Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Behavioral predictors of household food-safety practices during the COVID-19 pandemic: Extending the theory of planned behavior

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ABSTRACT

The epidemiological scenario of COVID-19, social distancing, and business restrictions has increased food preparation and consumption at home. Food mishandling at home can significantly raise the risk of foodborne diseases. This study investigates food-mishandling behavior predictors by applying the extended theory of planned behavior (TPB), with the addition of knowledge and risk perception, to households during the COVID-19 pandemic. One thousand and sixty-eight consumers (n = 1068) in Brazil participated in this study before the COVID-19 vaccination period. Data were collected using an online questionnaire with 40 questions and different anchors; they were analyzed using structural equation modeling. The following original TPB factors positively affected the intention to implement safe food-handling practices: attitude ($p < 0.001$), perceived behavioral control ($p < 0.001$), and subjective norms ($p < 0.001$). More robust effects of attitude and perceived behavioral control on intention were also observed. Although food-safety knowledge did not affect intention ($p = 0.30$), it positively affected the other TPB factors. Perceived risk positively affected all TPB factors. The results of this study support the usefulness of TPB and its extension, providing evidence that public-health crises can contribute to changes in food-safety-related consumer behavior.

1. Introduction

In January 2020, the World Health Organization declared the COVID-19 pandemic to be a global emergency (WHO, 2020). Breaking the coronavirus-transmission chain required a comprehensive set of strategic measures. One of the social-distancing measures used by Brazil and several other countries (Flaxman et al., 2020) was a combination of restrictions, including limited business-opening hours or the complete temporary shutdown of businesses, such as restaurants (Qureshi et al., 2021). As a result, many Brazilian consumers were wary of patronizing this type of business during the pandemic (Hakim et al., 2021). The epidemiological scenario of COVID-19, social distancing, and the associated business restrictions contributed to increased food preparation and consumption at home (Oliveira et al., 2020).

The home environment is a high-risk environment for foodborne diseases in several countries, including the USA and Canada (Byrd-Bredbenner et al., 2013; Redmond & Griffith, 2003; Vrbova et al., 2012) and Brazil (Finger et al., 2019). Studies carried out in Brazil and worldwide provide evidence of a large number of outbreaks of foodborne diseases in domestic environments prior to the COVID-19

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pandemic. Specifically, in Brazil, 2009–2018 data show that 37.2% (n = 6809) of cases involving food occur at home, more than double the number of cases in restaurants (16.0%) (Brazil, 2019). In addition, data from a range of different periods confirm the same scenario (Draeger et al., 2019; Finger et al., 2019). Unlike restaurants, home environments do not have food-preparation, handling, or storage guidelines (Farias et al., 2020), given the heterogeneous profiles of residents (Scott, 2001) and the many different ways that kitchen environments are used (Wills et al., 2015). This increases the risk of foodborne diseases.

Proper food-handling behavior results from a reasoned decision process (Smith et al., 2007), influenced by several factors, including knowledge (Gong et al., 2016) and risk perception (Young et al., 2017). Some authors (Clayton & Griffith, 2008; Mullan & Wong, 2010) have studied the variables covered by the Theory of Planned Behavior (TPB), in which intention is the main precursor of behavior (Ajzen, 1991). According to TPB, three conceptually independent factors contribute to human behavior: attitude, subjective norms, and perceived behavioral control (PBC) (Ajzen, 1985, 1991). "Attitude" refers to the degree of an individual's positive or negative behavior evaluation. Subjective norms involve perceived social pressure to perform or not perform a particular behavior. PBC, the ease or difficulty of performing a behavior, incorporates perceived control (or lack of control) of behavior (Ajzen, 1991).

This study presents empirical evidence of the ways in which consumer behavior can be influenced by TPB factors, including knowledge and risk perception. Unlike other studies, the present research was conducted during the pandemic, which affected consumer risk perceptions (Byrd et al., 2021). The lack of any relevant literature on the interrelationships influencing consumer food-handling behavior in households has motivated the use of structural equation modeling (SEM).

This study investigates the predictors of consumer food-handling behavior in households during the COVID-19 pandemic by applying the theory of planned behavior, extended through the addition of knowledge and risk perception.

Fig. 1 shows the hypotheses in the proposed research model. Based on the original TPB model, the consumer intention to perform safe food-handling practices is positively influenced by attitude (H1), subjective norms (H2), and PBC (H3). The knowledge and risk-perception variables are included in the research model, with expected positive effects in the TPB constructs (H4 to H11) (Soon et al., 2021; Chen, 2017), which is also called the "extended TPB model." We hypothesize that knowledge positively affects risk perception (H12) (Zanin et al., 2015; Parra et al., 2014). The decision to add knowledge was based on studies that verified the increased predictive power of the TPB model when including this variable (Koo et al., 2014; Li et al., 2018), as well as the understanding that the greater an individual's knowledge, the more confident he or she would be in making the right decision (Flynn & Goldsmith, 1999). Risk perception was included because the theory did not include this concept (Rezaei et al., 2019), even though risk perception is associated with the probability of danger, its severity, and the consequences of danger based on its classification as a rational or irrational belief (Mumpower et al., 2016). The consumer's decision is the result of a balance between the perceived benefits and risks of a particular practice. Risk perception is a person's understanding and evaluation of the possible negative outcomes derived from their decision-making process (Dowling & Staelin, 1994). In a pandemic situation, in which uncertainty is high, people will be more aware of hygienic behaviors, shaping their attitudes, intentions, and food safety practices. In the face of initial uncertainty about the transmissibility of COVID-19 about food and packaging, individuals were able to change their behaviors regarding food and food safety, as observed in Fanelli's (2021) study in which Italian consumers stated that food safety is an important attribute, especially in health emergencies. A previous study in Brazil noted that an increase in risk perception reduced the use of food delivery apps due to fear of contamination (Zanetta et al., 2021). Thomas and Feng (2021) state that although consumers do not associate food safety practices with food safety, high levels of risk perception may demonstrate their willingness to change behavior.

2. Materials and methods

2.1. Research design and sample

This cross-sectional study was conducted in different regions of Brazil, using an online questionnaire. Using non-probability sampling, participants were invited via a range of social-media platforms (Facebook, Instagram, and WhatsApp). The exclusion criteria were being

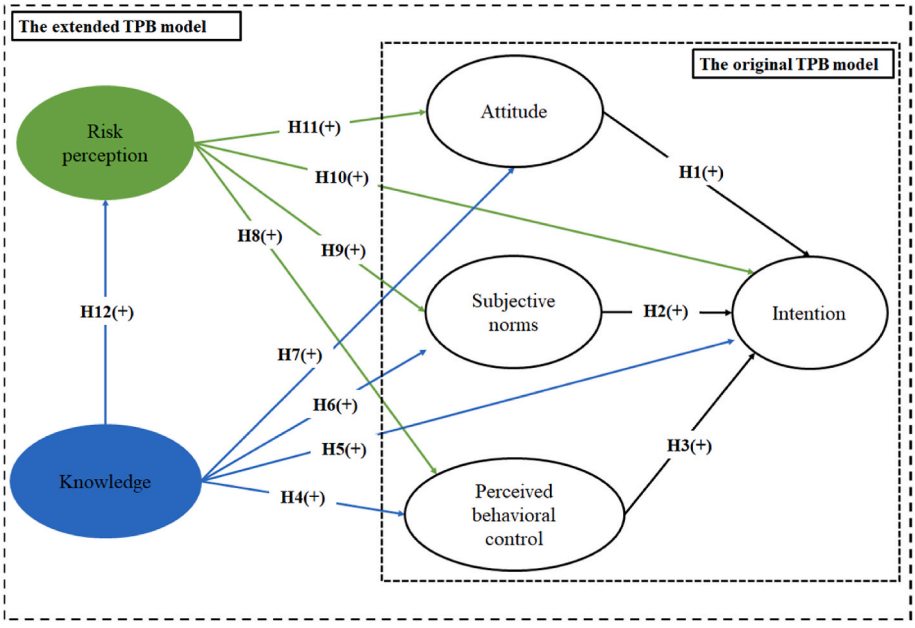

Fig. 1. Extended Model of the Theory of Planned Behavior, proposed in research that evaluates consumer food-handling at home.
Note: A positive sign indicates the direction of the hypothesis. The arrows indicate the direction of the effect.

under 18 years of age and not living in Brazil.

The Research Ethics Committee of the Federal University of São Paulo (UNIFESP) approved this study (CAAE no. 36992120.1.0000.5505). All participants provided written informed consent.

Consumers completed the questionnaire between October 2020 and January 2021, during the pre-approval period for COVID-19 vaccines in Brazil. When the questionnaire was launched, on October 4, 2020, Brazil had registered a total of 4,915,289 cases and 146,352 deaths from COVID-19. When the survey concluded, on January 10, 2021, Brazil had recorded 8,105,790 cases and 203,100 deaths (Johns Hopkins University, 2021).

2.2. Questionnaire design

The questionnaire design involved four steps: (A) elaborating the questions, (B) validating the content, (C) creating a qualitative and quantitative pilot, and (D) ensuring the validity and reliability of the instrument (Fig. 2).

Step A included the development of survey questions, based on the World Health Organization's "five keys to a safer food manual" (WHO, 2006), the Brazilian Legislation Resolution RDC 216/2004 (Brazil, 2004), and recommendations for preventing COVID-19 (FDA, 2020).

To validate the content in Step B, the process began with a Focus Group, composed of five intentionally selected experts (Greenbaum, 1998). Although prior studies have investigated TPB and food safety (Lin & Roberts, 2020), we chose to create an instrument that included COVID-19. During a discussion, each expert was invited to express his or her opinions, thoughts, and food safety-related experiences. The members suggested modifications to the text, by exchanging and/or excluding particular words and terms to make the language accessible to consumers. The proposed changes were summarized, analyzed, and carried out when pertinent.

Step C consisted of pilot tests. The qualitative pilot involved 10 consumers, while a quantitative pilot with 150 consumers ensured regional balance and a range of responses. The final instrument consisted of 51 questions, validated by the focus group and divided into four blocks: socioeconomic-demographic profile, consumer knowledge of food safety at home, consumer perception of food-safety risks at home, and TPB (intention, attitude, subjective norms, and perceived behavioral control) in relation to food safety at home.

Step D comprised an evaluation of composite reliability (CR) and average variance extracted (AVE); 11 questions were excluded to increase the validity and reliability of the instrument, totaling 40 questions overall. The electronic and self-administered questionnaire, "Is your food at home safe?" was structured using free online collaborative software via the Google® platform to facilitate access and disseminate information to all regions of Brazil.

2.3. Procedures

The first part of the questionnaire used eight questions to explore basic and demographic (family and individual) characteristics: age, gender, family income, education, resident status, geographic location of residence, number of residents, and the extent to which residents belonged to a risk group for COVID-19 in their residences. The risk group for COVID-19 included pregnant women, individuals aged 60 or above, and those with obesity, cardiovascular disease, diabetes, chronic lung disease, cancer, or immunosuppressive or cerebrovascular disease (CDC, 2021).

The second part of the questionnaire assessed consumer knowledge of food safety and the spread of COVID-19. It consisted of seven questions, each with three possible responses: "yes," "no," and "I don't know" (Baş et al., 2006). The distribution of correct answers was balanced, and the order was random, not following a pre-established pattern. One point was given for each correct answer; no points were

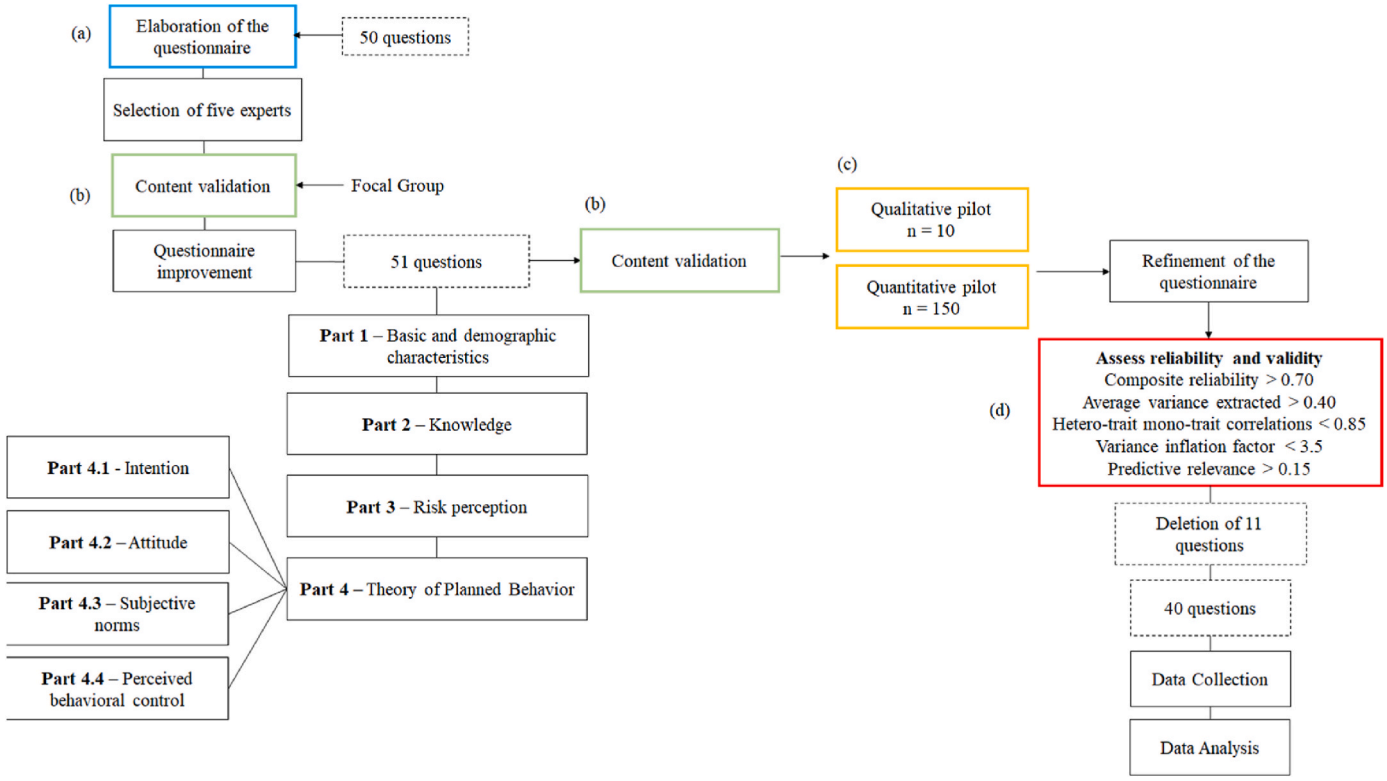

Fig. 2. Methodological summary of the questionnaire-creation process.
Note: Blue lines indicate Step A, green lines indicate Step B, yellow lines indicate Step C, and red lines indicate Step D. . (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

given for incorrect or "I don't know" responses. Thus, potential sources of knowledge ranged from zero to seven. To analyze the data, the scale was transformed into percentages. Low levels of knowledge were in the 0–50% range; moderate levels of knowledge in the 51–70% range, and high levels of knowledge in the 71–100% range (Da Cunha et al., 2014).

The third part of the questionnaire assessed consumer risk perceptions, using five questions. The answers were graded on a risk scale ranging from "very high" (5) to "very low" (1) (Da Cunha, Stedefeldt & Rosso, 2012). The overall score for the risk-perception variable was established by averaging the values of five answers.

The fourth part of the questionnaire contained twenty questions. It was subdivided into the TPB variables—intention, attitude, subjective norms—and PBC–assessed, using five-point scales with different anchorages. For intention, the scale ranged from "very unlikely" (1) to "very likely" (5), based on attitudes ranging from "necessary" (1) and "beneficial" (1) to "unnecessary" (5) and "not beneficial" (5), inverted when necessary. Questions related to "subjective norms" and "PBC" had responses ranged from "strongly disagree" (1) to "strongly agree" (5).

2.4. Data analysis

Descriptive statistical analyses (mean, standard deviation, and absolute and relative frequency) were carried out on sociodemographic characteristics. For an open-ended question on consumer ages, the mean and standard deviation were calculated. The indicators of TPB and risk-perception constructs were evaluated for common method bias using Harman's single-factor score (Podsakoff et al., 2003). A single factor explaining 18.6% of the total variance was extracted, indicating that the data were not affected by common method bias.

To evaluate the TPB, structural equation modeling, using partial least squares (PLS-SEM) was applied. This method was selected primarily because it allows the creation of latent variable scores and makes less stringent assumptions about data and error distribution (Henseler et al., 2009). The validity and reliability of the construct were verified via composite validity (CR $>$ 0.70) and the average variance was extracted (AVE $>$ 0.40). Discriminant validity was checked using heterotrait monotrait correlations (HTMT $<$ 0.85). Collinearity was verified using the variance inflation factor (VIF $<$ 3.5). The SEM was evaluated for predictive relevance ($Q^2 > 0.15$), effect size (f^2), and explanatory power (R^2). The effect size was classified as small (0.02), medium (0.15), or large (0.35) (Cohen, 1988).

There were no problems with missing data. The standard deviation (SD) between the indicator variables was checked for each participant. Fifty-seven participants were excluded because they had SD = 0, a possible indication of lack of engagement. Variables were constructed as reflexive latent variables, apart from knowledge, which was an observed variable (the sum of the correct answers). Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) v.20 (IBM Corp. (IBM Corp., Armonk, NY), and SmartPLS v3.2.8 (SmartPLS GmbH. Bönningstedt, Germany).

3. Results

3.1. Participant profiles

Of the 1,125 Brazilians from five regions (north, northeast, center-west, south, and southeast) who participated in the study, 1,068 submitted valid answers. The regions were made up of states with common characteristics, including physical and economic factors. More than half the respondents were in the southeast region (61.0%). The mean (SD) age was 38.8 (13.4) years; more women than men participated (76.4%). Almost all individuals had higher education (93.8%) and lived in urban areas (93.8%). Most had family incomes higher than four minimum wages (54.8%). More than 50% of the households had two or three residents. Regarding the risk factors for COVID-19, 51.6% either were or lived with a person or family member who was part of a risk group (Supplementary Material B).

3.2. Behavior predictors

The average percentage of correct consumer-knowledge responses was 83%, with high knowledge about proper food handling. Table 1 shows the percentage by question. The question that received the highest percentage of correct answers (93.4%) involved hand-hygiene frequency during food preparation to minimize the risk of foodborne diseases. A total of 73.1% of consumers were aware of the need for a hygiene procedure before and after receiving delivered food.

Table 2 presents the means and standard deviations of consumer risk perception in households. The overall score was 3.65 (1.05). The highest average was observed in consumer answers to the question about using non-potable water in food preparation (average = 4.02, SD = 1.11).

Using the extended TPB model, built to include knowledge and risk perception, it was possible to assess the positive effects of inter-variable relationships. The CR of all factors was greater than 0.70; factor loadings were greater than 0.43; and AVE values were greater than 0.40 (Table 2). The VIF and HTMT values were adequate, showing that no collinearity or discriminant validity problems were detected.

Fig. 3 shows the inner PLS model. Food-hygiene knowledge was found to positively affect risk perception ($\beta = 0.343$; $t = 12.17$; $p < 0.001$), attitude ($\beta = 0.267$; $t = 7.67$; $p < 0.001$), PBC ($\beta = 0.265$; $t = 7.20$; $p < 0.001$) and subjective norms ($\beta = 0.112$; $t = 3.48$; $p < 0.001$), but not intention ($\beta = 0.028$; $t = 1.01$; $p = 0.30$). Risk perception is a positive driver for attitude ($\beta = 0.229$; $t = 5.71$; $p < 0.001$), PBC ($\beta = 0.264$; $t = 8.24$; $p < 0.001$), subjective norms ($\beta = 0.173$; $t = 5.35$; $p < 0.001$), and intention ($\beta = 0.070$; $t = 2.35$; $p = 0.018$). Finally, attitude ($\beta = 0.337$; $t = 9.43$; $p < 0.001$), PBC ($\beta = 0.266$; $t = 7.72$; $p < 0.001$), and subjective norms ($\beta = 0.165$; $t = 5.68$; $p < 0.001$) positively affected intention. The effects ($f^2 > 0.02$) showed adequate values, except for the effect of perceived risk ($f^2 = 0.007$) on intention. Therefore, the second relationship, although significant, should be evaluated with caution. The predictive relevance of the intention model was $Q^2 = 0.15$, indicating reasonable relevance. In the intention model, $R^2 = 0.42$.

Table 1
Percentage of correct consumer responses to questions about food safety and the prevention of COVID-19.

Knowledge of food safety	Correct answer	Consumers (n = 1068)	IC 95%*
		Correct answers %	
Does frequent handwashing during food preparation decrease the risk of Foodborne Diseases?	Yes	93.4	0.92–0.95
Is it safe to wash fruits and vegetables with sanitary water prepared with water?	Yes	84.1	0.82–0.86
Can meals be prepared with non-potable water?	No	80.6	0.78–0.83
Can eat undercooked meat or eggs with a soft yolk cause Foodborne Disease?	Yes	83.1	0.81–0.85
Is it safe to eat food left out of the refrigerator from lunchtime until dinner time?	No	79.5	0.77–0.82
Knowledge prevention of COVID-19			
Thinking about delivery consumption, is it unnecessary to handwash after receiving meals if you have already done so before receiving them?	No	73.1	0.70–0.76
Does wiping 70% alcohol off the packaging of meals obtained from delivery prevent Covid-19 contamination?	Yes	89.1	0.87–0.91

Table 2
Validity and reliability of constructs.

Construct	Factor loadings	Mean (SD)	CR	AVE
Risk perception	–	3.65 (1.05)	0.802	0.450
What is the risk of a person having symptoms such as vomiting, nausea, and diarrhea when eating without handwash?	0.744	3.50 (0.98)		
What is a person's risk of experiencing symptoms such as vomiting, nausea, and diarrhea after consuming food prepared with non-potable water?	0.604	4.02 (1.11)		
What is a person's risk for symptoms such as vomiting, nausea, and diarrhea after consuming undercooked meat or eggs with a soft yolk?	0.743	3.36 (1.08)		
What is a person's risk of experiencing symptoms such as vomiting, nausea, and diarrhea after consuming food that has been left out of the refrigerator from lunch to dinner?	0.682	3.50 (1.02)		
What is a person's risk of contracting COVID-19 when receiving a meal by delivery service and not washing their hands afterward?	0.560	3.87 (0.92)		
Attitude (Att)	**-**	**4.33 (1.1)**	**0.758**	**0.400**
For you, handwashing with soap and water several times when you prepare meals is something:	0.616	4.57 (0.90)		
For you, washing fruits and vegetables with sanitary water prepared with water is something:	0.730	4.27 (1.15)		
For you, eating undercooked meat or egg with a soft yolk is something:	0.436	3.58 (1.44)		
For you, handwashing after receiving meals by delivery even if you have already washed before receiving them is something:	0.636	4.75 (0.71)		
For you, rubbing 70% alcohol on the packaging of meals purchased by delivery service is something:	0.672	4.46 (0.99)		
Perceived behavioral control (PBC)	**-**	**4.50 (0.9)**	**0.735**	**0.416**
I can easily handwash before, during, and after any breaks, activity changes, or when using the bathroom when preparing meals.	0.459	4.87 (0.39)		
I can easily wash fruits and vegetables with sanitary water prepared with water.	0.735	4.54 (0.89)		
I can easily avoid eating undercooked meat or egg with a soft yolk.	0.674	4.21 (1.12)		
I can easily avoid eating meals left out of the refrigerator from lunchtime until dinner time.	0.679	4.40 (0.91)		
Subjective norm (SN)	**-**	**4.20 (1.0)**	**0.845**	**0.477**
Most people who are important to you believe that you should handwash several times when you prepare meals.	0.680	4.37 (0.89)		
Most people who are important to you believe that you should wash fruits and vegetables with sanitary water prepared with water.	0.786	4.05 (1.13)		
Most people who are important to you believe that you should avoid eating undercooked meat or soft-boiled eggs.	0.679	3.74 (1.18)		
Most people who are important to you believe that you should avoid eating meals left out of the refrigerator from lunchtime until dinner time.	0.639	3.99 (1.09)		
Most people who are important to you believe that you should handwash after receiving meals by delivery service even if you have them washed before receiving them.	0.634	4.62 (0.74)		
Most people who are important to you believe that you should use 70% alcohol to clean the packaging of meals purchased by delivery.	0.715	4.42 (0.90)		
Intention (Int)	**-**	**4.40 (1.1)**	**0.757**	**0.400**
You intend to handwash several times when you prepare meals.	0.520	4.72 (0.59)		
You intend to wash fruits and vegetables with sanitary water prepared with water.	0.752	4.04 (1.21)		
You intend to avoid eating undercooked meat or soft-boiled eggs.	0.530	3.95 (1.24)		
You intend to handwash after receiving meals by delivery, even if you have washed before receiving them.	0.598	4.79 (0.62)		
You intend to handwash after receiving meals by delivery, even if you have already washed before receiving them.	0.685	4.26 (1.11)		

4. Discussion

The main objective of this study was to investigate the influence of behavioral predictors on consumer intentions to handle food correctly in households. An extended TPB model was proposed, with the addition of the construct's knowledge and risk perception during the COVID-19 pandemic, before the population was vaccinated.

4.1. Original TPB model (H1 to H3)

The TPB demonstrated the positive effect of attitude, PBC, and subjective norms related to the intention to perform safe food-handling practices at home. Among the variables, attitude was the predictor with the largest effect on intention, in contrast to the literature, which found that it was the weakest predictor of safe food-handling intention (Mullan et al., 2015; Seamen & Eves, 2010; Mullan & Wong, 2009; Fulham &, Mullan, 2011). However, Bai et al. (2014) found that attitude

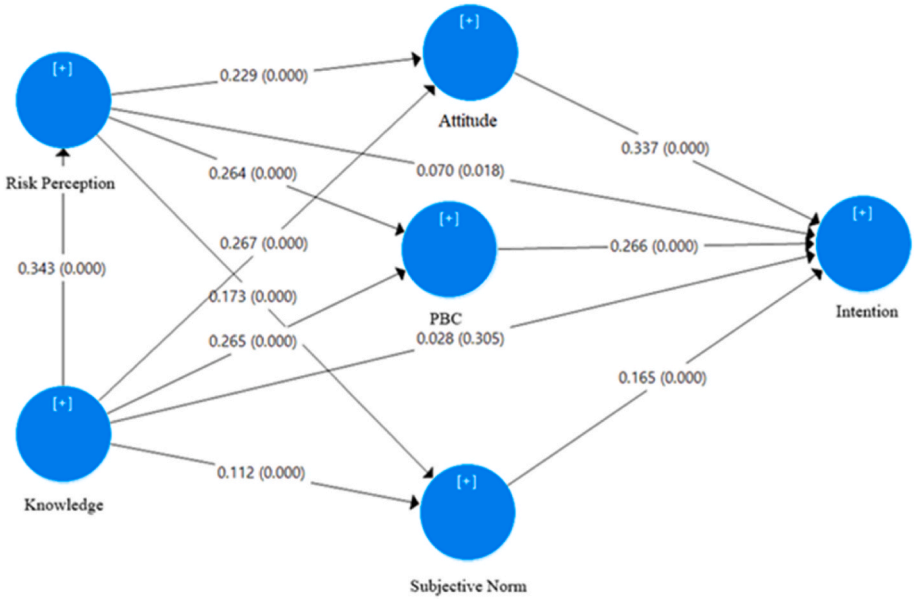

Fig. 3. Final inner path model.
Note: The numbers indicate the values of the path coefficient (β) and the p-values of the t-statistics, respectively; PBC: Perceived behavioral control.

was the strongest predictor of intention to implement safe food-handling practices at home. The same has been observed in other healthcare studies (Patch et al., 2005; Povey et al., 2000). Parallel to the data, attitude is known to be the key factor in understanding intention (Ajzen & Fishbein, 2005), as well as the first predictor of intention (Gao et al., 2017). In the current research, the COVID-19 pandemic scenario was found to influence behavior, especially in the face of the uncertainty, present to this day, arising from the virus and its consequences. COVID-19 is a salient danger, frequently discussed in the media. Consumers can shape their attention and risk perception by increasing feelings of fear and anxiety (Asai et al., 2021). Because they combine emotional and cognitive components (De Bruijn & J, 2010), the social consequences experienced by consumers influence risk-related decision-making (Veflen et al., 2020).

As a predictor, PBC has a positive effect on intention, showing that individuals are more focused on ensuring food safety, a finding consistent with previous behavioral studies (Mullan & Wong, 2009; Fulham & Mullan, 2011; Soon et al., 2021). Consumers are understood to perceive safe food handling as relatively easy, increasing their intention to perform it (Savari & Gharechaee, 2020). This ease may be linked to external factors, such as time, or internal factors, such as awareness (Lubran, 2010). It has been suggested that consumers feel capable of performing behaviors, in this case, safe food handling, which are under their control (Bakar et al., 2017). This finding is not consistent with the results of research on the same topic by Shapiro et al. (2011), who found that PBC was the strongest predictor of the intention to handle food correctly at home, diverging from the results of this study.

Although subjective norms have a positive effect, they are the weakest predictor. It can therefore be inferred that social pressure from others is an integral part, but to a lesser extent, of a consumer's intention to handle food correctly. Thus, consumers are more concerned about their attitudes and a wide spectrum of behaviors (Armitage & Conner, 2001). Several studies diverge from our findings. A similar study, conducted in Indonesia and Malaysia during the pandemic, found that subjective norms were the most significant predictor; this may be explained by the interdependent culture of these countries (Soon et al., 2021; Kurniawan et al., 2020). The weaker effect obtained in the Brazilian study may likewise reflect the local culture. Lin & Roberts' (2020) meta-analysis on the same theme concluded that the subjective norms-intention relationship was stronger among the predictors of TPB. Other data have shown that family expectations contribute to consumer intentions to handle food correctly when subjects listen to advice from family members or close people (Ruby et al., 2019). This finding has also been predicted in adolescent food-hygiene behavior (Mullan et al., 2013).

4.2. Extended TPB model (H4 to H12)

The present study also considers the relationship between knowledge and perceived risk in food safety, using TPB variables. Knowledge has an indirect effect on intention by affecting attitude, subjective norms, and PBC. Knowledge has no direct effect on intention. Although knowledge is necessary, studies have demonstrated that knowledge alone is not enough to change behavior (Taché & Carpentier, 2014); it must be related to motivational factors, including attitude, subjective norms, and PBC (Fishbein & Ajzen, 2009; Mullan et al., 2013). Other studies have pointed out that knowledge is one of the factors that determine proper food-handling behavior (Lim et al., 2016; Abbot et al., 2009). The strongest and most positive effect of knowledge is on attitude; in this, our findings converge with those of Ruby et al. (2019), who used an extended TPB model; the weakest effect is observed on subjective norms. Knowledge, attitude, and practice (KAP) studies of food safety confirm that knowledge influences attitudes (Agüeria et al., 2018; Parry-Hanson, Ofosu, Aboagye, & Tano-Debrah, 2016; Luo et al., 2019; Mihalache et al., 2021). Other studies contradict this finding by showing that knowledge is not translated into positive attitudes after training (Zanin et al., 2017; Da Cunha, 2021). Lim et al. (2016) have found that knowledge and attitude act independently of behavior.

Risk perception shows a positive effect on all TPB variables. It is more robust in relation to attitude and PBC, showing an indirect effect on intention. The direct effect of risk perception on intention is observed but to a lesser degree. Few studies have used an extended TPB model to assess risk perception. In these studies, the themes are food purchasing (Lobb et al., 2007), the assessment and prediction of food handling, and hygienic behaviors (Mullan & Wong, 2009; Mullan et al., 2013). During a health crisis, the assessment of risk perception is paramount. Perceptions are heightened in this scenario, contributing to the adoption of safe food-handling behaviors (Thomas & Feng, 2021).

The extension of TPB is pertinent to understanding the consumer intention to engage in safe food-handling practices, as observed in other

studies involving farmers and food workers (Burusnukul, 2011; Rezaei, Mianaji & Ganjloo, 2018). In the proposed model, the effect of the knowledge-risk perception relationship has been evaluated and shown to be positive. Thus, it is possible to infer that consumer knowledge of food-handling interferes with perceived risk, contributing to food-safety awareness. As both variables are commonly studied in food handling, risk perception is known to relate to knowledge, although the literature presents different relationships (Da Cunha et al., 2012; Zanin et al., 2015; Rossi et al., 2017).

In a public-crisis scenario, such as the COVID-19 pandemic, consumers are regarded as lay audiences (Lejano & Stokols, 2018), which lack objective knowledge of risk factors (Paek & Hove, 2017), impacting perceived risk and, consequently, practices. A study conducted in China on the impact of COVID-19 on food safety concludes that consumer knowledge is affected by the dissemination of information on the topic in various media (Min et al., 2020). Scopelliti et al. (2021) have identified psychological mechanisms that contribute to positive behaviors, including simple exposure to TV news discussions about COVID-19. Exposure to information contributes to increased knowledge and risk perception.

5. Study limitations and further research

Due to the COVID-19 pandemic, face-to-face interviews could not be used for data collection. This fact contributed to a bias related to economic class, as most respondents were middle-class and highly educated. Furthermore, because the data were self-reported, they were subject to cognition and may have differed from actual behavior.

Another limiting factor was the low adherence of some Brazilian regions, possibly because the study group was located in the southern and southeastern regions. Thus, the results could not be generalized to all communities.

In addition, the epidemiological scenario of COVID-19 fluctuates constantly, especially given the arrival of new variants and the advance of vaccination; this can change consumer knowledge, perceptions, and behaviors. Further studies are needed to assess the impact of various pandemic contexts on consumer perceptions and behavior. Because this was a cross-sectional study, it was not possible to verify changes in predictors of behavior and practices over time.

6. Conclusion

The present study uses an extended TPB model to assess the predictors of food-handling behavior among Brazilian consumers, in the context of the COVID-19 pandemic. The calculated SEM results validate the applicability of the TPB model because they provide evidence that behavioral predictors (attitude, subjective norms, and PBC) contribute, to varying degrees, to an increased intention to perform good food-handling practices at home. The findings also confirm the usefulness of the proposed extension of the TPB model; with the inclusion of the knowledge and risk-perception constructs, the robustness of intention predictors increases.

This study contributes to the food-safety literature by demonstrating the positive impact of the Covid-19 pandemic on predictors of consumer behavior, risk perception, and knowledge of food safety at home.

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CRediT authorship contribution statement

Raísa Moreira Dardaque Mucinhato: Conceptualization, Investigation, Methodology, Writing – original draft. **Diogo Thimoteo da Cunha:** Conceptualization, Investigation, Methodology, Writing – review & editing. **Simone Crispim Fernandes Barros:** Conceptualization, Investigation, Methodology, Writing – review & editing. **Laís Mariano Zanin:** Writing – review & editing. **Lígia Isoni Auad:** Conceptualization, Methodology, Writing – review & editing. **Grazielle Castagna Cezimbra Weis:** Conceptualization, Data curation, Formal analysis, Methodology, Writing – review & editing. **Ana Lúcia de Freitas Saccol:** Conceptualization, Methodology, Writing – review & editing. **Elke Stedefeldt:** Conceptualization, Data curation, Formal analysis, Methodology, Validation, Funding acquisition, Supervision, Project administration, Writing – original draft, Writing – review & editing.

Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodcont.2021.108719.

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