski Medeiros:** Writing – review & editing, Methodology, Investigation, Conceptualization. **Verônica Cortez Ginani:** Writing – review & editing, Investigation. **Priscilla Moura Rolim:** Writing – review & editing, Methodology, Investigation, Conceptualization. **Tatiana Evangelista da Silva Rocha:** Writing – review & editing, Methodology, Investigation, Conceptualization. **Iain Malcolm Ferris:** Writing – review & editing, Methodology, Investigation, Funding acquisition, Conceptualization. **Jan Mei Soon-Sinclair:** Writing – review & editing, Methodology, Investigation, Funding acquisition, Conceptualization. **Lisa Marie Winnall:** Writing – review & editing, Methodology, Investigation, Funding acquisition, Conceptualization. **Diogo Thimoteo da Cunha:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, we used ChatGPT and Gemini to assist with translation and to improve the text readability.

Declaration of competing interest

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

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Data availability

Data will be made available on request.

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