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Unlocking Healthy Food Markets in Developing Economies: The Interplay Between Consumer Psychology and Unconventional Last-Mile Logistics Channels

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Abstract

Background: The status of healthy food in emerging markets is questionable. Despite growing health awareness and e-commerce adoption among consumers, the impact of unconventional last-mile distribution on consumer purchase intention (PI) remains insufficiently explored, especially in emerging markets such as the Egyptian market. *Methods*: Survey data from 201 Egyptian consumers were analyzed using PLS-SEM via SmartPLS 4.0, employing bootstrapping with 5000 resamples to test direct, mediated, and moderated structural paths within the proposed extended Theory of Planned Behavior (TPB) framework. *Results*: All three TPB constructs significantly predicted PI, with attitude as the dominant driver. Online shopping exerted a marginally significant direct effect on purchase intention but did not significantly mediate any TPB–PI relationship. Furthermore, vending machine usage did not moderate the TPB–PI pathways. *Conclusions*: This study advances the understanding of last-mile logistics in behavioral food consumption models, suggesting that channel-level maturity may condition the role of digital and vending distribution in emerging markets and warranting future investigation.

Keywords: healthy food purchase intention; theory of planned behavior; vending machines; psychological motivations; e-commerce; last mile logistics

1. Introduction

Over the past decade, profound shifts in global consumption patterns have positioned healthy food purchasing as a critical behavioral domain within consumer research. Driven by escalating rates of lifestyle-related chronic conditions, including cardiovascular disease, obesity, and type 2 diabetes [1,2]. This behavioral shift is further accelerated by the post-COVID-19 heightening of personal health awareness, food safety consciousness, and immune system protection concerns, collectively transforming how individuals evaluate and select their food products [3,4]. This has prompted more studies on human purchase intention, defined as a consumer's cognitive disposition and readiness to engage in a specific purchasing behavior [5]. Intention has emerged as the most proximal predictor of actual healthy food consumption behavior, forming the cornerstone of behavioral food research across theoretical traditions [6,7].

On a global scale, the consumption of healthy food has become deeply ingrained within narratives of modern lifestyles, with main markets such as the United States, Germany, and France leading adoption of organic food driven by preferences for chemical-free dietary choices and sustainability awareness [8–10]. The evolution of dietary choices in Egypt is

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increasingly characterized by a complex interplay between external environmental constraints and internal psychological motivations, which matches recent research evidence that preferences toward healthy food consumption are rooted in a consumer's health concerns and their health consciousness [11,12]. Several operational constraints in Egypt hinder the acquisition of these healthy products, such as the high cost of these healthy products compared with the individual's average level of income and the relative unavailability of these products in traditional retail channels [13]. At the same time, digital transformation in Egypt is reshaping consumer behavior, with about 40% of Egyptian consumers using applications to track their dietary habits and around 50% engaging with AI-driven personalized diet and fitness plans [14]. The Egyptian organic food market is projected to grow from 2025 to 2032 at a compound annual growth rate of 7.1%, driven by health consciousness and expanding e-commerce delivery infrastructure [15], highlighting the need to understand the behavioral mechanisms that motivate healthy food purchasing in this evolving context. The Theory of Planned Behavior (TPB) is considered one of the most pivotal frameworks for predicting healthy choices in behavioral sciences [16].

Most existing studies testing healthy food purchase intention have focused mainly on internal psychological and behavioral determinants, particularly in the developed Western economies, overlooking the influence of infrastructural, socioeconomic, and culture-related factors that may shape purchasing behavior differently [17,18]. Although the previous literature has applied the TPB to healthy food purchasing intentions, two important research gaps remain. Firstly, the potential mediating role of online shopping usage in explaining how psychological determinants lead to healthy food purchase intention remains unexplored. Secondly, the moderating role of unconventional distribution channels, specifically vending machines, in shaping established TPB pathways has received limited empirical attention. These gaps are particularly relevant in developing markets such as Egypt, where empirical and theoretical evidence remains limited.

Therefore, this study directly addresses both gaps by empirically testing an extended TPB framework that integrates vending machine usage as a moderator and online shopping as a last-mile logistics mediator of healthy food purchase intention in the Egyptian context by achieving the following objectives:

1- To examine the direct effect of the Theory of Planned Behavior antecedents on consumers' purchasing intentions towards healthy food.
2- To investigate the indirect structural effect of the Theory of Planned Behavior antecedents on healthy food purchase intentions through online shopping usage.
3- To evaluate how usage of vending machines moderates the relationship between Theory of Planned Behavior antecedents and healthy food purchase intentions.

This research is structured as follows: firstly, the literature review, where the theoretical background is thoroughly examined, determining the main constructs to develop the research model and its hypotheses to be tested in the Egyptian context. Followed by the research methodology used to test the hypothesized framework. Then the paper concludes by presenting the results analysis, synthesizing empirical findings, and providing recommendations and future directions.

2. Theoretical Foundations

2.1. Theory of Planned Behavior (TPB)

The Theory of Planned Behavior (TPB) represents one of the most extensively validated frameworks for predicting consumers' behavioral intentions across consumer research domains [19]. Building upon the Theory of Reasoned Action (TRA), which mentioned subjective norms (SN) and attitude (ATT) as the main determinants of behavioral intention [20],

TPB introduced the perceived behavioral control (PBC) construct to account for the reality that consumers do not always possess complete control over their actual actions [21]. These three determinants from the theoretical base of TPB explain how consumers translate social influences, capability, and belief assessments into deliberate behavioral intentions [18,22].

The TPB has been applied thoroughly in food consumption research, consistently demonstrating explanatory power across different behavioral domains, including sustainable dietary choices, organic food purchasing, and healthy eating intentions. For instance, ref. [23] confirmed that healthy food habits are shaped not only by personal attitude but also by accessibility and convenience infrastructure. Ref. [24] applied TPB theory to examine the consumer's purchasing intention toward nutrition-labeled fast-food items, while ref. [25] used TPB as a dominant framework among marketing specialists and social psychologists to examine food choice behavior. Furthermore, one recent application explained 76% of the variance in intention to purchase sustainably sourced food [26], which highlights the considerable predictive utility of this framework.

Even though it has theoretical robustness, the TPB theory has been subject to several substantive critiques on different grounds that are salient in the present research context. For instance, this framework conceptualizes the pathway from TPB antecedents to intention as an internal psychological process, neglecting the role of environmental, situational, and logistical factors that condition whether the psychological intentions can be enacted [27,28]. In emerging markets such as the Egyptian context, the physical retail infrastructure is uneven, unconventional distribution channels are at nascent stages of adoption, and digital penetration is accelerating; this absence represents a significant theoretical limitation [29].

Furthermore, while TPB accounts for PBC as an internal capability assessment, it does not formally accommodate external channel-level enablers such as online shopping platforms or automated retail formats that structurally mediate or moderate the translation of intention into behavior. These limitations provide the theoretical motivation for the present study's extension of TPB to incorporate last-mile logistics mechanisms as formally specified mediating and moderating constructs.

2.2. Conceptual Framework and Hypotheses Development

Predicting healthy food purchase intention requires a theoretical architecture that transcends the explanatory boundaries of conventional psychological models. This study therefore proposes an extended TPB framework that preserves the theory's established psychological core while formally integrating two novel logistical constructs, online shopping and vending machine usage, to produce a more contextually complete and theoretically generative model of healthy food purchase intention.

The application of TPB to healthy food purchase intention has generated a substantial and largely convergent empirical literature, with ATT, PBC, and SN consistently emerging as significant predictors across diverse cultural and geographic contexts [14,30,31]. However, the relative magnitude and mechanisms of these effects vary meaningfully across contexts, suggesting that their operation is conditioned by cultural, economic, and infrastructural factors that warrant explicit theoretical attention.

2.2.1. The Direct Effect of the Theory of Planned Behavior Constructs

Within the context of this study, the antecedent of ATT is operationalized through two theoretically distinct sub-dimensions: food safety concern and health consciousness. This deconstruction approach responds to a review of unidimensional attitudinal measurement in food behavior research [32,33], recognizing that health-oriented attitudes operate through differentiated cognitive pathways that carry distinguishable predictive weight. Health consciousness represents the degree to which an individual is concerned

and attentive to their propensity to engage in health-promoting behaviors [34,35]. Additionally, it functions as an intrinsic motivational force that motivates consumers toward nutritionally superior food choices [6,36]. Food safety concern is considered a cognitive evaluative trigger to assess the integrity and credibility of food products against established safety standards [37,38]. These sub-dimensions together provide a theoretically precise account of the attitudinal driver of healthy food purchase intention rather than single-factor measures afford, enhancing the validity of the TPB framework in healthy food consumption contexts [39,40].

Attitude reflects individuals' favorable valuation of healthy food and serves as a primary direct indicator of healthy food purchase intentions [41,42]. Ref. [43] proved that ATT is the most influential TPB predictor of healthy food purchase intention, followed by PBC and SN, a hierarchy that aligns with the primacy of internal cognitive evaluation over external social and capability factors in individualist consumption contexts. In collectivist societies, this hierarchy may be modulated by stronger normative pressures and greater economic sensitivity, necessitating empirical investigation in this underrepresented context [44,45]. Ref. [46] confirmed that positive attitudes toward green packaging and healthy food are the main drivers of green buying behavior, and attitude significantly affected healthy food purchase intention among Korean consumers [47]. Also, ref. [42] confirmed a positive relationship between ATT and an individual's PI towards healthy products. Refs. [48,49] found that an individual's attitude towards purchasing healthy products influences their buying intentions. In extended TPB models, ref. [32] argued that health-related beliefs (health concern, consciousness) shape the overall evaluation of food choices. Based on this theoretical explanation, the following hypothesis is proposed:

H1. *Consumers' attitude has a positive impact on healthy food purchase intention.*

PBC is operationalized in this study through Availability (AVA) and Affordability (AFF) as theoretically distinct yet interdependent facets of consumer capability assessment [19,46]. It has also been consistently established as a significant positive predictor of healthy food purchase intention, as a high degree of the PBC factor, based on the consumers' anticipated ease and internal factors, leads to a stronger positive behavioral intention that may be developed into actual behavior [50,51]. The significance of PBC is well-established across TPB applications; however, its specific mechanism of influence in low-to-middle-income emerging market contexts differs meaningfully from that observed in developed economies. This aligns with [52]'s identification of PBC as a large necessary condition, suggesting that a minimum threshold of perceived capability must be met before purchase intention can meaningfully form. Furthermore, ref. [39] demonstrates that while consumers may maintain strong healthy eating intentions, actual retail choices are heavily constrained by perceived household expenses and the physical availability of products within their immediate community food environment, a dynamic particularly pronounced in Egyptian urban and peri-urban settings [15].

In the context of healthy food consumption, empirical evidence confirmed that perceived control mitigates the effort required, facilitating the transition from internal readiness to actionable intentions [53]. As ref. [12] confirmed, higher perceived ease of access elevates consumer intention towards healthy food purchasing. Refs. [50,54] demonstrate that consumers' psychological commitment to purchase healthy food increases when anticipating high product availability and low behavioral effort required. Therefore, the following hypothesis has been formulated:

H2. *Consumers' perceived behavioral control has a positive impact on healthy food purchase intention.*

SN, the third construct captures the influence of social pressure from family members, peers, and reference groups on individual behavioral decisions [22], that have been repeatedly confirmed as a significant predictor of healthy food purchase intention across diverse cultural contexts [55–57]. However, the strength of normative influence is meaningfully moderated by cultural orientation, with collectivist societies consistently demonstrating stronger SN effects on food-related behavioral intentions than individualist counterparts [45]. Egypt's predominantly collectivist cultural framework, wherein family approval and peer conformity constitute primary social reference points, therefore provides a theoretically favorable context for strong normative effects on healthy food purchase intention [58]. The integration of social network influences through the SN construct thus captures a mechanism of cultural salience in the Egyptian consumer context. Also, ref. [57] suggested that SN can be used as a forecasting tool for repurchase intentions. Subjective norms were considered significantly related to intentions in healthy food purchasing in Vietnam, Tanzania, Kenya, and Pakistan [59,60]. In the Thai market, subjective norms were the second most influential factor affecting purchase intentions after attitude [61]. Moreover, subjective norms affect attitude itself and moderate the attitude-intention and PBC–intention relationships. Therefore, the following hypothesis has been formulated:

H3. *Consumers' subjective norms have a positive impact on healthy food purchase intention.*

2.2.2. The Mediating Role of Online Shopping

The main limitation of applying conventional TPB in food consumption research is the exclusive focus on internal psychological factors, neglecting the external logistical drivers through which intentions are operationalized into purchasing behavior. With the developing retail infrastructure and the ease of physical access to healthy food remaining economically and geopolitically uneven, this absence represents a crucial theoretical gap. Online shopping platforms are considered a last-mile logistics tool that facilitates transactions and actively mediates the path of conversion of psychological health-oriented intentions to actual purchasing behavior by reducing economic, informational, and geographical barriers to healthy food access [62,63].

Within the TPB paradigm, consumers' intentions and subsequent actions are driven by three cognitive constructs: attitude, perceived behavioral control, and subjective norms [19,22]. In the context of healthy food, however, social pressure and positive attitudes often fail to translate into actual consumption because structural execution barriers create an intention-behavior gap [64]. Accordingly, the functionality of online shopping does not exist only as an external purchasing channel but is also considered an intervening mechanism that transmits the motivational impact of cognitive constructs into systematic purchasing decisions by eliminating physical and cognitive constraints [65]. Each TPB construct interacts differently with digital platforms to drive healthy food purchasing intentions.

First, attitude, which is reinforced by health concern and health consciousness, requires transparent product information to lead to actual purchase intentions, which could be fulfilled through different e-commerce platforms by providing supplementary health claims and comprehensive nutritional data, reinforcing favorable consumer evaluations and bridging the gap between positive health attitudes and purchasing intentions [25,59]. However, positive cognitive perceptions alone often fail to translate into purchase intentions when consumers face ambiguity regarding nutritional quality and product authenticity in conventional retail stores [66]. Through optimizing product visibility, information access, and online shopping channels, a favorable attitude towards healthy food is translated into concrete behavioral intention [67]. Despite the growing empirical attention to e-commerce utilization, the integration of online shopping usage as a mediator in the relationship

between attitude and purchase intention remains underdeveloped in emerging markets such as the Egyptian or Middle Eastern consumer context [68]. Therefore, the following hypothesis has been formulated:

H4. *Consumers' usage of online shopping mediates the association between attitude and healthy food purchase intention.*

Second, perceived behavioral control is directly enhanced when e-commerce platforms mitigate logistical friction through features such as real-time price comparison, time-saving search functions, and door-to-door delivery, which elevate consumers' perceived self-efficacy to maintain a healthy diet [63]. In the context of healthy food, PBC is constrained in traditional markets by the spatial distribution of specialty retailers, perceived high prices, and the time required to purchase healthy food [69]. When consumers perceive different logistical challenges, even strong self-efficacy will struggle to translate into purchasing intention [55]. Through enhancing convenience, expanding product availability, and optimizing information access, online shopping platforms serve as a critical mediator that converts consumers' perceived control over healthy food eating into actual purchase intentions [70]. Examining this mechanism addresses a notable empirical gap in how digital infrastructure resolves structural execution barriers in the developed Middle Eastern context. Therefore, the following hypothesis has been formulated:

H5. *Consumers' usage of online shopping mediates the association between perceived behavioral control and healthy food purchase intention.*

Third, subjective norms are boosted in digital environments where online social influence, peer recommendations, and family expectations prompt consumers to actively search for healthy food alternatives across e-commerce channels [71]. Instead of letting social pressure stall due to limitations in offline retailing, online shopping platforms will provide an immediate, viable pathway for consumers to act based on normative expectations and translate social encouragement into healthy food purchase intentions [72,73]. In the context of food consumption, normative beliefs and the motives of complying with health-conscious peer networks positively shape dietary aspirations [74,75]. Nevertheless, existing empirical studies find that subjective norms are among the weakest direct factors of purchase intention in traditional contexts, mainly because social encouragement dissolves when consumers face limited local availability and immediate retail inconvenience [76,77]. Therefore, the following hypothesis has been formulated:

H6. *Consumers' usage of online shopping mediates the association between subjective norms and healthy food purchase intention.*

2.2.3. The Moderating Role of Vending Machine Usage

The existence of vending machines as a healthy food distribution channel is considered a significant transformation in last-mile logistics thinking, challenging the historical alignment between automated retail and energy-dense items [78,79]. Driven by the development of cold-chain logistics, growing consumer health consciousness, and digital payment integration, the usage of vending machines has repositioned itself in developing markets as an unconventional contactless channel for distributing certified healthy food options, organic snacks, and fresh balanced meals [80]. In urban environments with high density, these vending machines offer round-the-clock accessibility, reducing traditional temporal, transactional, and geographical barriers to purchasing healthy food [81,82].

The theoretical case for using vending machines as a moderator of TPB frameworks draws on [83]. Diffusion of Innovation (DOI) theory confirms that behavioral influence is dependent on whether consumers surpass a minimum threshold of perceived advantage, trialability, and awareness. Where a distribution channel has achieved a sufficient level of diffusion, consumers' familiarity generates a stable channel utility perception that can amplify established behavioral intention pathways, such as in the United Arab Emirates, the United Kingdom, and Japan. In contrast, in markets where their channels remain at the early diffusion stages, their ability to function as a meaningful boundary of TPB relationships is theoretically constrained regardless of the strength of those pathways. This theoretical foundation is supported by the Food Environment Framework [84], which differentiates between the macro-level food environment incorporating the accessibility and availability of food retail chains, the community level, and the micro-level consumer environment which reflects the interactions of the individual-level channels. According to [85], environmental design elements do not directly change the baseline of psychological traits; rather, they modify the decision-making friction and situational entry barriers to determine the degree to which internal psychological drivers translate to behavioral actions. This represents a novel empirical contribution of the present study, offering important theoretical insights into the conditions under which emerging distribution formats can and cannot function as behavioral moderators.

The moderating influence of the TPB pathways operates through three distinct theoretical mechanisms in establishing a sufficient vending machine infrastructure. First, from the attitudinal perspective, the availability of different healthy food options in vending machines supports health-oriented attitudes by providing validation of a tangible environment of healthy consumption norms, which strengthens the attitude-intention relationship [86,87]. Ref. [88] mentioned that the purchases of healthy food will be increased when stocking vending machines with high-quality healthy food and labeling it with nutritional data, as the existence of these machines not only facilitates a purchasing transaction, but also can transform a pre-existing healthy food intention into a successful purchase. Despite the theoretical plausibility of these moderating mechanisms, no prior study has empirically tested vending machine usage as a boundary condition of TPB-based purchase intention pathways in a developing market context. Therefore, the following hypothesis has been formulated:

H7. *Consumers' usage of vending machines moderates the association between attitude and healthy food purchase intention.*

Second, from a PBC perspective, the accessibility of vending machines directly reduces the required effort and resources invested to enact healthy food purchasing intentions, which strengthens the relationship [88,89]. Under conditions of immediate spatial accessibility and high vending machine density, the linking path between normative drivers and attitude to purchase intentions is significantly intensified, as the presence of a convenient physical unconventional channel reduces the time cost and the cognitive effort associated with healthy food purchasing [90]. Conversely, when vending machines offering healthy options are scarce or geographically isolated, a state of "cognitive dissonance" arises, accompanied by the anticipation of difficulties or obstacles [91]. Even consumers with high normative motivation and strong healthy attitudes will experience a decline in purchase intention, as anticipated logistical barriers will affect the motivational force of their underlying beliefs [69]. Therefore, the following hypothesis has been formulated:

H8. *Consumers' usage of vending machines moderates the association between perceived behavioral control and healthy food purchase intention.*

Third, from a normative perspective, the widespread visibility of healthy vending machines in shared environments such as public spaces, schools, and workplaces is considered passive social endorsement that magnifies the pressure of SN towards healthy food selection [92,93]. The existence of healthy automated retail, when visibly integrated into daily life, will increase normative expectations that continuously intensify the link between social pressure and purchase intentions [94]. Nevertheless, when these healthy vending machines remain isolated or scarce, consumers with strong normative motivation will face anticipated logistical challenges that erode purchase intentions and trigger cognitive dissonance [95]. Since the relationship between perceived norms and behavioral intention is moderated by behavioral and environmental cues that signal outcome expectations and collective approval, visible usage of vending machines by peers in high-traffic areas amplifies normative compliance and reinforces perceived social consensus [96]. Most of the research shows the extent to which the presence of vending machines can shape healthy consumption behavior by moderating the effect of normative and attitudinal drivers [87,94]. Therefore, the following hypothesis has been formulated:

H9. *Consumers' usage of vending machines moderates the association between subjective norms and healthy food purchase intention.*

The proposed conceptual framework summarized in Table 1 synthesizes environmental, digital, and psychological drivers of healthy food purchase intention into a theoretically integrated model that extends TPB beyond its conventional psychological boundaries. The framework is anchored by the three constructs derived from TPB, each posited to exert a direct positive effect on healthy food purchase intention. Online shopping usage is positioned as a mediating mechanism that captures the structural pathway through which these psychological antecedents are converted into purchasing behavior via digital last-mile logistics facilitation. Vending machine usage is positioned as a situational moderator that conditions the strength of each TPB–intention relationship based on the availability and familiarity of this unconventional distribution channel within the consumer's immediate food environment. These interconnected paths form a holistic framework that captures both the cognitive determinants and the logistical enablers of healthy food purchase intention, offering a theoretically enriched and contextually grounded alternative to conventional TPB applications in food consumption research Figure 1.

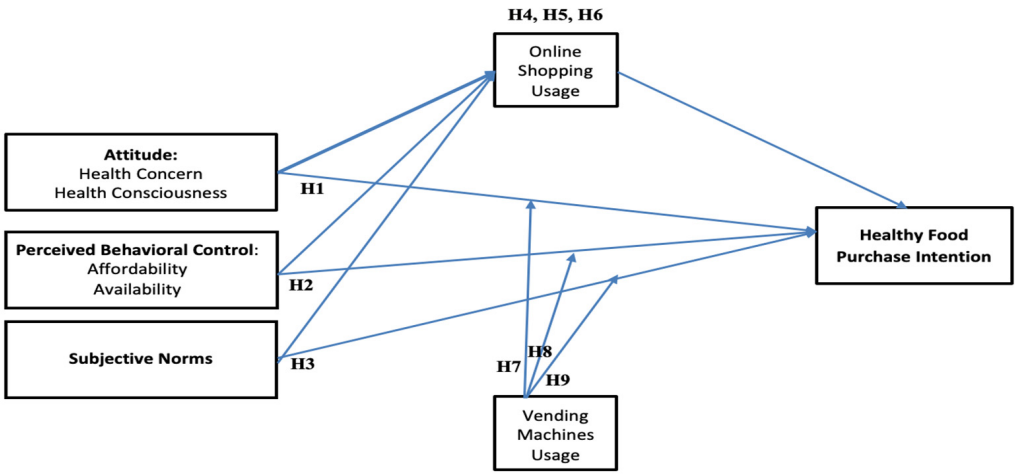

Figure 1. The proposed framework.

Table 1. Proposed hypotheses and supporting studies.

Proposed Hypotheses	Studies Supporting Hypotheses
H1. Consumers' attitude has a positive impact on healthy food purchase intention	[12,30,31,54,69,97,98]
H2. Consumers' perceived behavioral control has a positive impact on healthy food purchase intention.	[12,31,54,69,97]
H3. Consumers' subjective norms have a positive impact on healthy food purchase intention.	[12,31,54,69,97]
H4. Consumers' usage of online shopping mediates the association between attitude and healthy food purchase intention.	[67,70–72]
H5. Consumers' usage of online shopping mediates the association between perceived behavioral control and healthy food purchase intention.	[67,70–72]
H6. Consumers' usage of online shopping mediates the association between subjective norms and healthy food purchase intention.	[67,70–72]
H7. Consumers' usage of vending machines moderates the association between attitude and healthy food purchase intention.	[31,34,73,78]
H8. Consumers' usage of vending machines moderates the association between perceived behavioral control and healthy food purchase intention.	[31,34,94,95]
H9. Consumers' usage of vending machines moderates the association between subjective norms and healthy food purchase intention.	[31,34,94,95]

3. Methodology

In this section, the developed conceptual model is examined in addition to the measurement of the study's hypotheses. The study has employed partial least squares structural equation modeling PLS-SEM using SmartPLS software, whose default method is the orthogonalization (two-stage) approach [99]. This fits when examining the relationship between multiple unobserved variables known as latent constructs determined by a group of observed variables [100]. The developed conceptual model is based on a reflective–formative measurement model whose fitness is measured in two steps: firstly, the validity and reliability of the first (lower) order construct is assessed. Secondly, the formative weights of the second (higher) order construct are measured. Then, the 5000 bootstrapping method is run to test the proposed hypotheses.

3.1. Survey Development

The study employed cross-sectional research using survey to measure research hypotheses as the data was collected one time from the survey participants. The survey development process comprised two key phases. Initially, existing literature was reviewed to select appropriate survey items for measuring each variable. Subsequently, content validity using a pilot test was conducted to ensure the robustness of the instrument. The pilot test was conducted to refine the survey by identifying and addressing potential weaknesses before its final implementation [101,102]. Table 2 presents the literature sources that informed the survey, while the survey items of each variable are shown in Appendix A.

The survey began with a cover introducing the purpose of the research. The questions were divided into three sections. The first section presents the demographic questions; the second measures healthy food purchase intention; and the third lists the variables intended to be measured in this study. All the survey variables were measured using 5-points Likert

scale ranging from 1 'strongly disagree' to 5 'strongly agree. Eligibility was confirmed through a screening question at the survey entry point: 'Are you aware of healthy food products and have an understanding of what constitutes a healthy lifestyle?'.

Table 2. The literature sources that informed the survey.

Research Variables	Number of Items	Literature Sources
Purchase Intention	4	[85]
Health Consciousness	3	[86]
Health Concern	3	[86]
Availability	2	[87]
Affordability	3	[87]
Subjective Norm	3	[85]
Online Shopping usage	7	[88]
Vending Machine usage	4	[31,80]

3.2. Sampling and Data Collection

A purposive sampling technique was employed to gather responses from participants, ensuring they had a fundamental understanding of a healthy lifestyle. The required sample size was determined based on [103]'s guideline, which recommends a number of observations using ($N > 50 + 8K$); N = number of observations and K is the number of independent variables. Since the current research is studying 7 independent variables, resulting in $N = 50 + 8 \times 7 = 106$, while ref. [100] explained that the ratio needed to generalize the results is a range between 15 and 20 observations per independent variable; thus, the least number of observations needed to generalize the results is $15 \times 7 = 105$. Also following [99], the inverse square root method calculates the minimum sample size for 80% power at a 5% significance level (two-tailed) as $N_{min} > (2.486/beta_{min})^2$. Assuming a priori minimum path coefficient of $beta_{min} = 0.20$, the required sample size is $(2.486/0.20)^2$ = approx. 155.

An online version of the survey was created using Google Forms and was distributed through social media platforms Facebook, Instagram, and LinkedIn, as well as WhatsApp groups. The form was prepared to ensure that all the questions are answered before submission. Using this technique, the study succeeded in gathering 201 surveys for the period from January 2025–March 2025.

Partial least squares structural equation modeling (PLS-SEM) is used to test the developed hypotheses and the unconventional logistics role presented by the mediating effect of online shopping and the moderating effect of vending machine usage.

4. Results

4.1. Respondents' Demographics

Table 3 presents the demographic characteristics of the participants. The sample consisted of 42.08% males and 57.92% females, indicating a slightly higher representation of female respondents. The majority of participants (84%) were aged 18–33 years, followed by 12.9% aged 34–40 years, and 2.5% above 40 years. This distribution shows that younger consumers constituted the dominant group in the study, which means that Generation Z and younger millennials are the most predominant respondents. Around (61%) of the respondents reported a monthly income of less than 20,000; this indicates that the sample primarily represents low- to middle-income consumers. A large proportion (78%) of the respondents were single, while 22% were married; over half of the participants (53%) reported engaging in regular exercise.

Table 3. The demographic characteristics of the participants.

Participants	%
Gender	
Male	42.08%
Female	57.92%
Ages	
18–21	18.9%
22–33	65.7%
34–40	12.9%
Above 40	2.5%
Annual income	
Less than 20,000 L. E	61.88%
20,000 L.E to 34,999 L. E	12.38%
35,000 L.E to 49,999 L. E	6.93%
50,000 L.E to 74,999 L. E	4.46%
75,000 L.E to 99,999 L. E	1.98%
100,000 L.E to 149,999 L. E	2.47%
150,000 L.E to 200,000 L. E	1.98%
More than 200,000 L. E	7.92%
Marital Status	
Single	78%
Married	22%
Exercising habits	
yes	53%
No	47%

Table 4 presents the descriptive statistics for all constructs included in the structural model. All construct means fall above the scale midpoint of 3.0, indicating a generally favorable orientation toward healthy food purchasing across the sample. ATT recorded the highest mean score, reflecting strong positive evaluation of healthy food, with its sub-dimensions CON and CONS showing similarly elevated scores. SN and PI were also above the midpoint, suggesting that social influence and intention to purchase are present but with greater inter-respondent variability. PBC was more moderate, with its AFF scoring higher than AVA. The two last-mile logistics channels: ONL was only marginally above the midpoint with the highest standard deviation among main constructs, indicating considerable variation in healthy food online shopping engagement across respondents. VEN similarly showed moderate mean use alongside high dispersion, reflecting the emergent and uneven penetration of healthy food vending in the Egyptian market.

Table 4. Descriptive statistics for all study constructs.

Construct	Mean	SD	Min	Max
PI	3.785	0.798	1.40	5.00
CONS	3.939	0.774	1.00	5.00
CON	4.029	0.779	1.33	5.00
AFF	3.542	0.745	1.00	5.00
AVA	3.388	0.978	1.00	5.00
ONL	3.169	0.919	1.14	4.86
VEN	3.758	0.926	1.00	5.00

4.2. The Measurement Model

An examination of the variables' reliability and validity is conducted to assess the measurement model. Reliability is measured using internal consistency reliability (factor loading) and composite reliability. Also, validity is measured using convergent and discriminant validity [102].

Table 5 represents the results of validity and reliability for the latent variables in addition to healthy food purchase intention (PI). Table 6 reppresents the discriminant validity for the latent variables.

Table 5. The validity and reliability of the latent variables.

Constructs		Indicator Reliability	Internal Consistency Reliability		Convergent Validity	Discriminant Validity	Model Fit
	Items	Factor Loadings	Cronbach's Alpha	CR rho_a	AVE	Fornell–Larcker	SRMR
	Cutoff	**>0.6**	**>0.6**	**>0.6**	**>0.5**	**AVE > Squared Correlations**	**<0.08**
Affordability	AFF1	0.622	0.576	0.610	0.502		
	AFF2	0.767					
	AFF3	0.728					
Availability	AVA1	0.803	0.67	0.749	0.745		
	AVA2	0.919					
Health Concern	CON1	0.843	0.631	0.727	0.565		
	CON2	0.870					
	CON3	0.478					
Health Consciousness	CONS1	0.608	0.702	0.775	0.626		
	CONS2	0.875					
	CONS3	0.861					
Online shopping	ONL1	0.822	0.925	0.935	0.689		0.07
	ONL2	0.806					
	ONL3	0.862					
	ONL4	0.897					
	ONL5	0.872					
	ONL6	0.837					
	ONL7	0.699					
Purchase intention	PI1	0.836	0.843	0.847	0.681		
	PI2	0.825					
	PI3	0.765					
	PI4	0.870					
Subjective Norms	SN1	0.923	0.897	0.897	0.829		
	SN2	0.912					
	SN3	0.897					

Table 5. *Cont.*

Constructs		Indicator Reliability	Internal Consistency Reliability		Convergent Validity	Discriminant Validity	Model Fit
	Items	**Factor Loadings**	**Cronbach's Alpha**	**CR rho_a**	**AVE**	**Fornell–Larcker**	**SRMR**
	Cutoff	**>0.6**	**>0.6**	**>0.6**	**>0.5**	**AVE > Squared Correlations**	**<0.08**
Vending Machine Usage	VEN1	0.900	0.905	0.993	0.766		
	VEN2	0.872					
	VEN3	0.886					
	VEN4	0.842					

Discriminant validity—Fornell–Larcker (AVE > squared correlations).

Table 6. Discriminant validity for the latent variables.

	AFF	AVA	CON	CONS	ONL	PI	SN	VEN
AFF	0.708							
AVA	0.225	0.793						
CON	0.416	0.007	0.752					
CONS	0.485	0.141	0.532	0.791				
ONL	0.382	0.028	0.114	0.033	0.830			
PI	0.500	0.152	0.483	0.561	0.275	0.825		
SN	0.231	0.144	0.237	0.279	0.200	0.470	0.911	
VEN	0.241	−0.066	0.088	0.048	0.607	0.164	0.141	0.875

Using PLS, indicators' reliability is measured by examining the loadings of the items with their respective construct. All the items had loadings greater than the cutoff > 0.5. Although CON3 had a loading of (0.478), the overall CON reliability remains acceptable ($\alpha = 0.631$, CR = 0.727) and AVE = 0.565, which confirms convergent validity; accordingly, no items were deleted [100]. As for the Cronbach's alpha and composite reliability that measure how well the items measure their constructs; the results show that all the constructs had composite reliability > 0.7 except for AFF whose CR > 0.6 which is acceptable cutoff point according to [99] with respect to the context of the current study. The results of AVE convergent validity revealed that all the constructs had AVE > 0.5, indicating that more than 50% of the variance in the items is explained by the respective constructs and that convergent validity is established [104]. Also, the discriminant validity results showed that the shared variance between all constructs is not larger than the AVE (square root), which indicates that more variance is shared between the latent variable component and its block of indicators/items than with another component representing a different block of indicators/items [105]. These results prove the validity and reliability of the outer measurement model. Table 7 shows the results of the Variance Inflation Factor (VIF) used to measure the multicollinearity between the items were all less than 5, which indicates that no multicollinearity exists between the items.

In the current model, ATT and PBC, as higher-order constructs, were estimated using the disjoint two-stage approach [102], wherein latent variable scores from the first-stage measurement model serve as manifest variables in the second-stage structural model. This approach avoids the collinearity issues associated with repeated-indicators approaches while preserving the formative measurement logic of each higher-order construct.

To validate these higher-order constructs, VIF values were examined to check for collinearity, and their values were less than 5 as shown in Table 8. Also, the outer weights

values were checked and showed significance except for AVA; however, its outer loading values showed significance for its *p*-values [106]. Ref. [99] explained that the indicator should be retained if its outer loading exceeds 0.50 or is significant (*p*-value 0.043), as it contributes meaningful variance to the construct. Ref. [102] emphasized that formative indicators should not be removed solely for statistical non-significance, as this would compromise content validity, which was also supported by [107].

Table 7. Variance Inflation Factors (VIF) for each variable.

	VIF
AFF1	1.146
AFF2	1.094
AFF3	1.227
AVA1	1.341
AVA2	1.341
CON1	1.337
CON2	1.555
CON3	1.203
CONS1	1.199
CONS2	1.589
CONS3	1.656
ONL1	3.221
ONL2	2.349
ONL3	3.801
ONL4	4.178
ONL5	3.408
ONL6	3.292
ONL7	1.550
PI1	2.056
PI2	2.056
PI3	1.600
PI4	2.190
SN1	3.059
SN2	2.871
SN3	2.455
VEN1	2.420
VEN2	2.469
VEN3	3.522
VEN4	3.110

Table 8. The validity for the higher-order constructs.

	Outer Weights	Standard Deviation (STDEV)	T statistics (|O/STDEV|)	*p* Values	VIF	Outer Loadings	Outer Loadings *p* Values
LVS – AFF -> PBC	0.989	0.038	26.157	0.000	1.033	0.999	0.000
LVS – AVA -> PBC	0.052	0.145	0.361	0.359	1.033	0.229	0.043
LVS – CON -> ATT	0.389	0.119	3.260	0.001	1.397	0.782	0.000
LVS – CONS -> ATT	0.737	0.100	7.375	0.000	1.397	0.944	0.000

4.3. The Structural Model

The hypotheses proposed in this study are assessed using the path coefficients and their significance [108] as shown in Table 9, in addition to the coefficient of determination (R^2). Using PLS two-tailed, based on 5000 bootstrap resamples, the direct paths between TPB constructs and purchase intention revealed that ATT has a strong, significant effect

on healthy food purchase intention. This shows that consumers' health consciousness and food safety concerns play a decisive role in shaping their intention to purchase healthy food, which supports H1. PBC measured through AFF and AVA exerts a small but significant effect on purchase intention, which means that consumers who perceive healthy foods as affordable and accessible are marginally more likely to intend to purchase them; thus, H2 is supported. SN demonstrates a statistically significant relationship with purchase intention, highlighting the role of social approval and peer influence; accordingly, H3 is supported.

Table 9. Path coefficient.

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	*p* Values
Att -> ONL	−0.235	−0.232	0.076	3.084	0.002
Att -> PI	0.413	0.413	0.061	6.765	0.000
ONL -> PI	0.128	0.126	0.072	1.768	0.037
PBC -> ONL	0.480	0.479	0.081	5.959	0.000
PBC -> PI	0.171	0.173	0.071	2.410	0.016
SN -> ONL	0.168	0.169	0.063	2.650	0.008
SN -> PI	0.301	0.296	0.060	5.005	0.000
VEN -> PI	−0.040	−0.025	0.071	0.564	0.573
VEN × Att -> PI	0.020	0.015	0.064	0.319	0.750
VEN × PBC -> PI	−0.089	−0.087	0.076	1.171	0.242
VEN × SN -> PI	0.059	0.056	0.053	1.116	0.264

These results show that while TPB predictors have significant direct relationships with intention, their path coefficients also show their significant influence on online shopping. ATT negatively predicts online shopping adoption, suggesting that highly health-conscious and concerned consumers may be skeptical of online food purchasing channels concerning trust, quality, or delivery reliability [109], while the mechanism behind this negative relationship warrants further investigation. The path of PBC is significant, which means that PBC strongly predicted online shopping usage ($\beta = 0.480$, $p < 0.001$). This shows that AFF and AVA perceptions enhance consumers' likelihood of using online shopping as a channel. For SN, the path is strong and significant, showing that social norms positively shape online shopping usage ($\beta = 0.168$, $p = 0.008$), suggesting that peer and family influence play a role in encouraging consumers to use digital channels.

The results also examined whether ONL serves as a mediator between TPB constructs and PI. As a prerequisite for mediation, ONL was found to significantly predict PI ($\beta = 0.128$, $p = 0.037$), suggesting that ONL channel usage positively influences PI directly. However, the specific indirect effects, which constitute the formal test of mediation, were examined through bootstrapped confidence intervals.

Table 10 shows that the indirect effect of ATT through ONL on PI is negative and non-significant ($\beta = -0.081$, $p = 0.060$). The opposing signs of the direct effect and the indirect effect suggest a potentially inconsistent mediation pattern whereby health-conscious consumers are less likely to use online channels, partially suppressing the ATT and PI pathway; however, this pattern does not reach statistical significance and therefore remains inconclusive; thus, H4 is not supported. For PBC, the specific indirect effect is positive and not significant at the 5% level ($\beta = 0.098$, $p = 0.054$). This indicates consistency but nonsignificant mediation, with online shopping indicating the rejection of H5. The indirect

path of the SN is positive but not significant (β = 0.016, p = 0.151). Therefore, H6 is not supported.

Table 10. Specific indirect effect.

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	p Values	BCa 95%CI
LV scores − ATT -> ONL -> PI	−0.081	−0.083	0.043	1.884	0.060	(−0.0165–0.003)
LV scores − PBC -> ONL -> PI	0.098	0.101	0.051	1.928	0.054	(−0.002–0.198)
SN -> ONL -> PI	0.016	0.017	0.011	1.436	0.151	(−0.006–0.038)

These findings suggest that online shopping does not serve as an effective mediator between TPB constructs and healthy food purchase intention in Egypt. Notably, the indirect effects exhibit construct-differentiated patterns indicating that the online channel may interact asymmetrically with different psychological drivers, though these patterns remain statistically inconclusive at the current sample size. This warrants replication in larger samples and in markets with higher digital food retail penetration.

As for the usage of vending machines, the results revealed that the usage does not exert a statistically significant direct effect on purchase intention (β = −0.040, t = 0.564, p = 0.573). Furthermore, none of the hypothesized moderation effects reached statistical significance: the interaction between vending machine usage and ATT (β = 0.020, t = 0.319, p = 0.750), the interaction between vending machine usage and PBC (β = −0.089, t = 1.171, p = 0.242), and the interaction between vending machine usage and SN (β = 0.059, t = 1.116, p = 0.264) were all non-significant. These findings suggest that the influence of ATT, PBC and SN on consumers' PI operates consistently across varying levels of vending machine usage experience, indicating that prior exposure to vending machine technology does not amplify or attenuate the predictive relationships within the proposed model in the Egyptian market. This outcome aligns with prior research suggesting that technology familiarity does not always translate into a meaningful boundary condition in consumer behavior models [19,110]. Therefore, hypotheses H7, H8, and H9 are rejected. All the results are summarized in Figure 2.

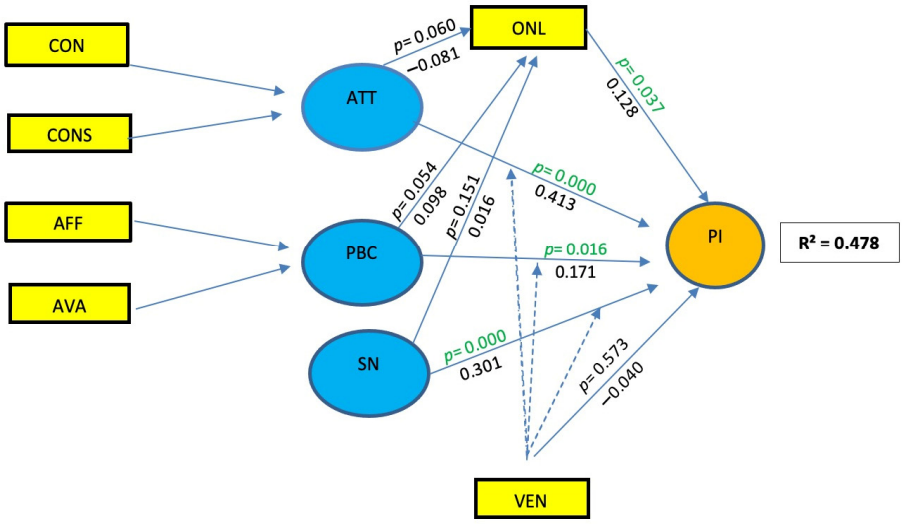

Figure 2. Structural Equation Modeling (SEM) using SmartPLS 4.0 software.

4.4. Model Explanatory Power, Effect Sizes, and Model Fit

The structural model demonstrated satisfactory explanatory power, with the latent variable for PI achieving an R^2 value of 0.489 and an adjusted R^2 of 0.478, indicating that approximately 48.9% of the variance in purchase intention was accounted for by the proposed model constructs. The bootstrapped R^2 estimate for PI is 0.486 ($t = 10.713$, $p = 0.000$), confirming the stability and statistical robustness of the model's predictive capacity across resampling iterations. These values fall within the moderate-to-substantial range as recommended by [102] for behavioral intention models in consumer research contexts.

Ref. [111]'s f^2 effect size criteria are examined to assess the relative contribution of each predictor to the explanation of purchase intention. ATT demonstrated a medium effect size ($f^2 = 0.235$), underscoring its substantive contribution to explaining variance in purchase intention beyond other predictors in the model. SN exhibited an effect size approaching medium ($f^2 = 0.143$), reflecting a meaningful though comparatively modest contribution. In contrast, PBC yielded a small effect size of $f^2 = 0.033$. ONL demonstrated a small effect size on PI ($f^2 = 0.021$), while the VEN showed negligible effect ($f^2 = 0.003$), consistent with its non-significant direct path; their unique incremental contribution to explaining purchase intention is limited [102,111].

Regarding overall model fit, the Standardized Root Mean Square Residual (SRMR) was 0.065 for both the saturated and estimated models, falling below the recommended threshold of 0.08 [112], thereby confirming an acceptable fit between the hypothesized model structure and the observed data. The convergence of SRMR values across both model specifications further indicates that the imposed structural constraints did not meaningfully distort model representation.

5. Discussion

The findings reinforce the relevance of the TPB in explaining healthy food purchase intentions in the Egyptian market, while also highlighting important contextual nuances.

The finding that ATT is the primary and most significant predictor of PI confirms that a positive evaluation of healthy food, driven by health consciousness and food safety, remains the core driver of consumer intent, which was also reported by [30,31]. This decomposition of ATT showed the strongest direct effect, confirming prior studies [19,113] that health concern and consciousness are decisive for predicting healthy food choices. Including food safety concerns and healthy consciousness as a measure for ATT provides a more nuanced understanding of the cognitive and affective factors that drive consumer intentions. This allows understanding of the internal psychological drivers and enables understanding of the correctly targeted emotional and cognitive bases of consumer decisions that should be considered. Additionally, enhances the predictive ability of TPB in contexts where health is a central concern. This is strongly supported by the construct Health-Centric Food Choice [114]; this construct demonstrates that prioritizing nutritional value and ingredient quality significantly influences how consumers distinguish healthy products and select their preferred retail environments [39]. Ref. [40] also highlighted that health consciousness worked as a significant stimulus that shapes a consumer's internal ATT and subsequent intent to adopt healthier food options. Also, Ref. [37] highlighted that food safety concern positively affects ATT and willingness to pay for healthy food, and ref. [33] emphasized that decomposing ATT into health-based subcomponents improves understanding of food choice behavior.

PBC and SN also significantly shaped purchase intention, aligning with research by [44,115]. The significance of PBC, operationalized partly through AFF and social approval, emphasizes that both economic and social ecosystems need to support healthy

consumption. This aligns with [40] finding that price fairness and social influences are essential antecedents for healthy food adoption.

The significance of PBC proved that if healthy food is perceived as easy to access and affordable, people feel empowered to act on their intentions. It validates the need to improve market infrastructure, pricing, and distribution, especially in underserved communities. This was explained by [52], which identified PBC as a large necessary condition, suggesting that a minimum threshold of perceived capability and resource availability must be met before a consumer can even form an intention to act. Ref. [39] explained that while consumers may have a strong intention to buy healthy food, their actual retail choices are heavily constrained by their perceived household expenses and the physical availability of products within their immediate community food environment. Ref. [40] results proved that Indian consumers, similar to the Egyptians, are sensitive to whether the price reflects the inherent value of the product. This is explained by the demographics of the study; the large share of respondents with low income (61% earning less than 20,000) highlights the importance of AFF as a dimension of PBC. This shows that financial constraints are key barriers to adopting healthy dietary behaviors in developing countries. This explains why PBC, operationalized through AVA and AFF, significantly affected healthy food PI.

The significant role of SN on healthy food purchase intention means that social pressure represented in family influence or peer behavior matters in consumers' decisions to buy healthy food. This is particularly relevant in collectivist cultures like Egypt, where social influence plays a significant role in shaping behavior. This is supported by [45,116], who emphasized that social expectations shape health-related behaviors. This suggests that healthy food suppliers should focus on leveraging influencers, health advocates, or peer-group endorsements. This aligns with the Social Network Theory [117] or [19], which posits that consumers frequently rely on social recommendations and peer influence to navigate food environments [39]. This aligns with the Indian study conducted by [52], which found that social pressure and peer alignment are critical, particularly for youth cohorts (Gen Z and millennials) who seek social acceptance in sustainable practices.

This is also justified by the higher proportion of female respondents (57.9%), which explains the influence of ATT and SN. Prior studies indicate that women are more engaged in food purchasing decisions and more concerned with nutritional value and food safety [118,119]. Thus, their presence in the sample elaborates the significance of ATT measured through CONS and CON, in addition to the social influence captured by SN. Also, the relatively high percentage of participants who exercise regularly (53%) explains the strong role of health-related attitudes. This shows that physically active consumers exhibit stronger health consciousness and are more likely to translate positive attitudes toward healthy food into purchase intention.

The marginal significance of the direct effect of ONL indicates that the use of online shopping translated into higher purchase intention for healthy food. It also shows that when consumers have convenient delivery options, such as online ordering, they are more likely to commit to healthy food consumption. This is motivated by the increasing internet penetration and shifting lifestyles, as Egyptians are now more open to e-commerce and alternative food access points. However, the small effect size ($f^2 = 0.021$) suggests the practical influence of ONL on PI remains limited in the current sample. This offers a pathway for businesses and policymakers to make healthy food more reachable. This supports emerging research, e.g., [120,121] that found digital channels and smart LML solutions enhance the adoption of healthier lifestyles, particularly post-pandemic.

The absence of confirmed mediation, with a lack of statistically significant mediation of TPB–PI relationships through ONL, suggests that the psychological pathways from ATT,

PBC, and SN are not reliably channeled through online shopping in the current sample. This contradicts [122], which reported significant online-channel mediation in Asian food contexts. Still, the negative effect of ATT on online shopping suggests skepticism about online food channels, possibly due to uncertainty about product freshness and ingredient authenticity in digital retail contexts. Prior studies confirm that mistrust and perceived risk hinder online grocery adoption, especially for perishable and healthy foods [123]. The same was explained by [39], who attributed this to the trust gap and the necessity for institutional trust to validate healthy food claims. This aligns with the Trust-Commitment Theory [124], which establishes that commitment to healthy eating requires a corresponding level of institutional trust in the enabling channel. Where that trust is absent, even strongly positive attitudes toward the end goal fail to generate engagement with the available means. Health-conscious consumers may view digital channels as prioritizing convenience over the product freshness and health certification they value in traditional or large-chain settings. Ref. [40] argued that consumers are often hesitant to use digital platforms without clear evidence of certification and LML reliability. This mirrors the conflicts identified by [52] regarding Ready-to-Eat (RTE) food delivery. Ref. [52] noted that while consumers may have a positive attitude toward sustainability, green delivery options often involve longer waiting times or potential trade-offs in food freshness, which can act as a deterrent. This skepticism among health-conscious consumers suggests that the instrumental evaluation of outcomes such as the reliability of delivery and product quality is currently a bottleneck for digital channels. Dual-Process Theory [125] can also interpret this as a conflict between two cognitive systems operating simultaneously within health-conscious consumers. System (1) is fast, intuitive, and emotionally driven, which generates a positive attitude toward healthy food based on deeply internalized health values and food safety concerns. System (2) is deliberative and analytically oriented, which then evaluates the available procurement channels and concludes that online platforms are insufficiently reliable to guarantee the product freshness, nutritional integrity, and safety certification that health-conscious consumers prioritize. Thus, stronger health-oriented attitudes paradoxically suppress engagement with digital food channels, as the deliberative evaluation of e-commerce reliability introduces friction that outweighs the convenience afforded by online procurement. This suggests that interventions aimed at increasing transparency in online healthy food sourcing, such as quality certification, real-time freshness tracking, and third-party verification, could reduce friction in System 2 deliberation and facilitate online channel adoption.

Regarding the absence of significant moderation between VEN and TPB constructs, this indicates that vending machine familiarity does not moderate the psychological pathways from ATT, PBC, and SN to PI. Combined with the non-significant direct effect of VEN on PI ($\beta = [-0.04]$, $p = [0.573]$), these findings confirm that vending machines have not yet established a meaningful role in the Egyptian healthy food consumption context, neither as a direct access channel nor as a boundary condition shaping existing TPB pathways. This could be interpreted through the Concept of Food Environment Framework [84], which emphasizes that individual behavior is shaped by the physical and policy context of their surroundings [39]. This contrasts with findings in developed markets [34], where smart vending machines are expanding healthy food access. This suggests that while vending machines could theoretically provide convenient access points for healthy food, their role in Egypt remains underdeveloped. Factors such as low availability of healthy options in vending machines, cultural preferences for fresh food, and trust in traditional retail channels may explain this non-significance [126]. While Ref. [40] explained that short food supply chains in developing markets face significant challenges, including poor infrastructure and a lack of technology integration, such that if vending machines have not established their role in the last-mile logistics of the healthy food market, they will likely fail to moderate the existing

psychological pathways between consumer attitude and intention. Furthermore, ref. [126] highlighted that for a retail or delivery format to influence intention, it must first surpass specific bottleneck levels of consumer familiarity and perceived utility. In the Egyptian market context, the results found that vending machines dispensing healthy food products have limited penetration in the market and are not a recognizable or trusted distribution modality within consumers' cognitive food environment schemas. Worth mentioning is that VEN exhibits adequate variance in this sample ($M = 3.758$, $SD = 0.926$), confirming that the non-significant moderation is not attributable to a floor effect or restricted moderator range. The absence of moderation therefore reflects a genuine null moderating effect in the current Egyptian context, theoretically interpretable through [83]. Diffusion of Innovation Theory reflects insufficient channel-level maturity, which posits that the adoption of a new technology or distribution channel is contingent upon consumers surpassing a minimum threshold of awareness, trialability, and perceived relative advantage. Consequently, consumer familiarity with this channel remains below the critical threshold necessary for it to function as a meaningful behavioral boundary condition that amplifies or attenuates the established psychological pathways between ATT, PBC, SN, and PI.

6. Conclusions

This study examined the determinants of healthy food purchase intention among Egyptian consumers by extending TPB to incorporate ONL as a mediating mechanism and VEN as a moderating construct. The findings confirm that ATT, SN, and PBC are significant predictors of PI, with ATT emerging as the most influential driver, underscoring the centrality of health consciousness and food safety concerns in shaping consumer decision-making within emerging market contexts.

The novel integration of ONL as a last-mile logistics mediator within the TPB framework yielded theoretically informative results, clarifying the boundary conditions of digital retail channels in healthy food consumption. Contrary to hypotheses, the mediation analysis revealed that ONL did not significantly mediate the relationships between any of the TPB constructs and PI. Notably, ONL demonstrated a marginally significant direct effect on PI, suggesting it functions as an independent driver of PI rather than as a channel through which TPB antecedents operate. However, the borderline *p*-values for the ATT- and PBC-mediated paths also suggest these relationships warrant further investigation.

Also, the moderating role of VEN was not supported in the current sample; the absence of significant moderation indicates that vending machine usage does not amplify or weaken the TPB–PI relationships in the Egyptian context. This likely reflects limited penetration and consumer familiarity with vending machines as a healthy food distribution channel, contrasting with their established role in developed markets.

6.1. Theoretical and Practical Implications

This study provides both theoretical and practical implications. These findings contribute to the growing body of literature advocating for context-sensitive extensions of TPB in food consumption research, particularly in developing economies where logistical infrastructure and digital adoption intersect with behavioral intention formation. The first contribution lies in the extended use of TPB through the introduction of LML to the Egyptian healthy food context, which is one of only a small number of such studies in MENA and confirms the model's cross-cultural applicability in a developing economy with distinct food culture, religiosity, and income-distribution constraints.

The second and most substantive theoretical contribution lies in the decomposition of ATT into CONS and CON and the decomposition of PBC into AVA and AFF as distinct yet theoretically coherent sub-dimensions. Conventional applications of TPB treat ATT as a

unidimensional evaluative construct, yet this study demonstrates that in health-related consumption contexts, attitude operates through distinguishable cognitive pathways that carry differential predictive weight. By operationalizing ATT through these two health-centric subcomponents, the study enriches TPB's attitudinal dimension with greater construct granularity, enabling a more precise mapping of the cognitive and affective mechanisms through which consumers evaluate healthy food choices. This decomposition approach responds directly to calls in the literature for more nuanced attitudinal measurement in food behavior research [31] and establishes a replicable methodological precedent for future TPB applications in health consumption domains. In a similar vein, the study decomposes PBC into AVA and AFF; operationalizing PBC through these two resource-based and access-based components extends the control dimension of TPB with greater construct granularity. The third theoretical contribution pertains to the introduction of online shopping and vending machine usage as novel mediating and moderating variables within a TPB-based healthy food consumption model. This finding advances a theoretical proposition that distribution is contingent upon channel maturity, which has not been explicitly articulated in prior TPB extensions, and which offers a productive theoretical agenda for future research in markets where innovative food retail formats are at earlier stages of consumer adoption.

From a practical standpoint, the results highlight the need to build trust and transparency in online platforms (e.g., cold-chain certification, clear labeling, customer reviews) to ensure that positive consumer attitudes are not offset by channel mistrust. Also, there should be policies that promote digital food safety regulations and logistics infrastructure improvements that could help convert the currently non-significant pathway into a meaningful channel by addressing the trust deficit that currently prevents health-conscious attitudes from translating into online purchasing behavior. Also, it is suggested that practitioners in the Egyptian healthy food market should focus on nudging consumer behavior through framed pricing and information by providing specific sustainability information (like carbon footprint details), which can be as effective as price discounts in encouraging healthy choices. This implies that online channels could overcome the observed negative attitude-adoption path by implementing SDG-aligned labels or transparency-focused features that reinforce trust and highlight the social responsibility of the purchase. Conversely, the non-significant moderating role of vending machine usage reflects the nascent state of this distribution channel in Egypt, suggesting that substantial investment in consumer familiarization and infrastructure development is a prerequisite before vending machines can meaningfully influence healthy food consumption patterns.

6.2. Limitations and Future Research

Despite its theoretical and empirical contributions, this study is subject to several limitations that should be acknowledged and that collectively outline a productive agenda for future research. The study's cross-sectional design precludes causal inference between the examined constructs, as all data were collected at a single point in time. While PLS-SEM provides robust path coefficient estimation, it cannot establish temporal precedence among the variables and PI. Future research should adopt longitudinal or experimental designs to trace the evolution of healthy food purchase intentions over time and to capture the dynamic interplay between psychological antecedents and logistical enablers as digital retail infrastructure in Egypt continues to mature.

Second, although purposive sampling was methodologically appropriate as the study specifically required respondents with awareness of healthy food products and healthy lifestyle practices, which cannot be verified through probability sampling frames in the Egyptian context, the reliance on social media platforms as the primary distribution channel introduces a recruitment boundary condition. The resulting sample skews toward younger

adults (84% aged 18–33) and single respondents (79.1%), which reflects both the digital recruitment channel and the documented concentration of health-conscious, digitally engaged consumers within these demographic groups. While this profile is consistent with the study's target population, it limits generalizability to older, married, and digitally disengaged segments. Future research should employ stratified or quota sampling across broader demographic bands to test whether the proposed framework holds equally across various profiles.

Third, the study relies on self-reported Likert-scale data, in which respondents may overstate their healthy food purchase intentions or health consciousness relative to their actual behavior. Although Harman's single-factor test and the measurement model diagnostics confirmed discriminant validity, future research should triangulate self-reported intentions with actual purchase records to strengthen criterion validity.

Also, this study is geographically bounded to the Egyptian consumer market, which, while offering valuable insights into a large and underrepresented emerging economy, limits the cross-cultural transferability of the findings. The collectivist cultural orientation of Egyptian society, the nascent state of its e-commerce food retail infrastructure, and the specific economic constraints facing its consumer base collectively constitute a unique contextual configuration that may not replicate in other developing markets. Future research should conduct cross-national comparative studies across Middle Eastern, African, and South Asian emerging markets to identify which elements of the proposed extended TPB framework are universally applicable and which are context-specific, thereby contributing to a more culturally sensitive and geographically inclusive theoretical understanding of healthy food consumption behavior.

A further limitation is that demographic characteristics were not included as control variables in the structural model. They were employed in the study as sample descriptive statistics rather than controlled effects, and future research should formally test their controlling roles.

Finally, as the sample size ($N = 201$) is adequate for estimating main structural paths in PLS-SEM, statistical power for detecting small moderation effects is limited; a larger sample would be required for 80% power [127]. Consequently, the non-significant VEN moderation results should be interpreted with caution, as they may reflect insufficient power for small interaction effects rather than a true null effect. The descriptive statistics of VEN showed adequate variance and a moderate-to-high level of vending machine familiarity in the sample, so future research should replicate the moderation analysis with larger samples and in contexts where healthy food vending machines are more systematically deployed to determine whether channel maturity transforms this moderating role.

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Abbreviations

The following abbreviations are used in this manuscript:

SEM	Structural Equation Modeling
TPB	Theory of Planned Behavior
ATT	Attitude
PBC	Perceived Behavioral Control
SN	Subjective Norms
AFF	Affordability
AVA	Availability
CON	Convenience
ONL	Online Shopping
PI	Purchase Intention
VEN	Vending Machine Usage
CONS	Health Consciousness

Appendix A

Table A1. Scale constructs.

Research Variables	Measurement Items	Literature Sources
Purchase Intention (DV)	How likely is it that you will purchase healthy food within the near future?	[97]
	To what extent do you see yourself as capable of purchasing healthy food?	
	I usually prefer to buy healthy food.	
	I intend to purchase healthy food products within the next near future.	
Health Consciousness (IV)	Are you knowledgeable about the harmful effects of artificial additives?	[98]
	I like to own a healthy lifestyle.	
	I tend to pay attention to my health.	
Health Concern (IV)	I'm very concerned about the amount of artificial additives and preservatives in food.	[86]
	The quality and safety of food nowadays concerns me.	
	Nowadays most foods contain residues from chemical sprays, artificial additives and fertilizers.	
Availability (IV)	It is easy to find healthy products.	[54]
	If I wanted healthy food, I could access it any time.	
Affordability (IV)	When I look for healthy food, I look for price information.	[54]
	I often choose to buy healthy food products, even if they are more expensive than other products.	
	Healthy food offers a good value for the money.	

Table A1. *Cont.*

Research Variables	Measurement Items	Literature Sources
Subjective Norm (IV)	Most people I value would buy healthy food rather than non-healthy food	[97]
	People who are close to me think that I should purchase healthy food products.	
	My family thinks that I should buy healthy food	
Online Shopping Usage (Mediating)	I prefer buying healthy food from an online retailer than buying from a real store/shop.	[70]
	Online shopping offers a broader selection of healthy products.	
	I trust buying healthy food products online.	
	I am likely to purchase healthy products from online websites in near Future.	
	I like online shopping as I have greater variety of healthy products available in every category.	
	I often choose to buy healthy products from websites.	
	An online store should provide timely nutritional facts about various healthy products.	
Vending Machine Usage (Moderating)	I like the idea of using the vending machine to purchase healthy food.	[34]
	I prefer buying the healthy products from a vending machine rather than from a store.	
	I will frequently shop from a vending machine in the future.	
	The idea of buying healthy food from a vending machine is a good idea.	

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