

# Psychological predictors of unhealthy eating and food security: a meta-analysis

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## Abstract

**Purpose** – This study aims to investigate how national food security moderates the predictive relationships proposed by the theory of planned behavior (TPB) – attitudes, subjective norms and perceived behavioral control (PBC) – in the context of unhealthy food consumption.

**Design/methodology/approach** – The authors conducted a meta-analysis of 75 studies, encompassing 427 effect sizes related to intention and behavior regarding unhealthy eating. The authors used random-effects models and meta-regressions to test the moderating role of the Global Food Security Index (GFSI), along with covariates such as sample nature, measurement strategy, behavioral framing and sample age.

**Findings** – All TPB constructs showed significant positive associations with unhealthy eating. However, GFSI significantly moderated these effects. Higher national food security levels weakened the relationships between attitudes, subjective norms, PBC and unhealthy food consumption. This suggests that in more food-secure environments, psychological predictors play a less central role in dietary decision-making.

**Research limitations/implications** – The findings advance TPB by demonstrating its conditional validity under different macrostructural conditions, reinforcing the integration of ecological and structural variables in behavioral models.

**Practical implications** – In food-secure contexts, public health interventions may benefit more from structural strategies than cognitive or motivational approaches. Conversely, in food-insecure settings, targeting attitudes and perceived control remains relevant.

**Social implications** – Tailoring health campaigns to food security contexts can increase effectiveness and support more equitable, sustainable food systems.

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**Originality/value** – To the best of the authors’ knowledge, this is the first meta-analysis to integrate TPB with national food security indicators, offering novel insights into how environmental structure shapes health behavior predictors in unhealthy eating.

**Keywords** Unhealthy eating, Theory of planned behavior, Food security, Meta-analysis, Public health policy

**Paper type** Research paper

## 1. Introduction

The rising global consumption of unhealthy foods rich in sugar, fat and refined carbs has become a major public health issue (Popkin et al., 2021). Unhealthy eating habits correlate with heightened risks of obesity, diabetes and cardiovascular diseases, leading to urgent demands for policies that foster healthier dietary choices (World Health Organization, 2021). While the appeal and emotional satisfaction of unhealthy foods often drive poor dietary choices (Dohle, Diel, & Hofmann, 2015), such decisions are not solely impulsive. According to the theory of planned behavior (TPB; Ajzen, 1991), choosing unhealthy foods can be a deliberate act, shaped by impulsive desires that may override rational intentions (Zhou et al., 2025).

The TPB asserts that three main components (attitude toward the behavior, subjective norms and perceived behavioral control [PBC]) influence an individual’s intention to act, which subsequently predicts actual behavior (Ajzen, 1991; Fishbein & Ajzen, 2011). Various studies have applied the TPB to food consumption, affirming its applicability even in indulgent eating contexts (McDermott, Oliver, Svenson, & Simnadis, 2015; Conner & Armitage, 2002). Specifically, favorable attitudes toward unhealthy foods, perceived social approval and ease of access to such foods correlate with stronger intentions and increased consumption (Chilón-Troncos, García-Salirrosas, Escobar-Farfán, Millones-Liza, & Villar-Guevara, 2024; Ajzen, 2015). However, the strength of these associations may fluctuate with broader contextual factors that affect both the perceived convenience and desirability of unhealthy eating.

Although unhealthy food consumption often follows planned behaviors, the indulgent nature of these foods and the social validation around their consumption foster environments where planned intentions may be easily overridden or diminished (Hofmann, Friese, & Wiers, 2008). Thus, grasping these psychological motivations is vital for crafting public policies aimed at curtailing unhealthy eating habits, as interventions are likely to be more successful when they align with the factors influencing intentional food choices (Sheeran, Harris, & Epton, 2016).

Despite the TPB’s effectiveness in clarifying eating behaviors (e.g. Hagger & Hamilton, 2024), TPB-based meta-analyses have largely overlooked macrostructural moderators, particularly national food security, implicitly assuming that the psychological drivers of unhealthy eating operate uniformly across food environments. Yet food-related behaviors do not occur in a vacuum: food environments shape the availability, affordability and social acceptance of unhealthy foods (Story, Kaphingst, Robinson-O’Brien, & Glanz, 2008; Swinburn et al., 2011), so national food security, as indexed by the Global Food Security Index (GFSI) (Economist Intelligence Unit, 2022), may condition the TPB pathways. No prior review or meta-analysis has examined whether the predictive strength of attitudes, subjective norms and PBC varies systematically with national food security, an empirical gap this study addresses.

Accordingly, the central research question is:

*RQ1.* Do national levels of food security moderate the predictive relationships proposed by the TPB in the context of unhealthy food consumption?

Using a meta-analysis of 75 studies and 427 effect sizes from various countries, we test whether higher GFSI levels weaken the links between attitude, subjective norms, PBC and

unhealthy food consumption. By combining the TPB with structural indicators of food accessibility, this research contributes to the convergence of consumer behavior, marketing and public policy, offering insights for interventions and regulatory approaches tailored to each country's food security context ([Andrews et al., 2022](#); [Swinburn et al., 2019](#)).

## 2. Theoretical background

### 2.1 *Theory of planned behavior and unhealthy food consumption*

The TPB ([Ajzen, 1991](#)) provides a well-established framework for predicting dietary decisions, proposing that behavior is driven by intentions shaped by attitudes, subjective norms and PBC. Meta-analyses demonstrate that these constructs explain substantial variance in both intentions and actual eating behaviors ([Armitage & Conner, 2001](#); [McEachan, Conner, Taylor, & Lawton, 2011](#); [McDermott et al., 2015](#)). In the context of unhealthy eating, favorable attitudes toward indulgent foods, permissive social norms and a sense of ease or control over accessing such foods are linked to stronger intentions and higher consumption ([Chilón-Troncos et al., 2024](#)).

Although TPB emphasizes deliberate decision-making, unhealthy eating often unfolds amid hedonic cues, emotional triggers and habitual patterns: foods high in sugar, fat and salt activate reward responses that may conflict with conscious goals ([Stice, Spoor, Bohon, & Small, 2013](#); [Hofmann et al., 2008](#)), social practices legitimize indulgence ([Bolhuis, Roodenburg, Groen, & Huybers, 2024](#)) and marketing saturation and low-cost availability undermine perceived control ([Story et al., 2008](#); [Swinburn et al., 2011](#)). These conditions can make attitudes more ambivalent, norms more lenient and perceived control more fragile, so applying TPB to unhealthy eating requires considering both rational and impulsive mechanisms alongside the macrostructural factors that shape food environments ([Sheeran et al., 2016](#)).

### 2.2 *Macrostructural food environment: Global Food Security Index*

Structural conditions shape food choices by facilitating or constraining dietary behavior ([Swinburn et al., 2011](#); [Story et al., 2008](#)). Among these, national food security is a key macro-level factor influencing how attitudes, subjective norms and PBC operate within the TPB framework. Defined as access to adequate, safe and nutritious food for all (Food and Agriculture Organization, 2012), food security is captured by the GFSI, which considers availability, affordability, quality, safety and resilience ([Economist Intelligence Unit, 2022](#)).

Higher GFSI scores reflect better access to healthy foods and stronger regulatory systems, whereas low-GFSI environments are marked by limited access, higher costs and weaker infrastructure ([Kirkpatrick & Tarasuk, 2009](#); [Loopstra & Tarasuk, 2015](#)); food security is therefore not a backdrop but a moderator of TPB mechanisms in unhealthy eating.

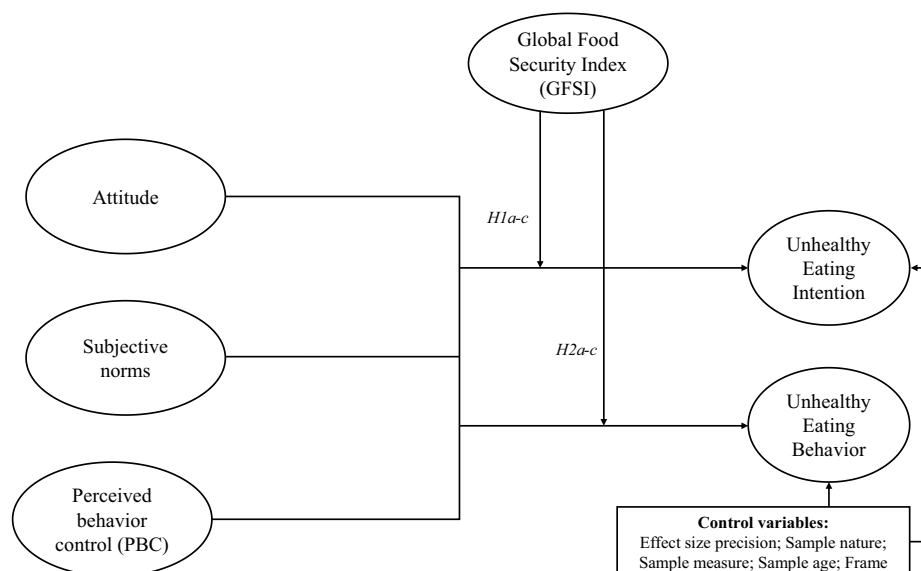
We use the contrast between higher- and lower-food-security contexts as an illustrative axis of a continuous moderation hypothesis (GFSI is modeled as a continuous variable), grounded in ecological and food-environment models of behavior ([Story et al., 2008](#); [Swinburn et al., 2011, 2019](#)) and in evidence on the socioeconomic gradient in diet quality ([Darmon & Drewnowski, 2008](#); [Loopstra & Tarasuk, 2015](#)), rather than treating the dichotomy itself as the basis for the hypotheses.

### 2.3 *Hypotheses development*

Macrostructural conditions, particularly national food security, play an important role in shaping the psychological mechanisms involved in unhealthy food consumption. Within the TPB ([Ajzen, 1991](#)), the influence of attitudes, subjective norms and PBC varies with structural and environmental contexts that differ between food-secure and food-insecure settings. Higher levels of food security increase access to nutritious foods and strengthen

regulatory frameworks (Economist Intelligence Unit, 2022; Kirkpatrick & Tarasuk, 2009), which may moderate the links between attitudes, norms, PBC and both intentions and behaviors related to unhealthy eating. In TPB, attitudes, norms and PBC exert their most direct influence on intention, the proximal antecedent of behavior (Fishbein & Ajzen, 2011), and meta-analyses show that these predictors explain substantial variance in dietary intentions (Armitage & Conner, 2001; McDermott et al., 2015; McEachan et al., 2011). Importantly, the relative weight of these predictors is not fixed. Recent preregistered evidence shows that the strength of the attitude–intention and subjective-norm–intention relations varies systematically with other factors (La Barbera & Ajzen, 2021), and Ajzen (2020) stresses that each construct’s predictive role is contingent on the behavior and context under study. This conditional view of the TPB provides the theoretical basis for treating national food security as a macrostructural boundary condition that shapes the construct–intention and construct–behavior pathways. In the case of unhealthy eating, favorable evaluations of indulgent foods, perceived social approval and perceived ease of consumption strengthen intentions to engage in such behaviors (Chilón-Troncos et al., 2024; Dohle et al., 2015). All hypotheses (H1a–H1c and H2a–H2c) are illustrated in Figure 1.

First, regarding attitudes, food-secure environments typically feature greater exposure to public health campaigns, nutrition education and policy efforts that discourage unhealthy eating and promote healthier choices (Darmon & Drewnowski, 2008). These initiatives tend to foster more negative evaluations of unhealthy foods and increase awareness of their health risks, thereby weakening the link between favorable attitudes toward unhealthy foods and the intention to consume them (Sheeran et al., 2016). In contrast, in food-insecure contexts, structural pressures such as price, limited availability of healthy options and marketing of cheap, energy-dense products may reinforce positive evaluations of unhealthy foods as convenient or necessary options, strengthening the attitude–intention relationship (Darmon & Drewnowski, 2008; Swinburn et al., 2011). Accordingly, we posit the following:



**Figure 1.** Framework theoretical

*H1a.* The positive relationship between attitude toward unhealthy food and intention to consume unhealthy food will be weaker in countries with higher levels of food security (GFSI).

Second, subjective norms capture perceived social approval and expectations surrounding unhealthy eating. In food-secure contexts, where institutions, media and public policy more strongly endorse healthy eating, the social desirability of unhealthy foods is likely lower, and normative pressure to engage in unhealthy eating may be attenuated (Story et al., 2008). As environments align more with health-promoting norms through restrictions on unhealthy food marketing, clearer front-of-pack labeling and the normalization of healthier diets, permissive norms should have less influence on unhealthy eating intentions (Swinburn et al., 2019). Conversely, in food-insecure or obesogenic contexts, where high-calorie, low-cost foods are socially normalized, permissive norms may strongly reinforce intentions to consume unhealthy foods (Story et al., 2008; Bolhuis et al., 2024). Thus, we propose:

*H1b.* The positive relationship between subjective norms favoring unhealthy food consumption and intention to consume unhealthy food will be weaker in countries with higher levels of food security (GFSI).

Third, PBC reflects perceived ease or difficulty in performing a behavior, including confidence in one's ability to manage food choices under situational constraints (Ajzen, 2015, 2020; La Barbera & Ajzen, 2021). Meta-analytic evidence indicates that PBC robustly predicts health-related intentions, particularly when behaviors require planning, self-regulation, or overcoming environmental barriers (Armitage & Conner, 2001; McEachan et al., 2011). In food-insecure settings, structural barriers, such as limited access to healthy alternatives, higher relative prices of nutritious foods and weaker regulatory protections, may heighten the role of PBC in shaping unhealthy eating intentions (Loopstra & Tarasuk, 2015). Individuals who perceive high control over accessing and consuming unhealthy foods are more likely to form strong intentions to do so when structural constraints favor cheap, energy-dense options (Ajzen, 2015). In food-secure environments, however, improved access to healthy foods and stronger policy safeguards may reduce the relevance of perceived control for forming unhealthy eating intentions, thereby weakening the PBC–intention link (Kirkpatrick & Tarasuk, 2009). Hence:

*H1c.* The positive relationship between perceived behavioral control over unhealthy food consumption and intention to consume unhealthy food will be weaker in countries with higher levels of food security (GFSI).

Beyond intentions, TPB also posits that attitudes, norms and PBC can be related to actual behavior, either directly or indirectly through intentions (Ajzen, 1991; Fishbein & Ajzen, 2011). However, a substantial body of research documents an “intention–behavior gap,” showing that intentions, although predictive, do not fully translate into behavior and that this translation is sensitive to contextual and structural factors (Ajzen, 2020; Fechner & Isbanner, 2025; McEachan et al., 2011). In the food domain, meta-analyses indicate that TPB constructs have meaningful, albeit weaker, associations with discrete dietary behaviors than with intentions (McDermott et al., 2015; Riebl et al., 2015). This suggests that the extent to which attitudes, norms and PBC translate into unhealthy eating behavior should also depend on macrostructural conditions such as food security.

Regarding attitudes, unhealthy food consumption occurs in environments saturated with hedonic cues, marketing stimuli and habitual patterns (Hofmann et al., 2008). In food-insecure

contexts, where cheap, ultra-processed products are disproportionately available and often represent a practical response to resource constraints, favorable attitudes toward such foods may readily translate into actual consumption (Darmon & Drewnowski, 2008; Swinburn et al., 2011). In food-secure environments, by contrast, greater availability of healthy alternatives, stronger regulatory frameworks and more supportive public health infrastructure can weaken the extent to which positive attitudes toward unhealthy foods translate into behavior. Structural facilitators of healthy eating may therefore attenuate the attitude–behavior relationship for unhealthy consumption (Story et al., 2008). Thus, we hypothesize:

*H2a.* The positive relationship between attitude toward unhealthy food and unhealthy food consumption behavior will be weaker in countries with higher levels of food security (GFSI).

For subjective norms, social and cultural practices surrounding food strongly influence not only what individuals intend to eat but also what they ultimately consume (Bolhuis et al., 2024). When unhealthy foods are embedded in social rituals and everyday eating practices, often the case in more food-insecure or obesogenic environments, permissive norms can exert direct pressure on behavior, encouraging overconsumption of energy-dense products (Story et al., 2008; Swinburn et al., 2011). However, in more food-secure contexts, public discourse, institutional campaigns and regulatory interventions may shift descriptive and injunctive norms toward healthier patterns (Swinburn et al., 2011), thereby reducing the direct impact of permissive norms on unhealthy eating behavior. As healthy diets become more socially valued and unhealthy options more stigmatized or restricted, the normative pathway to behavior should weaken (Swinburn et al., 2019). We therefore propose:

*H2b.* The positive relationship between subjective norms favoring unhealthy food consumption and unhealthy food consumption behavior will be weaker in countries with higher levels of food security (GFSI).

Finally, PBC is theorized to influence behavior both indirectly, via intentions and directly when perceived control closely matches actual control over performing the behavior (Ajzen, 2015, 2020; Armitage & Conner, 2001). In food-insecure settings, structural conditions such as limited access to healthy alternatives, higher costs of nutritious foods and marketing of cheap ultra-processed products may amplify how perceived ease of obtaining and consuming unhealthy foods translates into actual consumption (Loopstra & Tarasuk, 2015). In these environments, individuals who feel they can easily access and afford unhealthy options are more likely to enact those choices. In food-secure contexts, however, improved access to healthy foods, supportive retail environments and regulatory constraints on unhealthy products can reduce the behavioral relevance of perceived control over unhealthy eating (Kirkpatrick & Tarasuk, 2009; Story et al., 2008). Structural facilitators of healthier choices may diminish PBC’s direct influence on unhealthy consumption behavior. Hence, we hypothesize:

*H2c.* The positive relationship between PBC over unhealthy food consumption and unhealthy food consumption behavior will be weaker in countries with higher levels of food security (GFSI).

### 3. Method

To identify relevant studies, we conducted a systematic search in the Web of Science (Clarivate) and Scopus databases, which aggregate a broad range of scholarly content from

leading publishers, including Elsevier, Wiley, Taylor & Francis and Springer Nature, among others. The search used the following query:

((ALL = (theory of planned behavior)) AND ALL = (fast OR junk OR unhealthy OR sugar OR snack OR meat OR processed OR sweetened OR convenience OR fat OR sodium OR fried)).

This strategy initially identified 6,887 articles (5,402 from Web of Science [Clarivate] and 1,485 from Scopus). The search focused on studies published in English up until January 2025. We used a two-stage screening process to narrow the sample. In the first stage, we assessed titles and abstracts to exclude articles outside the review's scope. Specifically, we excluded 1,973 records, including 973 duplicates, 468 experimental designs, 470 qualitative designs and 26 review articles. During the second stage, a full-text review was carried out for 75 articles, resulting in the exclusion of 4,875 records, including 3,432 studies not examining eating acts, 1,093 focusing on healthy food, 238 conducted with special clinical groups, 62 with no effect size available, 15 that did not operationalize consumption as a dependent variable and 18 parental decision studies. The final sample comprised 75 studies, totaling 427 effect sizes.

For each study, we extracted detailed information, including the specific TPB construct investigated (attitude, subjective norms or PBC), the type of dependent variable (intention or actual behavior related to unhealthy food consumption) and the reported correlational statistics or sufficient data to compute effect sizes. In addition, we coded several study-level covariates: the country in which the data were collected; the nature of the sample (students vs nonstudents); the type of measurement employed (self-report vs observed behavior); the average age of the sample; and the framing of the behavior (approach vs avoidance). We also coded macrostructural moderators by country of data collection. Specifically, we documented the GFSI score ([Economist Intelligence Unit, 2022](#)) for each nation.

Meta-analytic procedures used a random-effects model to address the heterogeneity among studies ([Borenstein, Hedges, Higgins, & Rothstein, 2010](#)). We conducted meta-regressions to evaluate interaction effects, treating GFSI scores as continuous moderators and performed all analyses in Jamovi using the MAJOR module for meta-analysis and the GAMLj module for mixed-effects meta-regressions estimated via REML. All phases of the review and analysis followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines ([Page et al., 2021](#)) to maintain transparency, replicability and methodological rigor, as shown in [Figure 2](#).

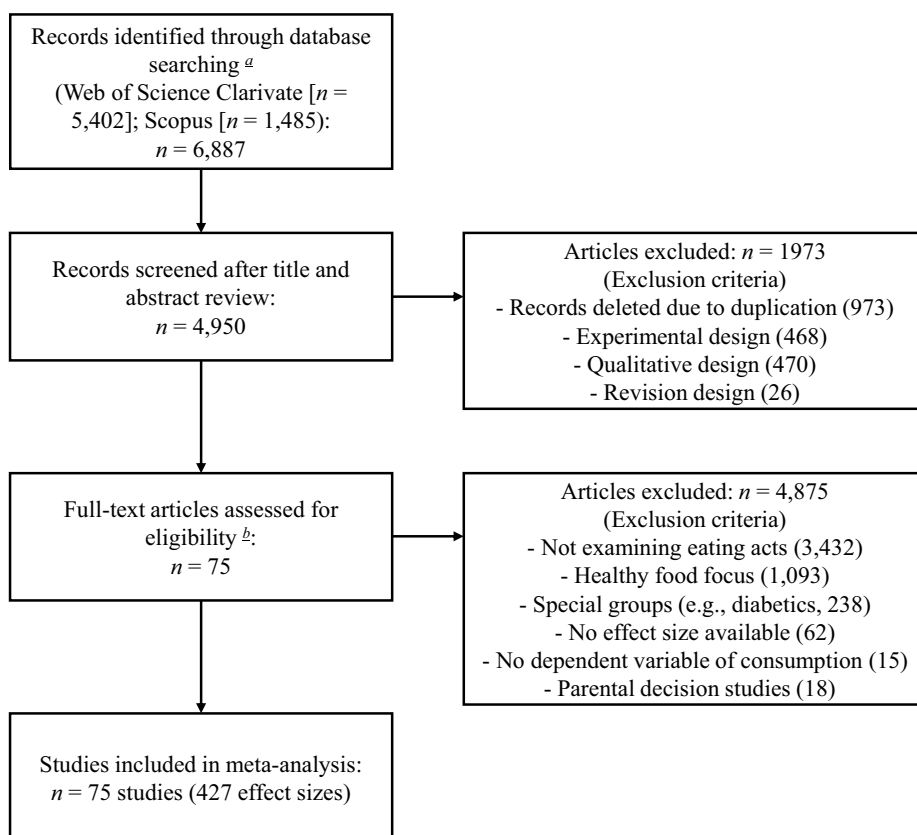
Potential publication bias was assessed using funnel plots, Egger's regression test and the trim-and-fill method ([Duval & Tweedie, 2000](#)). To assess the robustness of the meta-analytic findings to potential publication bias, we conducted Orwin's Fail-safe N test.

## 4. Results

### 4.1 Descriptive results

The temporal distribution of the 75 studies included in this meta-analysis spans from 1995 to 2025. While early publications were sporadic, output increased more consistently around 2007, peaking in 2020 with seven articles. This trajectory reflects a growing academic interest over the past two decades in applying the TPB to understand unhealthy eating behaviors.

In terms of the type of food examined, sugar-sweetened beverages emerged as the most frequently studied category, comprising 27.7% of all studies. This was followed by meat-based products (21.0%), snacks (19.7%), fast food (14.1%) and mixed-category studies (17.6%), which analyzed multiple types of unhealthy foods within a single design.



**Figure 2.** PRISMA protocol

**Note(s):** <sup>a</sup>Last search conducted on January 2025. Dissertations identified in the databases ( $n = 2$ ) were considered and included in the data set. Conference papers and some dissertations, although retrieved during the search, were excluded because they were duplicates of articles later published in peer-reviewed journals. No other sources (grey literature, registers, or references) were used; <sup>b</sup>Two independent reviewers screened titles/abstracts and full-texts; discrepancies were resolved by consensus

Regarding TPB constructs, subjective norms were the most commonly assessed predictor, appearing in 45.2% of the effect sizes. Attitudes and PBC appeared in 28.2% and 26.6% of cases, respectively. These frequencies highlight the prominence of normative and social influences in the theoretical modeling of food-related intentions and behaviors. Most primary studies (67.0%) framed the behavioral outcome in terms of allowing or engaging in unhealthy eating behaviors (e.g. likelihood of consuming junk food), whereas 33.0% adopted preventive framing focused on avoiding unhealthy eating practices. Regarding sample characteristics, 58.8% of the studies were conducted with university student populations, while the remaining 41.2% involved nonstudent participants. In terms of measurement strategy, self-reported intentions or behaviors predominated (93.1%), while only 6.9% of studies relied on direct observational measures.

Table 1. Effect sizes of the three dimensions of TPB and eating behavior

| IV                                       | K   | N      | ES fisher | SE   | z     | CI lower bound | CI upper bound | H <sup>2</sup> | Q       | Egger | Orwin |
|------------------------------------------|-----|--------|-----------|------|-------|----------------|----------------|----------------|---------|-------|-------|
| <i>TPB on unhealthy eating intention</i> |     |        |           |      |       |                |                |                |         |       |       |
| Attitude                                 | 65  | 27,255 | 0.52      | 0.03 | 15.50 | 0.45           | 0.58           | 35.09          | 2117.25 | -0.70 | 65    |
| Social norms                             | 80  | 29,096 | 0.33      | 0.03 | 12.60 | 0.28           | 0.39           | 28.60          | 2022.59 | -1.05 | 80    |
| PBC                                      | 60  | 26,634 | 0.37      | 0.04 | 8.71  | 0.29           | 0.46           | 54.32          | 2263.60 | -1.30 | 60    |
| <i>TPB on unhealthy eating behavior</i>  |     |        |           |      |       |                |                |                |         |       |       |
| Attitude                                 | 57  | 26,087 | 0.14      | 0.04 | 4.09  | 0.08           | 0.21           | 33.25          | 2393.28 | -0.79 | 57    |
| Social norms                             | 107 | 39,994 | 0.13      | 0.02 | 6.18  | 0.09           | 0.17           | 3.32           | 2946.26 | -0.82 | 107   |
| PBC                                      | 58  | 28,032 | 0.14      | 0.04 | 3.80  | 0.07           | 0.21           | 37.61          | 193.10  | -1.09 | 58    |

**Note(s):** ES Fisher denotes the effect size computed via Fisher's z-transformation. SD is calculated as  $(1 - r^2)/(n - 2)$ . Z (p-value) represents the z-score and corresponding significance level, derived from the lower and upper bounds of the confidence interval (CI). All z-test p-values were significant at  $p < 0.001$ , confirming the robustness of the estimated effects. K indicates the number of observations or effect sizes included. All heterogeneity indices ( $I^2$ ) exceed 95%, indicating substantial variability across studies and supporting random-effects modeling.  $H^2$  reflects the proportion of observed variance across studies. Q denotes the heterogeneity statistic (Q-test), serving as an omnibus test for variance in effect sizes. Orwin's fail-safe  $N_i$  calculated using Orwin's procedure, corresponds to a significance level of 0.05

#### 4.2 Meta-analytic effects of TPB dimensions on unhealthy eating

First, we estimated the overall associations between the TPB constructs and unhealthy eating outcomes, distinguishing between intention and behavior. As shown in Table 1, all effects were positive and statistically significant ( $p < 0.001$ ).

For unhealthy eating intention, attitude demonstrated the strongest effect (Fisher's  $z = 0.52$ ), followed by PBC ( $z = 0.37$ ) and subjective norms ( $z = 0.33$ ). For unhealthy eating behavior, all three constructs showed weaker magnitudes relative to intention, with effect sizes of 0.14 for both attitude and PBC and 0.13 for subjective norms.

These results align with TPB theory, which predicts that attitudes, norms and PBC more proximally determine intentions, while behaviors show attenuated effects. Across all models, heterogeneity was substantial ( $I^2 > 95\%$ ), indicating considerable variation across studies and underscoring the need for moderator analyses. Orwin's fail-safe  $N$  values (equal to  $k$  for each construct) also suggest robustness, indicating that a large number of null-effect studies would be required to negate the observed associations.

#### 4.3 Moderation effects of food security on TPB dimensions (H1a–H1c)

To test the proposed hypotheses, we estimated six mixed-effects meta-regression models, three predicting unhealthy eating intention (H1a–H1c) and three predicting unhealthy eating behavior (H2a–H2c), with GFSI as a continuous moderator. We estimated all models using mixed-effects REML meta-regression, controlling for sample age, sample type, measurement features, framing effects and precision. Table 2 reports the complete results.

H1a predicted that the effect of attitude on intention to consume unhealthy foods would weaken as food security increased. The results did not support this hypothesis, as GFSI did not significantly moderate the attitude–intention relationship ( $\beta = 0.00$ , ns). This indicates that, unlike other TPB pathways, the predictive strength of attitudes toward unhealthy foods remains relatively stable across different levels of national food security.

H1b proposed that subjective norms would exert weaker influence on intention in more food-secure countries. This effect was confirmed, as GFSI significantly moderated the norms–intention relationship ( $\beta = -0.10$ ,  $p < 0.05$ ). This suggests that where healthy eating is socially reinforced, permissive norms for unhealthy eating lose predictive power.

H1c stated that PBC would be less predictive of unhealthy eating intention in countries with higher food security. This hypothesis was not supported: the moderating effect of GFSI on the PBC–intention relationship was small and nonsignificant ( $\beta = -0.01$ , ns). These results suggest that, regardless of food security conditions, perceived control plays a similar role in shaping intentions to consume unhealthy foods.

H2a predicted that attitudes would be weaker predictors of unhealthy eating behavior in food-secure contexts. The analysis confirmed this, as GFSI significantly moderated the attitude–behavior link ( $\beta = -0.08$ ,  $p < 0.05$ ). Attitudes translate less strongly into consumption when healthier alternatives are accessible.

H2b stated that subjective norms would weaken as predictors of behavior with higher food security. This was supported: GFSI negatively moderated the norms–behavior relationship ( $\beta = -0.05$ ,  $p < 0.01$ ). Social approval of unhealthy eating diminishes when institutional norms favor healthier diets.

H2c predicted a weaker association between PBC and unhealthy eating behavior in more food-secure countries. Results strongly supported this hypothesis, with GFSI showing the largest moderating effect among all models ( $\beta = -0.12$ ,  $p < 0.001$ ). When structural conditions facilitate healthy decisions, individual control becomes less predictive of unhealthy eating.

In addition to the focal moderation tests, we included several covariates to account for methodological and sample heterogeneity across studies. As shown in Table 2, most controls

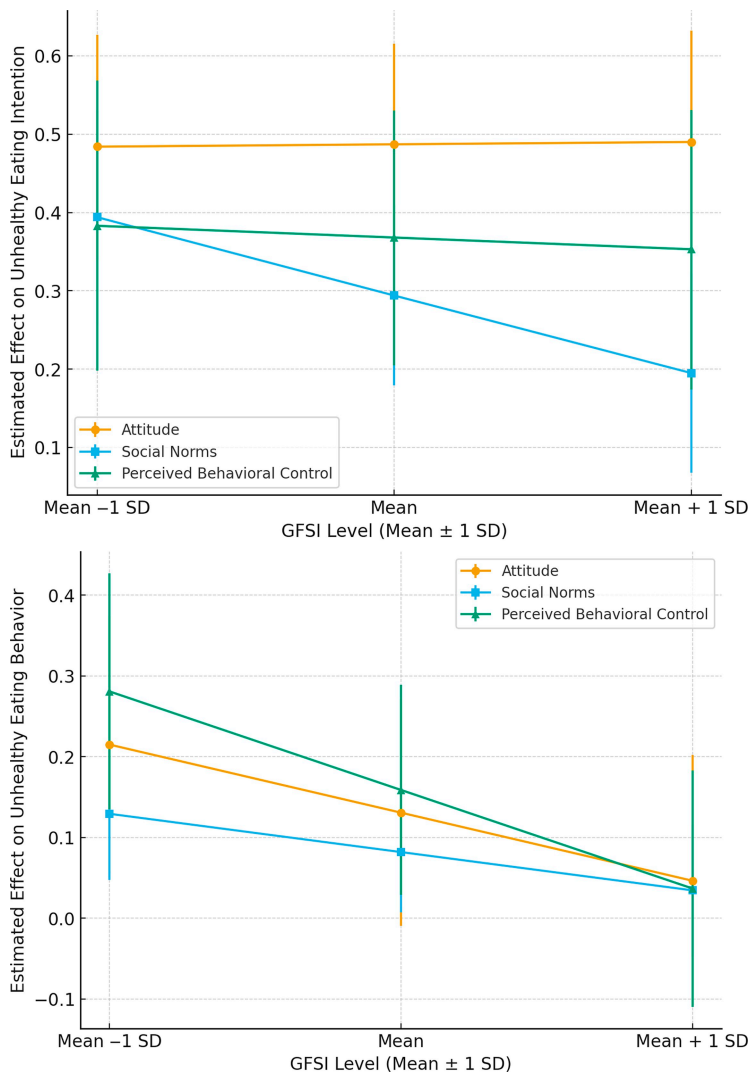
Table 2. Meta-regression of the three dimensions of TPB and eating behavior

| Independent variables | IV = attitude |       |  | DV = intention<br>IV = social norms |       |  | IV = PBC |       |  | IV = attitude |       |  | DV = behavior<br>IV = social norms |       |  | IV = PBC |       |  |
|-----------------------|---------------|-------|--|-------------------------------------|-------|--|----------|-------|--|---------------|-------|--|------------------------------------|-------|--|----------|-------|--|
|                       | $\beta$       | $t$   |  | $\beta$                             | $t$   |  | $\beta$  | $t$   |  | $\beta$       | $t$   |  | $\beta$                            | $t$   |  | $\beta$  | $t$   |  |
| (Intercept)           | 0.48***       | 7.67  |  | 0.29***                             | 5.15  |  | 0.37***  | 4.55  |  | 0.13          | 1.88  |  | 0.08*                              | 2.19  |  | 0.16*    | 2.47  |  |
| Effect size precision | 0.00          | 0.23  |  | -0.02                               | -0.77 |  | -0.03    | -0.88 |  | 0.02          | 0.59  |  | 0.04*                              | 2.07  |  | 0.02     | 0.50  |  |
| Sample nature         |               |       |  |                                     |       |  |          |       |  |               |       |  |                                    |       |  |          |       |  |
| Nonstudent (baseline) |               |       |  |                                     |       |  |          |       |  |               |       |  |                                    |       |  |          |       |  |
| Student               | -0.01         | -0.07 |  | -0.08                               | -1.28 |  | 0.05     | 0.55  |  | -0.11         | -1.24 |  | 0.06                               | 1.07  |  | -0.06    | -0.66 |  |
| Sample measure        |               |       |  |                                     |       |  |          |       |  |               |       |  |                                    |       |  |          |       |  |
| Observed (baseline)   |               |       |  |                                     |       |  |          |       |  |               |       |  |                                    |       |  |          |       |  |
| Self-report           | -0.05         | -0.44 |  | 0.05                                | 0.44  |  | -0.09    | -0.58 |  | 0.04          | 0.35  |  | 0.02                               | 0.31  |  | 0.03     | 0.29  |  |
| Sample age            | 0.02          | 0.76  |  | -0.02                               | 0.67  |  | 0.06*    | 2.69  |  | -0.00         | -0.06 |  | 0.08*                              | 3.10  |  | 0.00     | 0.22  |  |
| Frame                 |               |       |  |                                     |       |  |          |       |  |               |       |  |                                    |       |  |          |       |  |
| Allow (baseline)      |               |       |  |                                     |       |  |          |       |  |               |       |  |                                    |       |  |          |       |  |
| Avoid                 | 0.06          | 0.89  |  | 0.06                                | 0.94  |  | 0.07     | 1.09  |  | -0.04         | -0.47 |  | -0.10                              | -2.49 |  | 0.12     | 1.46  |  |
| GFSI_Overall_score    | 0.00          | 0.11  |  | -0.10*                              | -3.11 |  | -0.01    | -0.37 |  | -0.08*        | -2.35 |  | -0.05*                             | -2.74 |  | -0.12*   | -3.63 |  |
| K = number of effects | 65            |       |  | 80                                  |       |  | 60       |       |  | 0.57          |       |  | 107                                |       |  | 58       |       |  |
| Pseudo R square       | 0.04          |       |  | 0.19                                |       |  | 0.05     |       |  | 0.12          |       |  | 0.22                               |       |  | 0.25     |       |  |

Note(s):  $\beta$  = unstandardized beta,  $t = t$  de Student, DV = dependent variable, IV = independent variable, PBC = perceived behavior control; \*\*\* $p < 0.001$ ; \* $p < 0.05$

were non-significant. However, sample age exhibited a significant positive effect for both  $PBC \rightarrow Intention$  ( $\beta = 0.06, p < 0.05$ ) and  $Social\ Norms \rightarrow Behavior$  ( $\beta = 0.08, p < 0.01$ ), indicating stronger TPB effects in older samples. Precision effects were mostly nonsignificant, except for a small positive effect in  $Social\ Norms \rightarrow Behavior$  ( $\beta = 0.04, p < 0.05$ ).

To illustrate the moderation patterns, we calculated marginal Pearson correlations at three levels of national food security (one standard deviation below the mean, the mean and one standard deviation above). The two plots show (Figure 3) that subjective norms exhibit a



**Figure 3.** Estimated marginal effects of TPB dimension on unhealthy eating intention and behavior at varying levels of GFSI

clear decreasing pattern as food security increases, with estimated effects declining from  $r = 0.394$  at low GFSI to  $0.294$  at the mean and  $0.195$  at high GFSI. In contrast, attitude and PBC display relatively stable effects across GFSI levels, with only minimal changes in magnitude. Attitude remained virtually constant ( $r = 0.484, 0.487, 0.490$ ), and PBC showed only small fluctuations ( $r = 0.383, 0.368, 0.353$ ).

## 5. Final considerations

This meta-analysis synthesizes the relationships between the core TPB predictors – attitude, subjective norms and PBC – and both unhealthy eating intention and behavior. Across hundreds of effect sizes, all three constructs showed significant positive associations with unhealthy food outcomes, confirming that TPB is a robust framework even in hedonically charged food contexts and extending prior evidence (McDermott et al., 2015; McEachan et al., 2011) to the understudied case of unhealthy eating.

Beyond establishing these baseline relationships, this study examined whether national food security alters the strength of the TPB pathways. The results show that food security operated as a systematic moderator, significantly weakening four of the six relationships examined. For intentions, the influence of subjective norms declined as food security increased ( $\beta = -0.10, p < 0.05$ ), whereas the effects of attitude and PBC on intention remained stable across GFSI levels (both ns). For behavior, the pattern was more pervasive: food security significantly attenuated the effects of attitude ( $\beta = -0.08, p < 0.05$ ), subjective norms ( $\beta = -0.05, p < 0.01$ ) and PBC ( $\beta = -0.12, p < 0.001$ ), with PBC showing the strongest moderation among all models. The marginal-effects plots (Figure 3) confirm this pattern: the predictive strength of subjective norms on intention fell from  $r = 0.39$  at low food security to  $r = 0.20$  at high food security, and all three predictors of behavior converged toward near-zero effects in the most food-secure contexts. Taken together, these results indicate that macrostructural conditions shape the behavior-level pathways of the TPB more consistently than the intention-level pathways, a pattern that resonates with the intention–behavior gap (Ajzen, 2020; McEachan et al., 2011): where structural facilitators of healthy eating are strong, favorable attitudes, permissive norms and perceived control translate less readily into actual unhealthy consumption.

The findings contribute to TPB scholarship by clarifying when its predictors vary in strength. Much of the TPB literature assumes that attitudes, norms and PBC exert similar influence across contexts. This study challenges that assumption by demonstrating that environmental factors, specifically national food security, can shape at least some of the psychological pathways leading to unhealthy eating. The strong moderation of the PBC–behavior relationship, together with the attenuation of attitude and norm effects on behavior, aligns with ecological and socio-structural perspectives suggesting that individual agency becomes less influential as environmental supports for healthy behavior strengthen (La Barbera & Ajzen, 2021; Story et al., 2008; Sheeran et al., 2016).

From a public health and policy standpoint, the results suggest that structural improvements in food environments may reduce reliance on individual self-control as a determinant of unhealthy eating behavior. In food-secure countries, interventions that modify choice architecture, regulate unhealthy food marketing or increase the availability and affordability of healthy foods may have greater behavioral impact than campaigns that focus exclusively on cognitive or motivational factors. Conversely, in food-insecure contexts, where PBC remains more influential, interventions may benefit from strengthening individuals' sense of control and addressing social and attitudinal drivers of unhealthy food choices. Tailoring strategies to national food environments can therefore enhance the effectiveness of health promotion initiatives.

This study has several limitations that warrant acknowledgment. First, food security was measured at the national level, which may obscure within-country disparities that shape individual food decisions. Second, the meta-analysis relied primarily on correlational

evidence, limiting causal inference. Third, although the TPB constructs were consistently operationalized, measurement heterogeneity may still have contributed to unexplained variance. Future research should explore multilevel designs that incorporate both individual-level variables and regional indicators of food access. In addition, longitudinal or experimental studies are needed to test whether changes in food security over time produce corresponding shifts in the predictive strength of TPB constructs.

### Authors contribution

Juliano Domingues da Silva, Conceptualization (Lead), Data curation (Equal), Funding acquisition (Lead), Methodology (Lead), Supervision (Lead), Writing – original draft (Lead), Writing – review and editing (Equal); Valéria Abucarma Coplas Maximiano, Data curation (Equal), Formal analysis (Supporting), Project administration (Equal), Visualization (Equal), Writing – original draft (Supporting); João Otávio Montanha Endrici, Investigation (Equal), Methodology (Equal), Resources (Equal), Visualization (Equal), Writing – original draft (Supporting); Nayara Pelegrinello Panage, Resources (Equal), Validation (Equal), Visualization (Equal); Fernanda Cristina Ferro Malacoski, Methodology (Supporting), Project administration (Supporting), Supervision (Supporting), Validation (Supporting), Visualization (Supporting).

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**Further reading**

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