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# Food storage in household refrigerators: Exploring the role of psychosocial factors to improve food risk communication

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ABSTRACT

Although consumers claim to know how to manage food properly, they unconsciously engage in unsafe practices, which calls for tailored communication interventions to enhance health-related behaviours. The present study focuses on the storage of food in household refrigerators, as the poor organisation of the appliance can promote the growth of microorganisms and cross-contamination, posing a risk to consumer health. This work was aimed (i) to assess Italian consumers' refrigerator safety knowledge, perceptions and past behaviour, and (ii) to verify which psychosocial factors drive the implementation of the behaviour, using the Theory of Planned Behaviour (TPB) and its extensions (Model of Goal-directed Behaviour MGB - desire, positive/negative anticipated emotions PAEs/NAEs). Data were collected via an online survey ($N = 242$) conducted on smartphone app. Even though the respondents were found to have a good attitude and be willing to engage in the target behaviour, they revealed inadequate refrigerator organisation. Perceived behavioural control (PBC) was found to have a strong influence on intentions, together with desire, which was found to mediate the effects of attitudes, positive anticipated emotions, and PBC on intentions. Results suggest that communication interventions to enhance the correct storage of food in the refrigerator should specifically address the positioning of eggs, and messages should leverage PBC, desire, and PAEs.

## 1. Introduction

Foodborne diseases (FBDs) generally occur within domestic walls due to unsafe and improper food handling (Byrd-Bredbenner et al., 2013; Møretrø et al., 2021). This is due to several factors, such as the perception of food safety, together with individual knowledge and attitudes, that are not always based on scientific evidence or may stem from a lack of knowledge about food and production processes (James et al., 2023; Melios et al., 2025; Sameshima & Akamatsu, 2023).

Food is not usually considered a source of potential risk (Jenkins et al., 2020), and for many individuals, food preparation is a habitual behaviour that does not require cognitive effort (Byrd-Bredbenner et al., 2013): kitchen tasks are performed through automatic actions, failing to consciously assess the food safety risks associated. Indeed, a significant discrepancy exists between perceived and actual knowledge: consumers often report high self-efficacy and confidence despite suboptimal practices (Soon et al., 2020; Tiozzo et al., 2017). This overconfidence, coupled with the perceived complexity of technical safety information, often reduces the salience and effectiveness of public health campaigns. To improve interventions, risk communication must move beyond simple instructions and account for the cognitive and behavioural drivers (Mari et al., 2012; Young et al., 2017).

Within household food handling practices, the management of the refrigerator represents a critical site for food safety. If managed incorrectly, it can become a reservoir for pathogens introduced via raw foods or contaminated surfaces, leading to cross-contamination (Evans &

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Redmond, 2019a, 2019b; Jha et al., 2026). While literature has extensively explored refrigerator temperatures (Chaomuang et al., 2025a), hygiene (Andritsos et al., 2021), and food waste (Principato et al., 2021), a gap remains regarding how consumers organize products within the appliance. Proper food placement - matching product temperature requirements with specific refrigerator compartments - is essential to limit pathogen growth (Ferrero et al., 2022). Despite declaring adequate knowledge, many consumers fail to implement correct refrigeration layouts (Redmond & Griffith, 2003). While recent IoT solutions offer technological aids to mitigate these risks (Murugesh, 2024), understanding the psychosocial determinants of manual food placement remains vital. To investigate the role of determinants on the management of household refrigerators, this study employs the theoretical framework of the Theory of Planned Behaviour (TPB) (Ajzen, 1991), one of the most commonly used theories of behaviour across social science (Davis et al., 2015). The TPB posits that when an individual has a positive attitude towards a particular behaviour, they perceive that significant others expect them to perform the behaviour (subjective norm) and assumes that the behaviour is not too difficult to carry out (perceived behavioural control, PBC), which results in an intention to engage in the behaviour. This intention will lead to behaviour, unless unexpected internal or external barriers (e.g., lack of time, insufficient resources; see e.g., Ajzen, 2020; Mucinhato et al., 2022) arise. However, traditional TPB often fails to account for the "intention-behaviour gap" - where positive intentions do not translate into factual action due to habitual or emotional barriers (e.g. Mullan & Wong, 2009). For this reason, the basic TPB model has been extended with additional variables, such as past behaviour or habits (Mari et al., 2012) and perceived moral obligation (Conner & Armitage, 1998; Verbeke & Vackier, 2005), in an attempt to improve the prediction of behaviour and explain why some people fail to translate intentions into factual behaviour. The Model of Goal-directed Behaviour (MGB; Bagozzi, 2024; Perugini & Bagozzi, 2001) extends the TPB suggesting that behaviour is not only a reflection of intentions but also the result of motivational (i.e., desire to act) and emotional processes (i.e., anticipated emotions). These elements bridge the cognitive and affective aspects of motivation, providing a richer understanding of how people engage in goal-directed behaviour. Desire reflects a deeper drive that energizes and sustains goal-directed behaviour. Desire is supposed to directly influence behavioural intentions, and to mediate the effects of traditional TPB's antecedents on intentions. People with strong desires for a specific outcome (e.g., to prevent food risks in the household) are more likely to form strong behavioural intentions to taking action. Positive (PAEs) and negative anticipated emotions (NAEs) similarly constitute additional antecedents of desire to act. Anticipated emotions refer to the emotional reactions individuals expect to experience as a result of achieving (or failing to achieve) their goals. These emotions are future-oriented, based on the expected outcome of the behaviour. For example, the pride associated with ensuring household safety (PAE) or the disappointment resulting from a failure to do so (NAE) strengthens the motivation to adopt correct food-handling practices (Bagozzi, 2024).

While the TPB has been extensively applied to study food safety behaviours (Davis et al., 2015), our study is one of the first attempts to test the power of the extended TPB model on refrigerator organisation, specifically within the Italian context, where refrigerators have been identified as significant niches for pathogen persistence (Catellani et al., 2014).

First, building on the tools developed by Cairnduff et al. (2016), we aim to return a baseline snapshot of Italian consumers' knowledge and perception of refrigerator organisation, revealing whether consumers sufficiently acknowledge the importance of this practice.

Second, we test the efficacy of the TPB and its extension through the inclusion of desire, as well as positive and negative anticipated emotions, to elucidate the processes leading to the formation of intentions to correctly store food in household refrigerator. Specifically, we hypothesize the following:

- H1a: Attitudes, subjective norms, and PBC are positively associated with intentions to perform the target behaviour.
- H1b. Anticipated emotions and desire, as proposed by the MGB beyond the TPB framework, are positively associated with intentions to perform the target behaviour.
- H2: The extended model explains a significantly greater proportion of variance in intentions compared to the classical TPB.
- H3: Desire mediates the effects of attitudes, subjective norms, PBC, and anticipated emotions on intentions, consistent with the predictions of the MGB.

Ultimately, the study serves as formative research (Noar, 2006) that informs consumers' risk communication campaigns that address the advocated behaviour.

To meet the abovementioned aims, a study titled "FrigOK. Impara a usare correttamente il frigorifero per la sicurezza degli alimenti" ("FrigOK. Learn how to correctly use the refrigerator to keep food safe") was designed and implemented.

## 2. Material and method

### 2.1. Overview of the study

The current work is part of a wider project (Tiozzo Pezzoli et al., 2024) aimed to enhance the correct positioning of food in household refrigerators. Here we consider the first two questionnaires that were administered online via a smartphone app (i.e. Time2Rate for iOS and Android), which was developed by iMoobyte for the Bicocca Centre for Applied Psychology, University of Milano-Bicocca (iMoobyte, 2020), on consecutive days.

The first questionnaire (T0) investigated the management of household refrigerators in relation to food safety, along with sociodemographic variables. The survey instrument was adapted from the Consumer Refrigerator Safety Questionnaire (CRSQ; Cairnduff et al., 2016). This instrument was chosen because is a reliable tool for assessing systematically (i) consumer knowledge, (ii) perceptions and (iii) past behaviour in the area of refrigerator safety. The second questionnaire (T1) aimed to measure the constructs related to the TPB and its extension, the MGB. The beginning of the questionnaire included the informed consent and, with an informative intent, illustrated the importance of the correct positioning of food inside the refrigerator by means of a short instructional text accompanied by a summary image (see Supplementary materials S2). Afterwards, the participants answered measures of key variables of the tested models.

### 2.2. Participants and procedure

A Committee for the Research Evaluation[3] at the Psychology Department of the University of Milano-Bicocca approved the eligibility of the study as research at minimum risk (N. RM-2020-333). All procedures were conducted in accordance with international ethical standards, including the Declaration of Helsinki.

The participants were recruited via both the IZSVe Panel[4] and snowball sampling, the latter promoted by Facebook's paid advertising feature to enhance recruitment. To be enrolled in the study, participants had to give their informed consent and agree to the data processing (see

[3] A special internal committee within the Department of Psychology, which operates under the supervision of the University Ethics Committee.

[4] Part of the social research activities run by the IZSVe utilize a property panel, i.e., a group of citizens who declared themselves to be willing to participate in research activities (e.g., survey, focus group, interviews) to investigate specific issues on food safety and animal health and welfare. Information about the panel composition can be find here: https://www.izsvenezie.it/comunicazione/ricerca-sociale/panel-osservatorio-izsve/

Supplementary materials S1). In addition, they had to declare that they were at least 30 years old, responsible for the majority of food preparation and storage practices at home, and familiar with the use of smartphone apps. No upper age limits were given because food safety is an issue that affects different age ranges (Thaivalappil et al., 2020).

Following Schönbrodt and Perugini (Schönbrodt & Perugini, 2013), who demonstrated that correlations typically stabilize around N ≈ 250 for medium-sized effects (r ≈ 0.20–0.30), we aimed to recruit approximately 250 participants to obtain stable and reliable estimates of correlation coefficients. Thus, the primary objective of our sampling strategy was to ensure precision and stability of parameter estimates rather than statistical power per se. At the same time, we considered statistical power for testing the mediation model. Based on the recommendations by Fritz and MacKinnon (Fritz & MacKinnon, 2007), approximately 148 participants are required to detect medium-sized indirect effects (a = 0.26, b = 0.26) with 80% power (α = 0.05). Our final sample ($N = 242$, see the result section) exceeded this threshold, indicating that it was adequate to detect medium-sized indirect effects.

Data collection was conducted from September to November 2020 via the smartphone app Time2Rate. The Time2Rate app was designed to communicate directly with Qualtrics, which is a web survey system used to create and administer questionnaires. The participants were enrolled for two days: on Day 1, they were asked to register for the study, download the Time2Rate app and answer the T0 questionnaire, while on Day 2, they were asked to answer the T1 questionnaire.[5] Duplicates were avoided thanks to a unique alphanumeric code randomly assigned to each participant.

### 2.3. Measures

Multi-item scales from long tradition and well-established literature were used to measure the key variables in the questionnaire and adjusted to the behavioural domain, when necessary. Items were translated from English into Italian by field experts fluent in both languages, and any disagreements in translation were resolved through discussion (Brislin, 1986). As described below, the measures were then assessed for their psychometric properties to ensure reliability and validity.

#### 2.3.1. First questionnaire's measures

The following measures were collected at T0 and were adapted from the CRSQ (Cairnduff et al., 2016) except for past behaviour and COVID-19 measures. The complete list of items is presented in the Supplementary materials (S3). The PCAs for multi-item scales are presented in the Supplementary materials (S5, Tables S1 to S5).

*Responsibility for food procurement* was measured on a multi-item scale from 1. *Never* – 5. *Always* (i.e., "In this period, to what extent are you responsible for each of the following activities in your household? Buying food; Preparing and cooking food; Disposing food in the refrigerator"). The items were analysed both individually and as a whole (3 items; $\alpha = 0.79$). The frequency with which participants order food at home and/or take-away was also measured.

*Refrigerator management* was investigated with a series of multiple-choice questions (i.e., "Do you know the current temperature to which your refrigerator is set?"; "If yes, what is the temperature of your refrigerator? In degrees Celsius (°C)"; "How often do you check the temperature in your refrigerator?"; "Do you know how to set the thermostat of your refrigerator?"; "What information do you normally consider before adjusting the temperature of your refrigerator?"; "Which part of a refrigerator is normally the coldest?"; "How often do you clean the inside of your refrigerator?").

*Knowledge of food poisoning to correctly implement the target behaviour* was investigated with 3 multiple-choice questions (i.e., "In general, which foods do you think pose a higher risk of foodborne diseases (e.g., salmonellosis)?", followed by a list of options adapted from Arzenton et al. (Arzenton et al., 2005); "Which are the two safest ways to defrost raw meat?"; "Which is the safest place to store raw meat in the refrigerator?"). The questions specifically related to the management of the refrigerator were based on national guidelines authored by the Italian Ministry of Health (Ministero della salute, 2010) and were selected after discussion among those authors experts in the field; according to the subject matter experts' evaluation, these items were chosen as they pertinently question the consumers about their awareness of some of the most critical practices associated to the organisation of the refrigerator and of the food inside the appliance.

*Consumer perceptions* were investigated in terms of *perceived severity, perceived benefits, and perceived self-efficacy* based on a response scale ranging from "1. *Strongly disagree"* to "5. *Strongly agree*", and *perceived barriers* in terms of *lack of time* and *lack of knowledge* based on a response scale ranging from "1. *Not at all"* to "5. *Very much"*. *Perceived severity*: 2 items ($r = 0.39$, $p \leq .001$) e.g., "A foodborne disease would pose a serious problem for me and my family". *Perceived benefits*: 3 items ($\alpha = 0.61$); e.g., "Knowing where to place raw and cooked food in my refrigerator would reduce my family's risk of developing a foodborne disease". *Perceived self-efficacy*: 4 items ($\alpha = 0.82$); e.g., "I am confident that I know how to safely store food in the refrigerator". *Perceived barriers – lack of time*: 2 items ($r = 0.54$, $p \leq .001$); e.g., "Finding time to clean my refrigerator regularly". *Perceived barriers – lack of knowledge*: 2 items ($r = 0.78$, $p \leq .001$); e.g., "Lack of knowledge on proper storage of leftovers".

In T0 questionnaire, the following additional measure were present.

*Past behaviour when placing food in the refrigerator*. The participants were asked to choose from a drop-down menu the refrigerator shelf on which they habitually placed foods; the drop-down menu offered the following options: "*separate bottom drawer"*, "*side door*", "*top shelf*", "*middle shelf"*, "*bottom shelf*", "*where there is space"*, and "*I do not consume this food*'. In total, 12 foods that are generally considered in the literature and can pose a risk to health were considered. The 12 included foodstuffs were divided into two groups, namely "critical foods" (i.e., raw meat, raw fish, cheese and dairy products, eggs, cured meats, and cream-based desserts), and "less critical foods" (i.e., cooked meat, raw vegetables, cooked vegetables, cooked fish, fresh fruit, and butter and/or margarine), where "critical" reflects the level of risk a food can represent if not appropriately stored. The attribution of each food to one of the two groups was performed by two of the authors, as food safety experts.

The participants were also asked socio-demographic questions (e.g., age, gender, area of residence, education level, citizenship, working condition, children under 16 years old). As the data collection was conducted in the autumn of 2020 soon after the first wave of the pandemic, the participants also answered questions aimed at investigating the impact of COVID-19 on their lives, particularly in the area of food (see Supplementary materials S5, Tables S4-S6).

#### 2.3.2. Second questionnaire's measures

The second questionnaire (T1) included the following, adjusted from well-established measures, multi-item scales; items were randomized to control for order effect.

*Attitudes* towards the target behaviour were measured with the semantic differential. The participants responded to the following statement: "Regarding my goal, I believe that the correct placement of food inside the refrigerator for the next few days is a behaviour that is…" and indicated their attitudes via 5 items ($\alpha = 0.76$) on a 5-point response scale consisting of pairs of bipolar adjectives (i.e., harmful/beneficial, useless/useful, stupid/intelligent, unpleasant/pleasant, undesirable/

[5] For T0, participants received a first notification at 8:00 a.m., a second one at 6:00 p.m., and a reminder at 9:30 p.m. For T1, participants received a notification at 8:00 a.m., and a reminder at 6:00 p.m. Reminders were sent only if a participant had not yet completed the questionnaire.

Both T0 and T1 could be completed in the time window 8:00 a.m. – 11:59 p.m.

desirable; Perugini & Bagozzi, 2001)).

A 5-point response scale ranging from *"1. Completely disagree"* to *"5. Completely agree"* was used for subjective norms and PBC. *Subjective norms* were assessed with 2 items ($r = 0.46$, $p \leq .001$; e.g., "People who are important to me expect me to take care in correctly placing food inside the refrigerator in the coming days"; Ajzen, 2006).

*PBC* was assessed via 4 items ($\alpha = 0.84$; e.g., "Placing food correctly inside the refrigerator is a behaviour I would be able to keep under control during the next few days"; (Ajzen, 2006).

*Desire* was assessed via 2 items ($r = 0.68$, $p \leq .001$; e.g., "I want to correctly place food inside the refrigerator for the next few days in order to contribute to food safety in the household"; Perugini & Bagozzi, 2001) on a response scale ranging from "1. *False"* to "5. *True"*.

*PAEs* ($\alpha = 0.77$) were assessed using 3 items, "Proud"; "Confident"; "Satisfied", introduced by the statement: "Thinking about your goal of maintaining food safety in the household, if you succeeded in your task of correctly placing food inside the refrigerator, how would you feel?" (Perugini & Bagozzi, 2001), on a 5-grade response scale ranging from "1. *Not at all" to* "5. *Very much"*.

*NAEs* ($\alpha = 0.86$) were assessed on a similar scale: "Thinking about your goal of maintaining food safety in the household, if you did not succeed in your task of correctly placing food inside the refrigerator, how would you feel?"; 4 items followed: "Guilty"; "Regretful"; "Disappointed"; "Unable" (Perugini & Bagozzi, 2001); and the participants answered on a 5-point response scale ranging from "1. *Not at all"* to "5. *Very much"*.

*Behavioural intentions* were investigated via 3 items ($\alpha = 0.84$; e.g., "Correctly placing food in the refrigerator is a behaviour I will endeavour to perform in the next few days"; Ajzen, 2006) on a 5-point response scale ranging from "1. *Extremely unlikely*" to "5. *Extremely likely*".

The complete list of items is presented in the Supplementary materials (S4). The PCAs for multi-item scales are presented in the Supplementary materials (S5, Tables S10 to S14).

### 2.4. Data analysis

The analyses were conducted for only those respondents who completed both questionnaires. Analyses were conducted mainly with SPSS (Version 28); mediation analyses were conducted with JAMOVI (Version 2.3). The reliability of the measures was established by calculating Cronbach's alpha (α) for multi-item scales or with correlations (*r*), when constructs were measured with only two items. For Cronbach's alpha (α), values above 0.60 were considered acceptable. For correlations (*r*), values above |0.20| were considered acceptable. The validity of the measures was checked by performing Principal Component Analyses (PCAs; see Supplementary materials S5). Composite scores were computed for each dimension by averaging the items (except for the composite score of the measure of *Past behaviour when placing food in the refrigerator*, that was calculated by summing the correct scores) and *t-tests* from the mid-point of the scales were computed.

## 3. Results and discussion

### 3.1. Sample features

Out of 529 contacts that had registered to the study in the sampling phase, a total of 242 participants completed both T0 and T1 ($N = 242$) and were thus considered the final sample for the current study. The participants' mean age was 41.64 ($SD = 8.50$), they identified mainly as female (81%), lived mostly in North East Italy (51.7%; 19% North West; 12% Centre; 17.4% South and Islands); were mostly of Italian citizenship (98.3%), had an overall high level of education (21.9% high school diploma or lower; 45.4% Bachelor's or Master's degree; 31.4% PhD/Postgraduate specialization/Postgraduate master; 1.2% other), were mostly full-time workers (60.4%), lived mainly with their families (90.1%; 11.2% alone; 3.3% other), and about half of the sample (49.2%) had children under 16 years of age. Almost the entire sample had an omnivorous diet (86.4%). The level of concern about COVID-19 was found to be of a general nature ($M = 3.51$, $SD = 1.20$) and was not reported as affecting food decisions ($M = 2.09$, $SD = 1.01$); see Supplementary materials (Table S6) for additional details. The participants tended to prepare and cook their own food ($M = 4.44$, $SD = 0.58$) and did not order food at home and/or take-away ($M = 3.03$, $SD = 1.36$); in general, they took care of their own food procurement.

### 3.2. Descriptive and correlational results

A series of descriptive analyses were carried out on the variables included in the first questionnaire.

*Refrigerator management*. The majority of participants (66.5% of respondents) stated that they knew the temperature of their refrigerator, and 6.2% were uncertain. The average temperature reported by the participants ($M = 4.67$ °C, $SD = 1.61$) was above the optimal range between 0° and 4° indicated by the Italian Ministry of Health (Ministero della salute, 2010). Although 83.9% of the respondents said that they knew how to set the thermostat of their refrigerator, 14.9% of them had never checked the temperature of their refrigerator, while 15.7% reported checking it once a day. Before taking action, 35.5% of the respondents said that they checked whether stored food seemed too hot or too cold, 33.9% of them considered the load of the refrigerator, 25.2% of the respondents reported following the manufacturer's instructions for setting the thermostat, and 7.9% stated that they used an external thermometer. Alternatively (overall 5.8%), the respondents stated that the temperature of a refrigerator should be adjusted according to the season; the presence inside of critical food, and instructions reported on food labels; finally, some also declared to keep it unchanged. 27.7% of the respondents reported cleaning their refrigerator at least once a month, while 20.7% at least twice a month. Only a few people declared to clean it more frequently (7.4% once a week, or more). Almost one fourth of the respondents indicated to clean it just once a month (24%) or less (14.1%). Additionally, the participants reported knowing which is the coldest part of the refrigerator, i.e., the bottom shelf (55.4%); however, 27.3% indicated the upper shelf, 9.1% indicated the centre shelf and 8.3% declared not to know it.

*Knowledge of food poisoning to correctly implement the target behaviour*. The foods that the participants considered to pose the greatest risk of food poisoning were raw meat (80.2%), eggs (66.9%), raw fish (63.2%), shellfish (28.1%), and cream-based desserts (21.1%). They indicated that using the microwave oven defrost function immediately before cooking (52.1%), and using either the upper (46.3%) or the lower (41.3%) shelf of the refrigerator are the safest ways to defrost meat. Furthermore, 41.3% of the participants indicated the bottom shelf as the safest place in the refrigerator in which to place raw meat.

For all the key multi-item scales, the composite scores were computed. Table 1 reports the descriptive statistics of such variables.

*Consumer perceptions*. For the composite score, *t*-tests from the mid-point of the scale were computed. The participants showed a high degree of perception of the seriousness of foodborne diseases ($M = 4.23$, $SD = 0.87$, $p \leq .001$) and the benefits that can be derived from observing good food safety rules ($M = 4.10$, $SD = 0.74$, $p \leq .001$). Participants reported relatively high level of perceived self-efficacy with respect to the mid-point ($M = 3.70$, $SD = 0.82$, $p \leq .001$). Finding time to check the temperature of the refrigerator and to clean it regularly was not found to be a major problem for the respondents (*perceived barriers - lack of time*; $M = 2.50$, $SD = 1.08$, $p \leq .001$). Similarly, they did not consider a *lack of knowledge* about the correct way to store and defrost food and leftovers to be a major problem ($M = 2.78$, $SD = 1.19$, $p = 004$).

*Past behaviour when placing food in the refrigerator*. Behaviour when placing food in the refrigerator was weighted accounting for the actual consumption of foodstuffs for all the foods, critical foods, and non-critical foods, and the correct positioning of foodstuffs weighted for

**Table 1**
Descriptive statistics and correlations for the key variables.

| Variables | *M* | *SD* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Age | 41.64 | 8.50 | – | | | | | | | | | | | | | | |
| 2. Gender (0 = male, 1 = female) | / | / | −0.07 | – | | | | | | | | | | | | | |
| 3. Perceived severity of foodborne diseases | 4.23*** | 0.87 | 0.12 | −0.02 | – | | | | | | | | | | | | |
| 4. Perceived benefits | 4.10*** | 0.74 | −0.09 | −0.11 | 0.23*** | – | | | | | | | | | | | |
| 5. Perceived self-efficacy | 3.70*** | 0.82 | 0.08 | −0.11 | 0.16* | 0.27*** | – | | | | | | | | | | |
| 6. Perceived time barriers | 2.50*** | 1.08 | −0.13* | −0.07 | −0.13* | −0.01 | −0.14* | – | | | | | | | | | |
| 7. Perceived knowledge barriers | 2.78 | 1.19 | 0.04 | 0.04 | 0.02 | −0.06 | −41*** | 0.34*** | – | | | | | | | | |
| 8. Attitudes | 4.50*** | 0.50 | 0.09 | 0.13* | 0.15* | 0.24*** | 0.18** | −0.11 | 0.002 | – | | | | | | | |
| 9. Subjective norms | 3.50*** | 1.00 | 0.10 | −0.09 | 0.17** | 0.19** | 0.15* | −0.14* | −0.05 | 0.28*** | – | | | | | | |
| 10. PBC | 4.35*** | 0.69 | 0.03 | 0.06 | 0.13 | 0.08 | 0.20** | −0.22*** | −0.03 | 0.33*** | 0.42*** | – | | | | | |
| 11. Desire | 4.76*** | 0.50 | 0.07 | 0.08 | 0.18** | 0.08 | 0.12 | −0.04 | 0.05 | 0.52*** | 0.33*** | 0.37*** | – | | | | |
| 12. PAEs | 4.16*** | 0.75 | 0.03 | 0.02 | 0.17** | 0.29*** | 0.14* | 0.05 | 0.07 | 0.31*** | 0.25*** | 0.25*** | 0.37*** | – | | | |
| 13. NAEs | 3.10 | 0.97 | 0.07 | −0.05 | 0.15* | 0.26*** | −0.001 | −0.01 | 0.07 | 0.22*** | 0.34*** | 0.25*** | 0.18** | 0.47*** | – | | |
| 14. Behavioural intentions | 4.66*** | 0.51 | 0.09 | 0.11 | 0.17** | 0.07 | 0.22*** | −0.13* | −0.04 | 0.36*** | 0.21*** | 0.49*** | 0.54*** | 0.31*** | 0.16* | – | |
| 15. Past behaviour | 4.83 | 2.32 | 0.03 | −0.01 | −0.02 | 0.08 | 0.20** | −0.09 | −0.10 | 0.05 | −0.004 | 0.07 | −0.01 | −0.10 | −0.02 | −0.01 | – |

Note. The descriptive statistics refer to the whole sample ($N = 242$).
Method: listwise ($N = 237$).
* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$.

consumption – for all the foodstuffs - was considered (Table 2; see also Supplementary materials, Tables S8 and S9, for additional details). Handling errors were calculated for each food item, over and above actual consumption.

As shown in Table 2, on average, only 5 out of 12 foodstuffs were correctly positioned ($M = 4.83$, $SD = 2.32$), while for critical foodstuffs, the correct positioning was even lower ($M = 2.07$, $SD = 1.54$). Specifically, cooked vegetables, cooked meat, cooked fish, and eggs were the foods that the participants most often placed incorrectly in the refrigerator (see Supplementary materials, Table S7). A total of 23.1% of the participants reported placing raw meat on the middle shelf instead of the bottom shelf (37.6%), 42.1% reported placing cooked meat on the middle shelf instead of the top shelf (24.4%), 51.7% reported storing cooked vegetables on the middle shelf instead of the top shelf (20.7%), 19% reported disposing raw fish on the top or in the centre shelf (19.8%) instead of the bottom shelf (38.8%), 46.3% reported placing cooked fish in the middle shelf instead of the top shelf (19.4%), 29.8% reported storing cheese and dairy products on the top shelf instead of the middle shelf (39.3%), 59.5% reported storing eggs within the side door instead of the middle shelf (7%), and 23.6% reported placing cream cakes on the top shelf instead of the middle shelf (24.8%).

*TPB constructs*. Table 1 reports the descriptive statistics of the main constructs included in the TPB. *t*-tests from the mid-point of the scales were computed for each score. The participants showed positive attitudes towards the behaviour of correctly place food inside the refrigerator ($M = 4.50$, $SD = 0.50$, $p \leq .001$), high level of PBC ($M = 4.35$, $SD = 0.69$, $p \leq .001$), desire ($M = 4.76$, $SD = 0.50$, $p \leq .001$), and a slightly lower level of subjective norms ($M = 3.50$, $SD = 1.00$, $p \leq .001$), which was still above the mid-point of the scale. With respect to emotions, the participants stated that they felt high levels of PAEs ($M = 4.16$, $SD = 0.75$, $p \leq .001$) and low levels of NAEs ($M = 3.10$, $SD = 0.97$, $p = 107$); the difference between PAEs and NAEs was significant ($p < .001$, paired sample *t*-test). The participants' behavioural intentions were high ($M = 4.66$, $SD = 0.51$, $p \leq .001$).

*Correlation analysis*. As reported in Table 1, intentions were found to be correlated with measures of consumer perceptions, except for perceived benefits and perceived knowledge barriers. A greater perception of food poisoning, perceived self-efficacy, and the idea that time is not an obstacle to cleaning and adjusting the refrigerator temperature were found to be correlated with a greater intention to correctly place food inside the refrigerator. The past behaviour, on the other hand, was found to be positively correlated with only perceived self-efficacy – which correlates with the other measures of consumer perceptions – i.e., the more people feel able to enact correct food safety behaviour in the household, the more correctly the behaviour is enacted. Perceived self-efficacy also correlates with PBC (for more details about what is the relationship between the consumer perception measured with the CRSQ and PBC see Supplementary materials, Table S15).

The antecedent variables of intentions hypothesized by the TPB were all found to be correlated with each other and with the intentions themselves ($0.21 < r < 0.49$), supporting H1a. The variables included in the MGB model also showed a consistent picture of motivations fuelling the intention to perform the target behaviour ($0.16 < r < 0.54$), further supporting H1b. Past behaviour to correctly place food inside the refrigerator was not found to be correlated with the TPB antecedents and its extensions.

*Regression analysis*. To test H2, a hierarchical regression was

**Table 2**
Descriptive statistics of the correct positioning of foodstuffs weighed for consumption.

| Weighed correct positioning | M | SD |
|---|---|---|
| All foodstuffs (max count = 12) | 4.83 | 2.32 |
| Critical foodstuffs (max count = 6) | 2.07 | 1.54 |
| Non-critical foodstuffs (max count = 6) | 2.74 | 1.42 |

conducted to predict behavioural intentions incrementally (Table 3). Significant results were obtained from all the models except the first model ($R^2 = 0.02$), which considered only socio-demographic variables (i.e., gender and age). The second model included the antecedents of behavioural intentions in the TPB model ($R^2 = 0.29$), and attitudes and PBC were significant predictors. The third model added PAEs and NAEs ($R^2 = 0.32$), and the fourth model added desire ($R^2 = 0.40$). Behavioural intentions were explained in the fourth model by both PBC [B = 0.26, SE = 0.04, $p \leq .001$] and desire [B = 0.38, SE = 0.07, $p \leq .001$]. While PBC remained significant in all the other models in which it was included, the introduction of desire in the fourth model led to the loss of significance of attitudes and PAEs introduced in the third model, suggesting a mediation effect of desire. Subjective norms and NAEs, on the other hand, were never found to be significant. The extension of the TPB (which includes MGB variables) predicted and better explained behavioural intentions, supporting H2.

*Mediation analyses*. To test H3, mediation analysis was conducted to verify whether desire mediate the effects of the antecedents of the TPB on behavioural intentions (Fig. 1). Both direct and indirect effects were estimated. The model accounted for 33% of the variance in desire and 39% in the behavioural intentions (Fig. 1). Attitudes [β = 0.17, p ≤ .001, CI = 0.10, 0.24], subjective norms [β = 0.03, $p$ = .024, CI = 0.004, 0.05], and PBC [β = 0.05, $p$ = .009, CI = 0.01, 0.09] were found to have an indirect impact on behavioural intentions, via desire. Additionally, PBC affected behavioural intentions also directly [β = 0.27, $p \leq .001$, CI = 0.18, 0.35]. Desire was found to have a significant effect on intentions [β = 0.40, $p \leq .001$, CI = 0.28, 0.52], to be influenced by the antecedents of intentions, and to channel their effects onto the criterion.

A second mediation analysis was conducted to verify whether desire mediated the antecedents effects of the extended version of the TPB (MGB model) on behavioural intentions (Fig. 2). Both direct and indirect effects were estimated. Findings reveal that the extended TPB model accounted for 36.5% of the variance in desire and 40% of the variance in the intentions. By adding PAEs and NAEs to the mediation model, PBC remained the only antecedent with a significant direct effect on behavioural intentions [β = 0.26, $p \leq .001$, CI = 0.18, 0.35]. Attitudes [β = 0.14, $p \leq .001$, CI = 0.08, 0.21], subjective norms [β = 0.03, $p$ = .035, CI = 0.002, 0.05], PBC [β = 0.04, $p$ = .015, CI = 0.01, 0.08], and PAEs [β = 0.06, $p$ = .002, CI = 0.02, 0.09] had an indirect effect on behavioural intentions, via desire. The latter was found to have a significant effect on intentions [β = 0.38, $p \leq .001$, CI = 0.25, 0.50]. Desire is influenced by the antecedents of intentions, except for NAEs, and channels their effects onto the criterion, supporting H3.

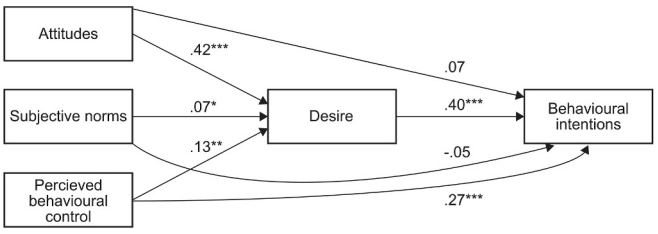


**Fig. 1.** Mediation analysis between attitudes, subjective norms, PBC and behavioural intentions, using desire as a mediator in the prediction of behavioural intentions. Note. * p ≤ .05, ** p ≤ .01, *** p ≤ .001.

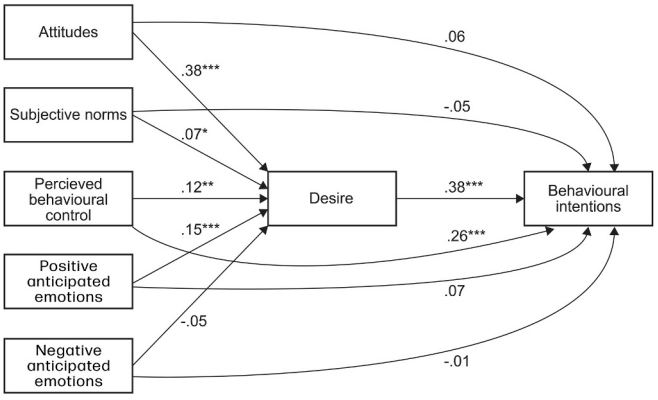


**Fig. 2.** Mediation analysis between attitudes, subjective norms, PBC, PAEs, NAEs, and behavioural intentions using desire as a mediator, in the prediction of behavioural intentions. Note. * p ≤ .05, ** p ≤ .01, *** p ≤ .001.

### 3.3. Participants' knowledge and risk perception about food storage in the refrigerator

In this study, the initial set of items provided insight into participants' knowledge and risk perception about food storage in the refrigerator, highlighting the cognitive dimensions that may shape everyday food-safety behaviours. *Knowledge and refrigerator organisation*. Overall, the data collected on knowledge highlighted the existence of well-educated consumers with regard to food safety. However, the respondents correctly placed, on average, less than half of the consumed foodstuffs in the refrigerator. The main safety issue concerns the storage of eggs, which the vast majority of the respondents reported storing in the refrigerator door. The other foods were generally allocated in the right place within the refrigerator; however, the right placement was not the only option because it was often paired with incorrect options as

**Table 3**
Behavioural intentions.

| | Model 1 | Model 2 | | Model 3 | | Model 4 | |
|---|---|---|---|---|---|---|---|
| Variables | *B* | *B* | 95% IC | *B* | 95% IC | *B* | 95% IC |
| Age | 0.01 | 0.004 | [−0.003, 0.01] | 0.004 | [−0.003, 0.01] | 0.003 | [−0.003, 0.01] |
| Gender | 0.16 | 0.08 | [−0.07, 0.23] | 0.08 | [−0.07, 0.22] | 0.07 | [−0.07, 0.21] |
| Attitudes | | 0.22*** | [0.10, 0.35] | 0.18** | [0.06, 0.31] | 0.04 | [−0.08, 0.17] |
| Subjective norms | | −0.02 | [−0.08, 0.05] | −0.02 | [−0.09, 0.04] | −0.05 | [−0.11, 0.01] |
| PBC | | 0.32*** | [0.22, 0.41] | 0.31*** | [0.21, 0.40] | 0.26*** | [0.17, 0.35] |
| PAEs | | | | 0.13** | [0.04, 0.21] | 0.07 | [−0.01, 0.15] |
| NAEs | | | | −0.02 | [−0.09, 0.04] | −0.01 | [−0.07, 0.06] |
| Desire | | | | | | 0.38*** | [0.25, 0.50] |
| $R^2$ | 0.02 | 0.29 | | 0.32 | | 0.40 | |
| $F$ | 2.57 (0.079) | 19.17*** | | 15.29*** | | 19.43*** | |
| $\Delta R^2$ | 0.02 | 0.27 | | 0.03 | | 0.09 | |
| $\Delta F$ | 2.57 (0.079) | 29.60*** | | 4.26* | | 33.36*** | |

Note. PBC = Perceived behavioural control. PAEs = Positive anticipated emotions. NAEs = Negative anticipated emotions.
* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$.

well. Additionally, some respondents even reported placing food where there is room within the refrigerator. Most respondents (66.5%) reported knowing the temperature of their refrigerator; however, the reported temperatures were often unfortunately higher than that recommended (between 0 °C and 4 °C) by the Italian Ministry of Health (Ministero della salute, 2010). Similar results were obtained by the Istituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia Romagna, who analysed the temperatures of domestic refrigerators in Italy (Calò et al., 2019).

*Risk perception.* The participants showed a fairly high degree of perception of the severity of foodborne infections and the benefits that can be derived from adhering to good food safety standards. Additionally, they were aware that FBDs could represent a serious problem for themselves and their family; this is the reason why the respondents reported that properly adjusting the temperature of the refrigerator and frequent cleaning it could help reduce their exposure to developing a FBD. On average, the participants' level of self-efficacy was found to be high; they felt that they follow good food safety standards and feel comfortable with the advocated behaviour. They reported feeling confident about how to safely store food in the refrigerator, how often to clean it and what is the best refrigerator temperature. Accordingly, they did not report perceiving any barriers to implementing the target behaviour; spending time checking the temperature and regularly cleaning the refrigerator were not major problems reported by the participants. Similarly, the lack of knowledge on the correct way to store and defrost food and leftovers was not found to be a concern for the respondents. This picture is in line with the literature on food risk perception traits of consumers; owing to the nature of the (biological) hazard itself, high levels of both self-confidence and self-efficacy prevent people from paying adequate attention to food, which is enhanced by an optimistic bias that negatively impacts both self-protective behaviour and efforts to promote risk-reducing behaviours (Miles & Scaife, 2003).

These data support the knowledge-behaviour gap that hinders safe food management at home: in our study, well-informed consumers still persist in improper food storage practices, notwithstanding their high risk perception. High self-efficacy, together with low perceived barriers, further complicate the picture, leading to complacency and to a false sense of safety. Additionally, for the specific investigated target behaviour, high self-efficacy may paradoxically attenuate actual risk awareness and lead to complacency in safe food practices. In this context, elevated self-efficacy could function as a blocking factor for the proper disposal of food in household refrigerators, even though it has consistently been identified as a significant predictor of safe food-handling behaviour (van Rijen et al., 2021).

Although previous research has suggested that COVID-19 positively influences risk perceptions in predicting food-handling behaviours in some contexts, our findings indicate that concern about the pandemic has led to more generalized outcomes (Mucinhato et al., 2022). Specifically, it has not significantly altered food choices or related behaviours; rather, such a concern has primarily increased participants' attention to hand washing during meal preparation.

Overall, the results enabled us to assess Italian consumers' refrigerator safety knowledge and behaviour of use; as intended and suggested by Cairnduff et al. (Cairnduff et al., 2016), this information is valuable for informing future communication interventions to mitigate deviations in refrigeration practices from the recommended ones. In-depth studies could specifically address the positioning of eggs rather than to urge consumers to generally remember proper and safe fridge organisation.

In this study, we also investigated the cognitive processes that lead to the formation of intentions to implement the behaviour of storing food in household refrigerators, a behaviour that ensures food safety at home.

*Predictors of behavioural intentions.* Socio-demographic variables were found to be more background variables. They were not found to have an effect on intentions and to be weakly correlated with a few variables. Older people reported that having the time to check the temperature of the refrigerator and clean it is not a problem for them (perceived barriers - time). With respect to gender, women were found to have more favourable attitudes towards the target behaviour than men did.

The antecedent variables of intentions considered by the TPB model (attitudes, subjective norms and PBC) and its extensions (PAEs, NAEs, and desire) were all correlated positively ($0.18 < r < 0.52$), showing a consistent pattern of relationships (Table 1). The variables considered in the TPB model and its extension, the MGB model, represent a coherent framework of motivations that are linked to the intention to engage in the target behaviour - correctly placing food in the refrigerator - and contribute to explain the participants' cognitive processes (Table 3). Intentions to realise the target behaviour were found to be directly predicted by all the expected variables, except subjective norm and NAEs. The impact of attitudes and PAEs disappeared when introducing desire to act as additional antecedent. Mediation analyses uncovered the underlying psychological mechanisms that explain how desire drives the influence of the antecedent variables on intentions. When considering only the predicting variables related to the TPB (Fig. 1), desire was found to be influenced by all the predictors: attitude, subjective norms and PBC. Interestingly, a total mediation of the effects of attitudes and subjective norms on intentions through desire, and partial mediation of the effect of PBC on intentions by desire as a mediator, were observed. In other words, the respondents' evaluation of the advocated behaviour's reasons to act (attitudes, the evaluations of the costs and benefits related to the correct placement of food in the refrigerator, normative pressure, and perceptions of control over the action) was found to influence the intention to implement the behaviour entirely through the role of desire.

PBC alone was found to influence intentions also directly, revealing the importance of evaluations about the ability to keep under control the behaviour in terms of time and confidence about how to safely store food in the refrigerator (Table S15). Thus, respondents were found to be influenced by contextual factors and to be able to cope with obstacles or barriers to the implementation of behaviour (McEachan et al., 2011).

When considering the variables within the MGB model (TPB extensions), it also emerged that PAEs towards the target behaviour influenced the intention to implement it through the role of desire. This is a process of emotional self-regulation that intervenes to feed desire. The participants reported PAEs (they anticipated being happy if they succeeded in achieving the behavioural goal) and this fuels the desire to act, as people are generally prone to approach positive emotions. Interestingly, the possibility of feeling disappointed (NAEs) for failing to protect their household did not result in stronger intentions to engage in the desired behaviour to prevent these negative emotions, contrary to our prediction (Bagozzi, 2024). This is in line with other research on risk decision-making that indicates that NAEs, such as guilt or regret, do not always significantly influence behavioural intentions (e.g., Loewenstein et al., 2001).

Previous studies (Young et al., 2017) have stressed the importance of social norms as a construct to be targeted in consumer risk communication; in contrast, our results suggest that for the specific investigated behaviour, this variable is a weak predictor of intentions via the desire to act. Veflen and colleagues (Veflen et al., 2020) showed that the strength of social norms depends strongly on situational context, with some situations characterised by high and others by low pressure to comply, rather than by familiarity per se. In line with this, respondents who were themselves responsible for food preparation reported feeling free to behave as they thought appropriate in the kitchen environment, indicating relatively low perceived normative pressure in this setting.

Correlation analyses also showed that cognitive processes are disconnected from the implementation of action; past behaviour was not found to correlate with any of the TPB or MGB variables. It was also found to have no effect on either the intentions or the desire to achieve the target behaviour, thereby confirming a gap between the intention to enact the behaviour and its implementation. The results suggest that the target behaviour is much more dependent on the situational context in which participants usually live when preparing food; in such situations,

people feel capable of managing obstacles or barriers that prevent them from carrying out the behaviour. Therefore, future interventions should focus on the perceptions that individuals have about the control of their own behaviour in situational contexts.

In relation to the various points raised so far, an additional aspect that merits consideration concerns the habitual and routinized nature of domestic food preparation. Food storage behaviours are typically embedded in low-visibility everyday routines and are often performed with minimal deliberation. From a psychological perspective, habits are automatic, cue-contingent responses acquired through repetition in stable contexts and can be triggered with minimal conscious deliberation (Verplanken & Orbell, 2003). This automaticity may help explain why high levels of knowledge, risk perception, and even strong intentions do not always translate into consistently correct refrigerator practices.

When behaviours are guided by established routines, individuals may rely on familiar scripts rather than actively reflecting on recommended safety standards. Moreover, strong habits are often found to weaken the intention–behaviour relationship, particularly for frequently repeated behaviours (Gardner et al., 2020). Therefore, future studies and interventions aimed at improving home food safety might not only target cognitive and motivational determinants, but also seek to disrupt maladaptive routines and reshape environmental cues that sustain them.

The mediation models account for a significant portion of variance in both intentions and desire. When inclusion of the emotional processes in the MGB model helps to increase the explanation and prediction of desire, thus confirming its valuable addition (Bagozzi, 2024). Desire captures the motivational force driving an individual towards action, translating cognitive appraisals and anticipated emotions into behavioural intentions. In some health-related behavioural domain it is necessary to make emerge the distinction between intending and wanting to do something (Esposito et al., 2016). Overall, our findings support the usefulness of incorporating motivational and emotional components (Gaube et al., 2019), as emphasized in the MGB (Bagozzi, 2024), also in the food handling domain. By identifying desire as a central mediating mechanism, our results clarify the psychological process underlying intention formation.

### 3.4. Implications for food risk communication

The results of this study confirm that the TPB and the extensions we considered herein (MGB) represent a useful model to explain the factors associated with consumers' intentions to implement adequate food safety behaviours, such as the proper storage of food in household refrigerators. Importantly, the application of the TPB/MGB also offers theory-driven consumer behaviour information that communication practitioners can use to tailor communication efforts. As the application of theories of behaviour is advocated as an integral step in intervention design (Davis et al., 2015), our study is not limited to confirming the need to improve consumers' education to properly organize food in the refrigerator; rather, it also offers suggestions to craft these initiatives from a risk communication perspective.

First, this study indicates that enhancing domestic food safety requires a renewed focus on consumer education concerning the proper management of the refrigerator - specifically hygiene and temperature regulation — as well as adequate food placement to account for thermal gradients and cross-contamination risks. As recent literature points out, a synergy between advancements in refrigerator design, consistent maintenance, and robust educational initiatives is crucial for ensuring that household refrigeration systems adhere to established safety guidelines. Addressing these factors is paramount not only for reducing energy expenditure but also for controlling microbial hazards, thereby optimizing food safety and shelf life in domestic settings (Chaomuang et al., 2025b; Licata et al., 2024).

The results also explain why it is generally difficult for risk communication to be effective in promoting safe food management practices at home; the level of self-efficacy related to refrigerator management was found to be high in the current study, and this represent a potential risk because food handling may be associated with optimistic bias, with a consequent negative impact on self-protective and risk-reducing behaviours (Miles & Scaife, 2003). Since self-efficacy related to refrigerator management impacts PBC (see Table S15), and consequently behavioural intentions, people might overestimate their capability and therefore, might not engage in risk communication. Preventive messages may fail or simply remain unattended because people already consider themselves to be sufficiently informed. Indeed, people should be reminded that each step in the manipulation of food should receive careful attention and be performed with full knowledge of its implications in terms of both risk prevention (when appropriately performed) and exposure (when not appropriately performed).

Second, as socio-demographic variables were found to have no impact on intentions, this should not be interpreted as evidence against tailored communication. Our sample indeed was limited as exhibited low socio-demographic variability, being largely composed of women and highly educated participants. Segmented communication approach recommends designing communication interventions based on socio-demographics (Maxim et al., 2021; Patil et al., 2005; Verbeke et al., 2007). Indeed, we corroborate the need to perform target audience analysis (according to, e.g., gender or age and other relevant variables) in terms of unveiling psychosocial processes and drivers of behaviour that could help guide communication strategies because the inclusion of psychological determinants leads to a better model for the prediction of food-related behaviours (Fischer & Frewer, 2008).Third, our results suggest that risk communication should support PBC and the desire to perform the action; i.e., reinforcing the motivations that fuel the desire to act. Concerning the PBC, as its level was found to be high, in order to avoid an overconfidence effect, it is necessary to draw one's attention to the intended behaviour. In other words, improving the appropriate storage of food in the refrigerator requires that people pay attention to this practice as if each time is the first time. For example, communication messages should induce the recipient to question their food safety knowledge to act more reflectively, such as “Are you truly sure of how to best store eggs in your fridge?”, “Are you sure that how one stores food in the fridge poses no serious health risks?”. Concerning the reinforcement of desire, messages should not be based alone on attitudes (e.g., messages stressing that the target behaviour is useful and not unpleasant to put into practice) or on subjective norms (e.g., messages stressing the benefit from the implementation of the target behaviour for health of either the individual or their reference group).

It is also necessary to leverage PAEs that were also found to influence desire, i.e., making people realise that if they properly implement the task, they will feel better emotionally. We recommend placing similar messages in the headings of communication materials to trigger the reader and then continue with the main information (e.g., the pathogen's description, symptoms, vulnerable groups, dos and don'ts list, etc.).

From a practical standpoint, identifying desire as a key mediator suggests that communication interventions should not only aim to improve knowledge or shape favourable evaluations, but also actively foster motivational engagement. Communication strategies that make the behavioural goal personally desirable may be more effective in promoting safe food practices than purely informational campaigns. In other words, stimulating the “want to” component may be crucial for translating favourable beliefs into concrete behavioural intentions.

### 3.5. Limitations and further research

This study presents some limitations that can be overcome in future research. We have already indicated the limited variability of the sample; future research might consider bigger quota samples, to depict a clearer representation of the underlying processes in different segments of the population.

In terms of strengths, unlike other studies in the field of food safety

risk perception, our study focused on the prediction of a specific food-handling behaviour; this prevented us overestimating the measurement of intentions and behaviour, which is a risk that may occur when measuring food-handling behaviours as a whole.

We collected data regarding how participants reported generally placing food in the refrigerator. Future studies could further investigate this aspect—possibly in a situated context—to verify how consumers actually store food in refrigerators, while also considering the different levels of criticality of each food category and their actual consumption.

The exclusive use of a questionnaire was consistent with the study's aim of assessing cognitive and motivational constructs derived from the TPB and MGB, which are inherently subjective and best captured through self-report measures. However, we acknowledge that this approach does not allow direct observation of actual food-handling practices and may be affected by self-report biases. Future research could therefore adopt mixed-methods designs (see e.g. Bulochova et al., 2024), combining validated questionnaires with observational measures (e.g., structured observation of refrigerator organisation, food storage diaries, or digital temperature sensors), to enhance ecological validity in the study of domestic food safety.

Although classical risk perception includes both severity and probability (Slovic, 2010), our study limited the assessment to CRSQ (Cairnduff et al., 2016), which assesses risk primarily through perceived severity and benefits of preventive action. Within the TPB/MGB framework, perceived severity served as contextual information influencing key variables rather than directly predicting intentions. Future research could include both severity and probability to more fully capture risk appraisal. Importantly, because perceived severity was not modelled as a direct predictor of intentions, the core findings regarding TPB/MGB processes and the mediating role of desire remain unaffected.

Ultimately, our results apply to a well-defined target behaviour; however, PBC and desire might have a different impact on intentions when considering other domestic food safety behaviours.

## 4. Conclusion

The present study provides a baseline for Italian consumers' knowledge, perceptions and habits related to food storage and placement in refrigerators. Even though consumers may declare that they are well informed and have a favourable attitude towards this practice, the findings indicate that food distribution inside refrigerators still deserves education and appropriate consumer attention. In our work, intentions were found to be guided by attitudes, PBC, and PAEs. The impact of these variables was found to occur through desire, which was found to not only guide all reasons to act but also transform such reasons into a willingness to act. Only a direct impact of PBC was found to remain. Thus, messages aimed at enhancing the correct storage of food in the refrigerator should leverage PBC, desire, and PAEs. The findings confirm that investigating the psychosocial processes behind intentions to perform food safety behaviour is a valuable strategy for informing food risk communication.

## CRediT authorship contribution statement

**Barbara Tiozzo Pezzoli:** Writing – original draft, Supervision, Project administration, Conceptualization. **Valentina Demasi:** Writing – original draft, Methodology, Investigation, Formal analysis. **Mirko Ruzza:** Writing – original draft, Conceptualization. **Ulderica Calandra:** Validation, Software, Conceptualization. **Emanuela Zinni:** Investigation, Formal analysis. **Mosè Giaretta:** Writing – review & editing, Conceptualization. **Antonia Ricci:** Writing – review & editing, Supervision. **Silvia Mari:** Writing – review & editing, Supervision, Methodology, Investigation, Conceptualization.

## Institutional review board statement

The study was conducted in accordance with the Declaration of Helsinki and evaluated by the local commission for minimal-risk studies of the Psychology Department of University of Milano-Bicocca (Protocol no. RM-2020-333).

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The funding sources had no involvement neither in the study design nor in the collection, analysis, and interpretation of data.

## 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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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodres.2026.119163.

## Data availability

The dataset is available at the following link: https://osf.io/by6zq/?view_only=9b9c53f6fec74d9db8cd98abd06e21eb

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