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COVID-19 contamination through food: A study with Brazilian consumers of different socioeconomic and demographic characteristics

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Abstract

This study aimed to investigate through free word association the perception of Brazilian consumers regarding the possibility of infection with the SARS-CoV-2 virus through food. One thousand individuals answered the questionnaire via an online platform. Most cited terms (hygiene—8%, fear—8%, caution—5%) and categories (negative attitudes and feeling—72% and sanitization—60%) were related to overall COVID-19 infection rather than their specific infection through the food. The perception of the possibility of risk of this type of cross-contamination was greater for male participants, within the food field, with high income (>10 minimum wages), and from the midwest region. Nonetheless, there are still doubts regarding this possibility, especially for participants with low income (≤10 minimum wages), females, higher education (≥secondary school), who exercise professional activity outside the food sector and from most regions of Brazil.

Practical applications

Although the SARS-CoV-2 virus was discovered 2 years ago, the emergence of new variants such as Omicron has increased infection and mortality rates worldwide. A possible way of COVID-19 infection is cross-contamination through food handling and contact surfaces if preventive measures are not applied. In this context, understanding the consumer perception from a continental-size country such as Brazil, with a wide variety of socioeconomic profiles, is crucial to minimize the severe impacts of the pandemic. Our study demonstrates the need to disseminate scientific information in different media to reduce misinformation, especially social media because most Brazilian consumers had doubts and uncertainties about the possibility of COVID-19 infection from cross-contamination through food.

1 | INTRODUCTION

The acute respiratory syndrome caused by the new coronavirus (SARS-CoV-2) is still causing death in several countries worldwide, including the emergence of the Omicron variant that is affecting several African and European countries (BBC, 2021a, 2021b). Up to now, the COVID-19 pandemic has resulted in more than 448 million infected people and more than 6 million deaths (WHO, 2021a), leading to the oppression of health systems and economic and psychological consequences (Böger et al., 2021). In Brazil, the COVID-19 provoked a high infection rate (over 29 million people) and mortality (more than 653 thousand dead people) until mid-March 2022 (Brazil, 2022).

In order to contain the transmission of the virus, prevention measures have been applied worldwide (Rees et al., 2020). Nonetheless,

these measures have impacted peoples' lives, leading to changes in consumer behavior, particularly concerning food and food safety (Thomas & Feng, 2021). This trend was globally identified in mid-March 2020, where terms such as "food" and "immune system" increased 670% in the prevalence of internet searches (Ayseli, Aytekin, Buyukkayhan, Aslan, & Ayseli, 2020).

Foodborne illnesses are the leading preventable causes of deaths and economic losses (Parra, Kim, Shapiro, Gravani, & Bradley, 2014), with over 600 million cases resulting in 420,000 deaths and US$ 110 billion lost each year all around the world (WHO, 2021b; WHO, 2022). Regarding the Americas, it is estimated that 77 million people are affected every year, and more than 9,000 people die of a foodborne illness (PAHO, 2021). Most individual outbreaks of foodborne illnesses are attributed to pathogenic bacteria (*Salmonella*, *Listeria* or *Escherichia coli*) and viruses (norovirus or hepatitis A; FDA, 2021a). So far, cases of the SARS-CoV-2 virus have been reported on the surface of chicken meat and utensils used to handle salmon meat (Aday & Aday, 2020; Castro, 2020). However, food is not officially considered a source of contamination for SARS-CoV-2, and specialists consider this risk low (CDC, 2020; WHO, 2020).

Nevertheless, many consumers are hesitant to buy any raw or packed product that could have come in contact with the virus (Lufkin, 2020), which can be associated with feelings of vulnerability and fear caused by previously disclosed information about COVID-19 outbreaks involving food (Ali, Harris, & Ryu, 2019). For example, in the United States, restaurant closings were interpreted as an indication that the food offered in these establishments was unsafe, which resulted in losses of US$ 120 billion between March and May 2020 (Byrd et al., 2021).

Conflicting information shared from government agencies, media, and social platforms can influence people's risk perception (Faour-Klingbeil, Osaili, Al-Nabulsi, Jemni, & Todd, 2021; Haas, 2020). Some communication channels may also present false equivalence between scientific evidence and uninformed opinions (Hartley & Vu, 2020). Finger et al. (2021) demonstrated that, in Brazil, the main channels for obtaining information for COVID-19 were television (55.7%), government sites (55.0%), news sites (52.1%), social media (32.6%), and messaging apps (24.2%). Therefore, it is crucial to understand the perception of Brazilian consumers in exceptional circumstances, considering that trust in authorities and scientific information is essential to reduce unnecessary fears and erroneous risk perception and attitudes (Faour-Klingbeil et al., 2021).

Despite that, there are few studies concerning the Brazilian consumers' perception of the overall COVID-19 pandemic scenario, and no study to date has evaluated this perception regarding SARS-CoV-2 infection by food. It gets more important in Brazil, which is considered a continental-size country with a wide variety of socioeconomic profiles (Finger et al., 2021). Therefore, understanding consumers' perception in the current pandemic context in a regionalized manner is essential for developing clear and effective communication policies. This research offers an opportunity to fill this gap, contributing to improving specific public policies related to food and health, mainly in the case of a new wave of COVID-19 infection, which is already taking place in European countries (WHO, 2021c).

The Free Word Association (FWA) is a projective technique widely used in market research and psychology to study consumers' knowledge, perceptions, feelings, motivations, and attitudes (Gero et al., 2020; Popoola, Anders, Feuereisen, Savarese, & Wismer, 2021). As this technique has no right or wrong answers, respondents evoke their spontaneous thoughts, feelings, and attitudes, which is crucial to identify a subject's actual state, overcoming the limitations of predefined questionnaires (Gero et al., 2020). The FWA has contributed with relevant information regarding the consumers' perceptions and attitudes toward functional foods (Rojas-Rivas, Espinoza-Ortega, Martínez-García, Moctezuma-Pérez, & Thomé-Ortiz, 2018), herbal infusions (Rocha, Moura, & Cunha, 2020), wine (Celhay & Remaud, 2018), fermented milk (Pinto et al., 2018), maize tortilla (Sánchez-Vega, Espinoza-Ortega, Thomé-Ortiz, & Moctezuma-Pérez, 2020), fish as a meal by Brazilians (Viana et al., 2021) and the overall COVID-19 pandemic scenario (Melo et al., 2021). In this context, the present study aimed to investigate how the COVID-19 infection through food is perceived by Brazilian consumers using the FWA and exploring different socioeconomic and demographic characteristics.

2 | MATERIAL AND METHODS

2.1 | Participants

The present study was conducted with a convenient sample with no planning to represent an actual population but rather provide valuable qualitative inferences. A total of 1,000 participants (Table 1) were recruited by email and publications on social networks. The criteria for selecting the participants were age over 18 and the interest and availability to participate in the study. The experimental procedure was approved by the Ethics Committee of the University Hospital Clementino Fraga Filho at the Federal University of Rio de Janeiro, Brazil (N° 40890220.9.0000.5257).

2.2 | Procedures

First, participants were asked to give consent to participate in the study. Then, the participants read the statement "What do you think about contamination by COVID-19 through food?" and they were requested to write the first four words, terms, or phrases that came to mind. For this purpose, space was provided, allowing participants to place as many words or phrases as needed. After that, they were asked to answer six multiple-choice questions concerning socioeconomic and demographic characteristics (gender, age, education, income, living region, and education field). The questionnaire was implemented in a web interface (Google Forms), and data were collected from November 2020 to January 2021.

TABLE 1 Socioeconomic and demographic information of the consumers ($n = 1{,}000$)

	Consumers (%)
Gender	
Female	70.8
Male	29.2
Age (years old)	
18–25	22.9
26–35	31.8
36–45	21.6
46–55	10.9
56–65	8.2
>65	4.6
Living region	
South	22.5
Southeast	54.1
Midwest	5.0
Northeast	13.0
North	5.4
Income—Brazilian minimum wage (R$ 1,045.00)[a]	
1–5	41.0
>5–10	31.7
>10–20	18.5
>20–30	6.3
>30	2.5
Education	
Primary school	0.7
Secondary school	4.1
University and/or postgraduate	95.2
Education field	
Food field[b]	35.7
Other fields	64.3

[a]In Brazilian currency (real).
[b]Veterinary medicine, nutrition, pharmacy, food engineering, or food science and technology.

2.3 | Data analysis and multivariate statistic approach

Data analysis was adapted from Andrade, Sobral, Ares, and Deliza (2016). All valid responses from the participants were considered. Then, the frequency of mention of each word, term, or phrase was calculated. Terms with similar meanings were grouped into different categories utilizing inductive triangulation coding. Likewise, the categories were merged into dimensions. The categorization of terms and the definition of categories and dimensions were determined by three consensus researchers with experience in studies related to consumer behavior to reduce subjective influences (Guerrero et al., 2010).

When cited by at least 5% of the participants, the categories and dimensions were considered for analysis. The frequency of mention of words, categories, and dimensions was calculated without considering whether the words were provided by the same participant or by different participants. For this reason, the relative frequency of mentioning categories/dimensions can be over 100% (Andrade et al., 2016; Guerrero et al., 2010; Viana et al., 2021).

Chi-square tests were used to assess statistical differences in the frequency of mention of categories and dimensions among participants with different socioeconomic and demographic characteristics. In addition, a chi-square test per cell was used to identify the source of variation of the global chi-square (Symoneaux, Galmarini, & Mehinagic, 2012).

For hierarchical cluster analysis (HCA), the first two dimensions with a cumulative variance percentage (CVP) above 86% were used as input using the Euclidean distance and Ward's linkage algorithm (Krieger, Cabaset, Pestoni, Rohrmann, & Faeh, 2018). Correspondence analysis (CA) was used to identify associations between categories and socioeconomic and demographic characteristics. The HCA was used to form consumer groups by their socioeconomic and demographic characteristics, and CA was used for characterizing them considering the categories. The CA and HCA analyses were performed using the R Studio software (version 4.1.0). The CA analysis was performed with the FactoMineR package and the HCA analysis with the Cluster package (Kassambara, 2017a, 2017b).

3 | RESULTS AND DISCUSSION

3.1 | Consumers' associations with COVID-19 contamination through food

When asked about the first four words, terms, or phrases that came to their minds when thinking about COVID-19 contamination through food, most of the answers given by the participants consisted of individual words. In the present research, 1,000 participants mentioned 3,499 terms, of which 888 were different, resulting in an average value of 3.49 associations per participant. According to Guerrero et al. (2010), the high number of responses indicates that the participants were familiar with the topic addressed in the task, and average value ≥2.42 associations per participant suggests a clear mental formation of words. The words *hygiene*, *fear*, and *caution* were some of the most cited (Figure 1). This may be due to the constant dissemination of information regarding the protective measures and the COVID-19 pandemic in general.

Most of the terms were related to overall COVID-19 infection rather than their specific infection through the food. The current scenario of uncertainty about the virus SARS-CoV-2 regarding its high transmission and mortality rates around the world in association with ambiguous and conflicting information causes concerns and confusion in the population (Lee & Morling, 2021). Therefore, it is expected that consumers evoke negative feelings when they face matters concerning COVID-19. Moreover, these feelings can induce consumers to take extreme measures beyond official recommendations due to the fear of contracting the virus (Thomas & Feng, 2021). As the previous analysis does not consider the potential synonyms, the words and

terms with similar meanings were grouped (Viana et al., 2021), resulting in 18 categories, which formed eight dimensions, enabling a better understanding of consumers' perceptions (Table 2).

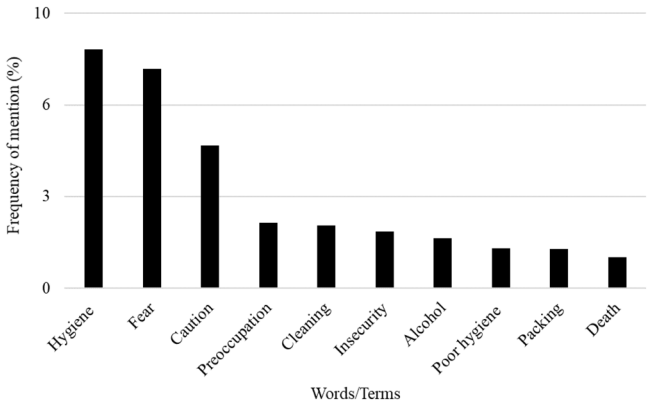

FIGURE 1 Frequency of mention of the most frequently mentioned individual words or terms when participants were asked to write down the first four words, terms, or phrases that came to their minds when thinking about COVID-19 contamination through food

The participants mainly related the possibility of SARS-CoV-2 infection through food to the dimension *attitudes and feelings* (72%), in which the category *negative* was the most representative, featuring terms such as *fear*, *worry*, *insecurity*, *sadness*, *anxiety*, and *anguish*. Although it's not an actual risk, the idea of the possibility of COVID-19 transmission through food can naturally evoke negative emotional patterns facing the disastrous consequences of this pandemic. Ahorsu et al. (2020) reported that the fear of COVID-19 infection is due to its high transmission rate, morbidity, and mortality, leading to a panic situation in which individuals may not think clearly and rationally concerning any matter related to this virus. In partial agreement with our study, Gómez-Corona et al. (2021) reported that consumers from Peru, Spain, and Mexico classified their fear of COVID-19 into dimensions: emotional fears (unhappiness, return to normality, emotional instability, and isolation social) and social fears (possibility of increased hunger, recession, price increases). Therefore, our findings may reflect the high number of deaths and confirmed cases of COVID-19 in Brazil (Brazil, 2022).

The second most cited dimension was *sanitization* (70%), which included the categories of *sanitization* and *poor hygiene* (Table 2),

TABLE 2 Frequency of the dimensions, categories, and examples of individual associations identified when consumers were asked to write down the first four words, terms, or phrases that came to their minds when thinking about COVID-19 contamination through food (in decreasing order of frequency)

Dimensions	Categories (examples of the most relevant individual words/terms)	Percentage of mention (%)
Attitudes and feelings		72
	Negative (fear, worry, insecurity, sadness, anxiety, anguish)	72
Sanitization		70
	Sanitization (hygiene, cleanliness, alcohol)	60
	Poor hygiene (lack of hygiene, dirt)	10
Aspects of COVID-19		67
	Prevention measures (care, prevention, precaution)	38
	Symptoms and implications (dying, hospital, sneezing, tiredness, intensive care unit)	12
	Modes of transmission (cross-contamination, contact, hand, saliva agglomeration)	10
	General aspects (disease, virus, immunity, pandemic, bat)	7
Risk perception		38.5
	Possibility of risk (likely, possibility)	17
	No risk (unlikely, fake, impossible)	14
	Low risk (difficult, rare)	7.5
Productive chain		37.5
	Places of purchase and consumption (restaurants, supermarkets, fairs)	17
	Packing (packaging, contaminated packaging, plastic)	8
	Food handling (handling, improper handling)	7
	Food safety (security, quality)	5.5
Other associations		14
	Others (family, transport, temperature, China, faith)	9
	Social and political matters (lack of information, information, research)	5
Food		12
	Food type (fruits, raw foods, meat, vegetables)	12
Unfamiliarity		9
	Doubt (doubt, uncertainty, "really?")	9

suggesting that Brazilian consumers are aware of the importance of hygienic practices and inadequate sanitization of food and utensils may increase the contamination levels. International organizations have widely released Good Manufacturing Practices and Good Hygiene Practices (GMP/GHP) recommendations for collective food establishments and practices, mainly during the COVID-19 pandemic (CDC, 2020; FDA, 2021b; WHO, 2020), highlighting the adequate safety standards in the mind of participants.

The *aspects of COVID-19* dimension was also frequently mentioned by consumers (67%; Table 2). The most representative categories within this dimension, in decreasing order of frequency, were: *prevention measures*, *symptoms and implications*, *modes of transmission*, and *general aspects*. The category *prevention measures* included words such as *care*, *prevention*, and *precaution*. It is known that some attitudes can minimize the possibility of transmitting the virus, such as avoiding human proximity in daily interactions (*supermarkets*, *restaurants*, and *fairs*) and contact with droplets and contaminated surfaces (Manigandan et al., 2020). In this way, the participants' knowledge regarding the collective and individual care protocols recommended by the health agencies was clear. The category *symptoms and implications* comprised the words/terms *dying*, *hospital*, *sneezing*, *tiredness*, *Intensive Care Unit (ICU)*, among others concerning symptoms from SARS-CoV-2 contamination and hospital context. The category *modes of transmission* included words related to possible contamination routes of COVID-19, such as *cross-contamination*, *contact*, *hand*, *saliva*, and *agglomeration*. The *general aspects* category included words such as *disease*, *virus*, and *immunity*. These terms are associated with the general process of susceptibility to viral contamination. Likewise, the words *pandemic* and *bat* were also observed in this category. The word *bat* may be related to information released by the media stating scientific evidence points to this animal as a source of the SARS-CoV-2 virus (Lu et al., 2021). The most expressive categories of the *aspects of COVID-19* dimension reflect the Brazilian context of fighting the pandemic. Besides the Unified Health System (SUS) facing severe hospital capacity and structure problems, Brazil has stood out in the absolute number of cases and deaths caused by COVID-19 worldwide (Marinho, Cordeiro, Coelho, & Brandão, 2020; Ranzani et al., 2021). These factors may have alerted the participants about the possible consequences of SARS-CoV-2 infection.

The fourth most cited dimension was *risk perception* (38.5%), which was the first one where the participants associated COVID-19 and food directly (Table 2). The most expressive categories in this dimension were in decreasing order, *possibility of risk*, *no risk*, and *low risk*. The category *possibility of risk* indicates the presence of doubt on the part of the participants regarding the possibility of contamination by SARS-CoV-2 through food. In contrast, the categories *no risk* and *low risk* demonstrate a tendency to deny this possibility. These results may be related to participants' different levels of confidence in health agencies and other sources of information, considering the huge amount of reports, contradictions, and misunderstandings. Thus, the dissemination of information can strongly influence people's behavior (Cinelli et al., 2020; Kivi & Shogren, 2010). A study by Thomas and Feng (2021) showed that the US participants presented great concern in contracting the virus from other people than from food, attributing low risk to contamination by SARS-CoV-2 through food. It can be attributed to the high trust of US consumers in agencies such as the CDC, the World Health Organization (WHO), and health professionals in general. In contrast, the high mention of *possibility of risk* by participants of Brazil may indicate the need for greater efforts to increase the population's trust in health agencies.

The *productive chain* dimension comprised categories related to various sectors of the food production chain (37.5%) (Table 2). The *places of purchase and consumption* category was the most cited. Places with the possibility of overcrowding as *restaurants*, *supermarkets*, and *fairs* were highly mentioned, indicating a concern regarding the possible contamination with SARS-CoV-2 by food. Byrd et al. (2021) reported that consumers' concern regarding food marketing establishments might be associated with the lockdown measures, which caused consumers to infer a greater viral risk to these establishments due to the possibility of crowding people. Likewise, the *packing*, *food handling*, and *food safety* categories were frequently cited within *productive chain* dimension. The words/terms *packaging*, *improper handling*, and *security* were expressively mentioned in these categories, respectively. Food packages are usually exposed and susceptible to handling. In this way, consumers see the packaging surface as a possibility of virus contamination. Along with that, these terms may be attributed to constant warnings by health agencies and media regarding the hygiene of surfaces (FDA, 2021b). It is noteworthy that, although there is no report concerning the transmission of COVID-19 through food packing, there is evidence of persistence of SARS-CoV-2 in plastids up to 72 hr and in steel, cardboard, and copper for 48, 24, and 4 hr, respectively (Van Doremalen et al., 2020). These facts highlight the importance of constant disclosures toward good hygiene practices.

Within the dimension *other associations* (14%), the categories *others* and *political and social matters* were the most expressive. The *others* category included words such as *family*, *transport*, *temperature*, *China*, and *faith*, which are related to the COVID-19 pandemic origin, concerns about family members, and the possibility of SARS-CoV-2 infection by using public transport rather than by food. The category *social and political matters* was mainly composed of the words/terms *lack of information*, *information*, and *research*. These terms may be related to limited access to information and the need for trust information about the actual possibility of COVID-19 infection through food based on scientific evidence (Lee & Morling, 2021), which reinforces our findings concerning the *risk perception* dimension.

The *food* dimension (12%) was represented by the *food type* category, in which different types of food such as *fruits*, *raw foods*, *meat*, and *vegetables*, were more related to the possibility of contamination by COVID-19. This may be attributed to the fact that these food are usually sold and consumed raw or undercooked (Han et al., 2021), which lead to increased concern by consumers toward food outbreaks (Byrd et al., 2021; Painter et al., 2013).

The *unfamiliarity* was the least frequently mentioned dimension (9%), represented by the category *doubt*, highlighting the participants' disbelief in the possibility of food transmitting COVID-19. This

dimension demonstrates the lack of knowledge on the part of the participants to attribute an opinion on the subject, a fact that could also be previously observed through the divergence of opinions explained in the dimension *possibility of risk*, and the most cited words/terms in the *social and political matters* category within *other associations* dimension.

3.2 | Effects of socioeconomic and demographic characteristics on consumers' associations with COVID-19 contamination through food

Some patterns of terms were identified depending on the participants' socioeconomic and demographic characteristics, indicating that the personal context significantly influenced the concern about the possibility of transmission of COVID-19 by food.

Regarding gender, women evoked more *negative attitudes and feelings* than men. Otherwise, unexpectedly, women mentioned less frequently words/terms related to *places of purchase and consumption*, *packing*, and *food safety* when compared with men (Table 3). In general, women are more concerned with health and contamination risks than men, which may have led them to present a lower hospitalization rate when compared to men in many countries (Rana et al., 2021). However, Broche-Pérez, Fernández-Fleites, Jiménez-Puig, Fernández-Castillo, and Rodríguez-Martin (2020) demonstrated that the female population was more vulnerable to fear of COVID-19 than the male population. Indeed, fear may suppress reasoning concerning the COVID-19 pandemic (Ahorsu et al., 2020). Therefore, our findings for women may be attributed to a suppressed risk perception by fear.

Factors like age may shape how individuals perceive the threat of the SARS-CoV-2 virus (Alschuler, Roberts, Herring, & Ehde, 2021). Younger participants demonstrated low concern with *symptoms and implications* and *general aspects* (18–25 years) and a greater concern with *modes of transmission* (18–25 years), *packing* (18–25 years), and *poor hygiene* (26–35 years). In contrast, middle-aged participants presented a high mention of terms in the *low risk* category (46–55 years), and the elderly participants (>65 years) demonstrated low concern with *poor hygiene*. Younger participants are not considered a risk group; however, they showed great concern about not being responsible for the transmission of COVID-19 to older individuals. The middle-aged participants demonstrated to be more informed and careful about health agency warnings of the low risk of SARS-CoV-2 in food (Geçer, Yıldırım, & Akgül, 2020). Moreover, the low internet access of elderly participants in Brazil (Statista, 2021) can justify the lack of information about the importance of hygiene practices.

Regarding living regions, the southeast demonstrated the greatest concern for *sanitization* and *food type*, while lower for the *possibility of risk* (Table 3), suggesting that consumers of this region believe that food is not a relevant source of contamination if hygiene standards are followed. Otherwise, the south region mentioned less frequently *food security* and *no risk* and more frequently *possibility of risk* and *packing*, attributing the possibility of risk of spreading SARS-CoV-2 in food to packing materials. In the midwest region, the participants also addressed the chance of infection through food, but it was associated with the *food handling* category, which presented a high frequency of mention in this region. Moreover, the north region mentioned the categories *symptoms and implications* and *others* more frequently. These results can be explained by the context of the north region that showed the highest numbers of accumulated cases per 100,000 inhabitants being most affected by COVID-19 compared to other regions at the first wave of the pandemic (Galvan, Effting, Cremasco, & Conte-Junior, 2021).

Regarding income, the low-income participants (1–5 BMW) presented a high frequency of mention for *negative attitudes and feelings*, *general aspects*, and *modes of transmission* categories (Table 3), while a low frequency of mention for *no risk* and *low risk*. In contrast, individuals with income above 10 BMW mentioned more terms relating to the categories *low risk* (>10–20 BMW) and *no risk* (>30 BMW) and evoked less frequently terms concerning *negative attitudes and feelings* and *modes of transmission* (>10–20 BMW). Income is one factor that influences the risk perception of COVID-19 infection (Alam & Chakraborty, 2021), which was clearly observed in our study. This may be attributed to a lack of availability or low quality of healthcare services and less access to qualified information and instruction for low-income individuals (Chen, Feng, Chen, Lee, & An, 2021).

Concerning education, the primary school participants cited the *no risk* and *food type* categories more frequently, while participants with secondary school more mentioned the *negative attitudes and feelings* category. On the other hand, the participants with high education levels showed low mention of *negative attitudes and feelings*. The high mention of the category *no risk* and *negative attitudes and feelings* can express the lack of scientific information on the part of participants with primary education and secondary school, respectively, due to less experience in medicine and science and greater susceptibility to believe rumors and conflicting information from different media. Bhuiya, Klares III, Conte, and Cervia (2021) reported that individuals with lower socioeconomic or educational status are more likely to have misperceptions regarding COVID-19.

Participants with the formation in the food field attributed the *low risk* of spreading the SARS-CoV-2 virus to good hygiene and good handling practices with high mention of categories like *no risk*, *low risk*, *food security*, and *food handling*. Moreover, they mentioned less *negative attitudes and feelings*, *sanitization*, and *places of purchase and consumption*. In contrast, *negative attitudes and feelings*, *sanitization*, and *places of purchase and consumption* were more frequently mentioned by the participants with the formation in other fields, who mentioned less the *modes of transmission*, *no risk*, and *low risk categories*. It can be attributed to knowledge of the participants of the food field about *low risk* or *no risk* of COVID-19 infection through food when prevention measures are applied, while superficial knowledge of the participants of other fields associated with unscientific information through the different media wrongly influencing the level of risk.

Four consumers groups were formed through data fusion with HCA and CA concerning the perception of contamination by COVID-19 through food considering their socioeconomic and demographic characteristics. Cluster 1 grouped participants of all ages (Figure 2).

TABLE 3 Frequency of mention of the categories identified in the free word association about COVID-19 contamination through food by different participant groups considering their gender, age, living region, income, education, and education field

		Gender		Age (years old)						Living region				
Dimensions	**Categories**	**Female**	**Male**	**18–25**	**26–35**	**36–45**	**46–55**	**56–65**	**>65**	**South**	**Southeast**	**Midwest**	**Northeast**	**North**
Attitudes and feelings														
	Negative	527 (+)***	186 (–)***	142	170	118	58	33	16	174	368	32	98	41
Sanitization														
	Sanitization	444	168	48	67	48	17	16	12	137	357 (+)**	20 (–)***	73	25
	Poor hygiene	87	25	31	46 (+)***	21	9	5	0 (–)***	29	61	7	12	3
Aspects of COVID-19														
	Prevention measures	267	112	24	33	22	11	7	6	84	191	23	60	21
	Symptoms and implications	82	37	136 (–)***	200	148	76	54	28	20	57	5	21	16 (+)*
	Modes of transmission	78	21	71 (+)**	64	40	19	21	9	30	46	4	14	5
	General aspects	48	22	20 (–)***	38	30	17	9	8	17	36	1	11	5
Risk perception														
	Possibility of risk	124	42	31	34	27	15	5	4	51 (+)***	70 (–)**	17 (+)*	24	4
	No risk	93	44	31	32	19	11	11	6	22 (–)***	77	11	16	11
	Low risk	46	29	8	12	7	9 (+)***	4	0	19	43	2	8	3
Productive chain														
	Places of purchase and consumption	107 (–)***	63 (+)***	27	44	28	14	6	6	42	92	2 (–)***	28	6
	Packing	42 (–)*	38 (+)*	13 (+)***	10	4	3	1	2	27 (+)***	41	3	8	1
	Food handling	51	19	7	12	10	2	1	3	13	41	7 (+)***	8	1
	Food safety	28 (–)**	27 (+)**	2	5	6	1	1	1	5 (–)***	33	4	10	3
Other associations														
	Others	60	30	43	63	36	18	14	5	15	48	6	12	9 (+)***
	Social and political matters	32	18	22	39	25	10	9	5	11	23	4	8	4
Food														
	Food type	84	34	19	33	14	13	8	2	26	79 (+)**	2	9	2
Unfamiliarity														
	Doubt	26	10	5	6	5	3	4	1	10	20	0	3	3

		Income—Brazilian minimum wage					Education			Education field	
Dimensions	**Categories**	**1–5**	**>5–10**	**>10–20**	**>20–30**	**>30**	**Primary school**	**Secondary school**	**University[a]**	**Food field[b]**	**Other fields**
Attitudes and feelings											
	Negative	334 (+)**	224	101 (–)**	43	11	4	42 (+)*	667 (–)*	210 (–)*	503 (+)*

(Continues)

TABLE 3 (Continued)

Dimensions	Categories	Income—Brazilian minimum wage					Education			Education field	
		1–5	>5–10	>10–20	>20–30	>30	Primary school	Secondary school	University[a]	Food field[b]	Other fields
Sanitization											
	Sanitization	236	199	124	45	8	1	23	588	197 (–)***	415 (+)***
	Poor hygiene	51	38	20	2	1	0	4	108	39	73
Aspects of COVID-19											
	Prevention measures	149	130	72	18	10	2	14	363	138	241
	Symptoms and implications	49	35	19	11	5	0	7	112	44	75
	Modes of transmission	54 (+)**	29	10 (–)***	4	2	0	1	98	49 (+)**	50 (–)**
	General aspects	39 (+)***	15	14	2	0	0	4	66	25	45
Risk perception											
	Possibility of risk	78	49	30	6	3	0	5	161	71	95
	No risk	40 (–)**	43	27	13	14 (+)*	4 (+)*	1	132	76 (+)*	61 (–)*
	Low risk	19 (–)**	25	25 (+)*	5	1	0	1	74	37 (+)***	38 (–)***
Productive chain											
	Places of purchase and consumption	73	52	28	13	4	0	3	167	42 (–)**	128 (+)**
	Packing	40	15 (–)***	21	1	3	1	0	79	33	47
	Food handling	25	20	16	7	2	0	1	69	45 (+)*	25 (–)*
	Food safety	21	17	10	6	1	0	2	53	33 (+)*	22 (–)*
Other associations											
	Others	32	32	18	6	2	0	2	88	35	55
	Social and political matters	23	15	9	2	1	0	2	48	15	35
Food											
	Food type	47	39	24	4	4	2 (+)***	1	115	40	78
Unfamiliarity											
	Doubt	13	13	5	4	1	0	2	34	12	24

Note: (+) or (–) indicate that the observed value is higher or lower than the expected theoretical value.

[a]University and postgraduate.

[b]Veterinary medicine, nutrition, pharmacy, food engineering, or food science and technology.

*p <.001. **p <.01. ***p <.05, effect of the chi square per cell.

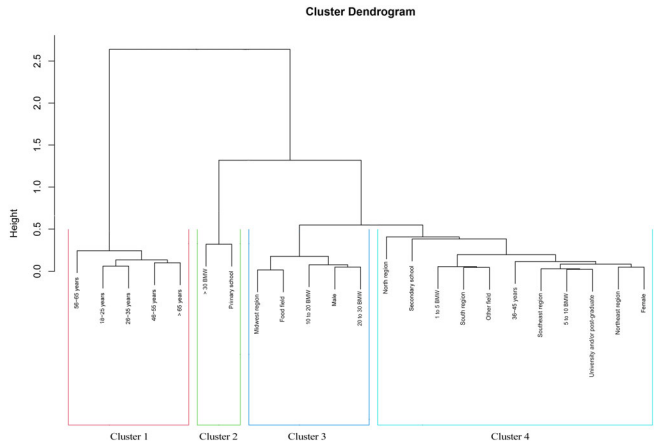

FIGURE 2 Hierarchical cluster analysis (HCA) of the frequency of mention of the categories from free word association task about COVID-19 contamination through food considering the different socioeconomic and demographic characteristics of the participants. BMW, Brazilian minimum wage

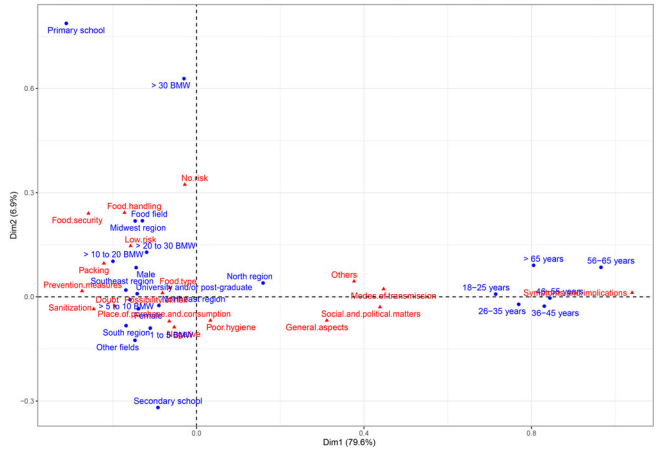

FIGURE 3 Correspondence analysis (CA) of the participant characteristics (blue) and frequency of mention of the categories (red) from free word association task about COVID-19 contamination through food. BMW, Brazilian minimum wage

Based on CA, this group associated contamination by COVID-19 through food with *symptoms and implications*, *modes of transmission*, *general aspects*, *social and political matters*, and *other associations* (Figure 3). This can be due to the media's regular broadcast generally focusing on the consequences of COVID-19, such as symptoms, potential transmission in collective places, and the need to respect the social distance (Sheldon, Antony, Charoensap-Kelly, Morgan, & Weldon, 2021). At the same time, there were many COVID-19 cases and deaths in Brazil associated with political issues influencing the perception of individuals of all age groups (Gramacho & Turgeon, 2021).

Cluster 2 was composed of consumers with primary school and higher income (>30 BMW), who attributed *no risk* of SARS-CoV-2 infection through food, excluding the possibility of cross-contamination (Figures 2 and 3). In this cluster, the participants showed differences in perception compared to the other socioeconomic characteristics. The participants with primary school possibly do not have the scientific knowledge to conclude about the possibility of risk. On the other hand, higher-income participants have access to different information channels being subject to fake and conflicting news that enable them to conclude that there is no risk. However, in the study of Thomas and Feng (2021), US participants with the highest income (>$50,000 annually), regardless of education's level, perceived lower risk of contracting COVID-19 from food through proper hygiene habits.

Cluster 3 (Figure 2) included men, participants within the food field, midwest region, and income >10–30 BMW. These participants related this possible cross-contamination to *food safety*, *food handling*, *low risk*, and *packing* (Figure 3). In contrast, Cluster 4 included women outside the food field with income ranging from 1 to 10 BMW, secondary school education level, university and/or postgraduate, and from northwest, southeast, south, and north region (Figure 2). This group associated contamination by COVID-19 through food with *prevention measures*, *sanitization*, *food type*, *poor hygiene*, *negative attitudes and feelings*, *places of purchase and consumption*, *doubt*, and *possibility of risk* (Figure 3). In our study, most consumers did not consider the possibility of cross-contamination of the SARS-CoV-2 virus through food, except those with previous food field knowledge, which have access to trustworthy information. This can be explained by a large amount of information and little or no disclosure of the actual risk generating doubts among individuals, including those with a high level of education.

Overall, fear, less, or inadequate information can generate misconceptions among consumers who may consider food as possible COVID-19 disease spreaders (Franco, Landgraf, & Pinto, 2020). Nevertheless, the consumer segment (Cluster 4) with the widest variety of socioeconomic and demographic characteristics may reflect the increased awareness of hygiene practices in the food production chain brought by COVID-19 (Djekic et al., 2021). However, there are still doubts about the possibility of food cross-contamination, even with the statements of health agencies emphasizing that food and food packaging are not sources of COVID-19 contagion (WHO, 2020).

Chen et al. (2021) point out that the general public does not have access to complete evidence, so trust in TV news and information communicated by government websites and, thus, mass media is closely related to risk perception. According to Thomas and Feng (2021), with the increased use of the internet, this communication media has become an economical way to disseminate information, increasing the risk of incorrect information that can lead consumers to confusion and more doubts. Therefore, there is a need for intensive efforts from Brazilian public institutions to mitigate misinformation, deliver reliable information, and inform individuals about reality.

4 | CONCLUSION

The present study demonstrated that the possibility of COVID-19 infection by food through cross-contamination was considered by

participants with high income, within the food field, midwest region, and males. Otherwise, there are still doubts regarding the possibility of risk of this type of cross-contamination, especially for participants with low income, females, who exercise professional activity outside the food sector, with secondary school education level, university and/or postgraduate, and from most regions of Brazil (northwest, southeast, south, and north). Nonetheless, in general, Brazilians are aware of the need for good hygiene practices and sanitization of surfaces and foods. As in Brazil, the television and the internet are the primary sources of information for the population, the increase of dissemination of scientific information in different media, especially social media, would be helpful to minimize misinformation. Finally, most of the participants in this study presented higher education (university and postgraduate), not covering the most vulnerable Brazilian population, which must have even more doubts and uncertainties about this matter. Therefore, future research should focus on the most susceptible strata of society since they are more subjected to misinformation and are more dependent on public policies implemented by the government.

AUTHOR CONTRIBUTIONS

Luiz Torres Neto: conceptualization, formal analysis, data curation, writing- original draft. **Maria Lúcia Guerra Monteiro:** conceptualization, formal analysis, data curation, writing-review, and editing. **Fernanda Medeiros Viana:** conceptualization, formal analysis, data curation, writing-review, and editing. **Carlos Adam Conte-Junior:** funding acquisition, project administration, supervision, and writing–review, and editing.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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