
Perceived food environments and fruit & vegetable consumption among Hungarian single mothers

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Perceived Food Environments and Fruit & Vegetable consumption among Hungarian single mothers

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Abstract

Despite clear health benefits of regular fruit and vegetable (F&V) consumption, intake in Hungary remains below WHO recommendations. High inflation and limited political and economic support increase food insecurity risk, particularly for vulnerable groups such as single mothers. Although it is well known that perceptions of the food environment influence eating behaviour, little is known about how single mothers experience these environments when dealing with financial concerns.

This study used quantitative methods to measure the perceptions of three food environments (Community, Consumer and Home) and their direct and indirect relationships with F&V consumption among Hungarian single mothers. The NEMS-P survey was used and confirmatory factor analysis was employed to validate the theoretical constructs. A conceptual framework based on the Model of Perceived Nutrition Environments was tested using structural equation modelling.

Results show the central role of the Home food environment in influencing F&V consumption. It had a direct effect on consumption and mediated the influence of the Consumer nutrition environment. Economic concern negatively affected F&V consumption, the Home food environment, and perceptions of the Consumer Nutrition Environment. In contrast, F&V consumption was not associated with the perceived community nutrition environment, suggesting relatively good access to stores offering quality and variety of F&V.

These findings highlight the strong relationship between the home food environment and healthy eating behaviours and underline the importance

of further research on psychosocial and sociodemographic factors to develop context-specific and targeted policy interventions.

Keywords: Perceived nutrition environments; single mothers; NEMS-P; fruit and vegetable consumption

Introduction

Consuming adequate amounts of fruit and vegetables is a key component of a healthy diet and has been shown to reduce the risk of non-communicable diseases such as cardiovascular disease, obesity and certain cancers [1], [2]. The World Health Organization (WHO) recommends consuming at least 400 g of fruit and vegetables per day to achieve these protective effects [3]. However, daily fruit and vegetable (F&V) intake in Hungary remains persistently below WHO recommendations, according to the latest national food consumption survey [4], [5]. These consumption trends among adults are exacerbated by exceptionally high inflation affecting the country: during 2022-2023 consumer experienced consumer price growth exceeded 25% at its peak and the highest value added tax applied on fresh fruit and vegetable (27%) in Europe, level not observed for decades [6], [7], [8]. As a result, Hungary ranks as the fourth worst-performing EU member state in terms of food poverty [9], [10] with food insecurity becoming an increasing concern, particularly among low-income households.

Single parents in Hungary are among the most vulnerable social groups in terms of risk of poverty and social exclusion [11], [12]. Despite the country invests in a relatively extensive family support system, the national family policy, particularly under its current pro-natalist and traditionalist orientation, tends to prioritize married, two-parent families, often marginalizing single-parent households [13]. According to the latest national census data from 2022, there are around 341,000 single parents in Hungary, over 80% of whom are headed by women [11], [14], [15]. Many of these households struggle with limited employment opportunities and inadequate social support [16]. The financial difficulties are often exacerbated by limited access to stable employment, as single mothers frequently balance multiple responsibilities, including childcare, work, and household duties. Many rely on state welfare, yet support remains insufficient [17].

Despite facing these challenges, several studies show that single mothers are highly aware of the importance of providing healthy meals at home, especially fruit and vegetables [18], and often prioritise providing nutritious food for their children, even if this means compromising their own diet [19],

[20], [21], [22]. Therefore, when navigating their local food environments, their food choices are affected by the complex interplay of coping strategies that strike a balance between limited economic resources and healthy choices [23], [24], [25], [26].

Extensive research has demonstrated that objective and subjective characteristics of food environments can negatively impact the decision to purchase healthy food [27], [28]. Observational studies in various contexts, focused on single mothers under financial constraints, demonstrate that they often reside in neighbourhoods with fewer retail outlets offering affordable fresh produce, contributing to poorer diet quality [29], [30], [31], [32]. However, a large and growing body of literature has emphasised that perceptions of food environments play a critical role in influencing food choices, alongside their objective characteristics [33], [34], [35], [36], [37], [38]. A systematic review on perceived food environments and nutrition-related behavioural outcomes [39] highlighted individuals' perceptions of food availability, affordability, accessibility, and quality are consistently associated with dietary behaviours. Across studies, positive perceptions of the food environment were linked with higher F&V intake, while negative perceptions were associated with poorer diet quality and greater consumption of ultra-processed foods [35], [40]. Negative perceptions of affordability, availability, and quality act as barriers to healthy eating, even when healthy foods are physically present [35], [41], [42], [43]. Indeed, in the study of Williams et al., [44] women who perceived low quality and availability of F&V in their neighbourhood were more likely to perceive F&V as expensive, so discouraging their consumption. Although some research has been conducted on how perceived food environments influence eating behaviours, there is limited understanding of how single mothers perceive their everyday food environments [45].

The aim of this study was to evaluate the impact of perceived food environments on F&V consumption among single mothers in Hungary. Using a quantitative approach, this study tested and validated the Model of the Perceived Nutrition Environment developed by Glanz and Green [46] in the Hungarian context. The methodology applied enables the measurement of the direct and indirect relationships between different perceived food environments and F&V consumption. It also gathers insights into the perceived barriers experienced by single mothers in Hungary, which can inform future policies and contribute to reducing health disparities.

Theoretical and conceptual framework

The Model of the Perceived Nutrition Environment is itself an extension of the Model of Community Nutrition Environments as developed by Glanz and colleagues in 2005 [47]. It stipulates that eating behaviours are influenced

by what is available in the home environment which itself depends on individuals' shopping behaviour. What consumers are buying, in turn, depends on their access to the various food outlets (stores, restaurants), where they purchase food (Community Nutrition Environment), and on how these outlets offer food to the consumer (Consumer Nutrition Environment). Finally, consumer background characteristics, as well as psychological factors such as the perceived significance of nutrition, experiences with food insecurity, motivations related to food choice, may affect how both community and consumer environments are perceived.

The Model of the Perceived Nutrition Environment is tested by measuring its different components through the Perceived Nutrition Environment Survey (NEMS-P). NEMS-P is one of the most widely used tools for measuring the perceived food environment [48], [49]. It is a validated and reliable instrument that has been adapted for use in different contexts, demonstrating its cultural adaptability [34], [50], [51], [52], [53], [54].

The present study aimed to test a conceptual model (Figure 1) examining the influence of perceived consumer and community nutrition environments, as well as the home food environment, on F&V consumption among single mothers in Hungary. In addition, the study assessed the impact of concerns about affording nutritious meals on these perceptions. This factor reflects the psychosocial dimension outlined in the Model of Perceived Nutrition Environment, which is expected to be particularly influential for this target group.

The questionnaire was validated and adapted to the Hungarian context for the definition of the constructs specified by the theoretical model.

Consumer and Community Nutrition Environments

The Perceived Community and Consumer Nutrition Environments measure how consumers perceive the availability, desirability (through high quality and selection) and affordability of fruit and vegetables in the stores where they make most of their food choices (Consumer Nutrition Environment), as well as the accessibility of these stores in the places where they live or spend most of their time (Community Nutrition Environment). Oladele et al. [35] demonstrated that positive perceptions of affordability and quality of F&V were associated with higher F&V intake among vulnerable groups. Similarly, Jilcott et al. [55], reported that low and moderate-income midlife women living in urban areas perceived food outlets as physically accessible, but sometimes described barriers related to limited transportation and disparities in the price, quality and availability of healthy and unhealthy food within food outlets located in the areas where they usually purchase fresh food. More recently, Inac et al. [30] confirmed that perceptions of the

external environments varied among consumers with different socioeconomic status also in the a European countries.

Furthermore, negative perceptions of the local consumer environment were also associated with less availability of fruit at home [56]. Similarly Moffat et al. [57] confirmed the correlation between perceptions of F&V availability in the neighbourhood with F&V home availability. Smith et al. [58] show that less healthy local community and consumer environment determine more obesogenic home food environments. Based on the theoretical framework [46], we formulated the following hypotheses:

Hp1: The Community and Consumer Nutrition Environments are directly associated with F&V consumption.

Hp2: The Community and Consumer Nutrition Environments are directly associated with the Home Food environment.

Home Food Environment

The Home Food Environment, as indicated in the theoretical framework, refers to the availability and accessibility (visibility in the refrigerator or counter) of F&V at home. The Home Food Environment is a critical determinant of healthy eating behaviour of both adults and children, and its influence has been proven in several studies [59], [60], [61], [62], [63]. These findings highlight that high availability and accessibility of F&V at home has a positive influence on F&V consumption.

Hp3: The Home Food Environment is directly and positively associated with F&V consumption.

Hp3.1: The Home Food Environment serves as a mediator on the impact of the Community and Consumer Nutrition Environments on F&V consumption.

Concerns about affording nutritious meals

Literature consistently shows that single mothers are highly dedicated to providing their children with healthy food, particularly by including F&V in their everyday meals [18] [19] [20]. Consequently, they may be particularly sensitive to concerns about their household food budget and access to nutritious food [64]. This heightened sense of responsibility makes issues of affordability particularly salient: even when healthy foods are physically available in the external and domestic environments, they may be perceived as less accessible and available due to financial constraints and the need to balance limited resources [25], [32], [65]. As single mothers often prioritise their children's nutritional needs, such concerns may also negatively affect their own eating behaviours [66]. Economic pressures interacting with caregiving responsibilities shape both perceptions and

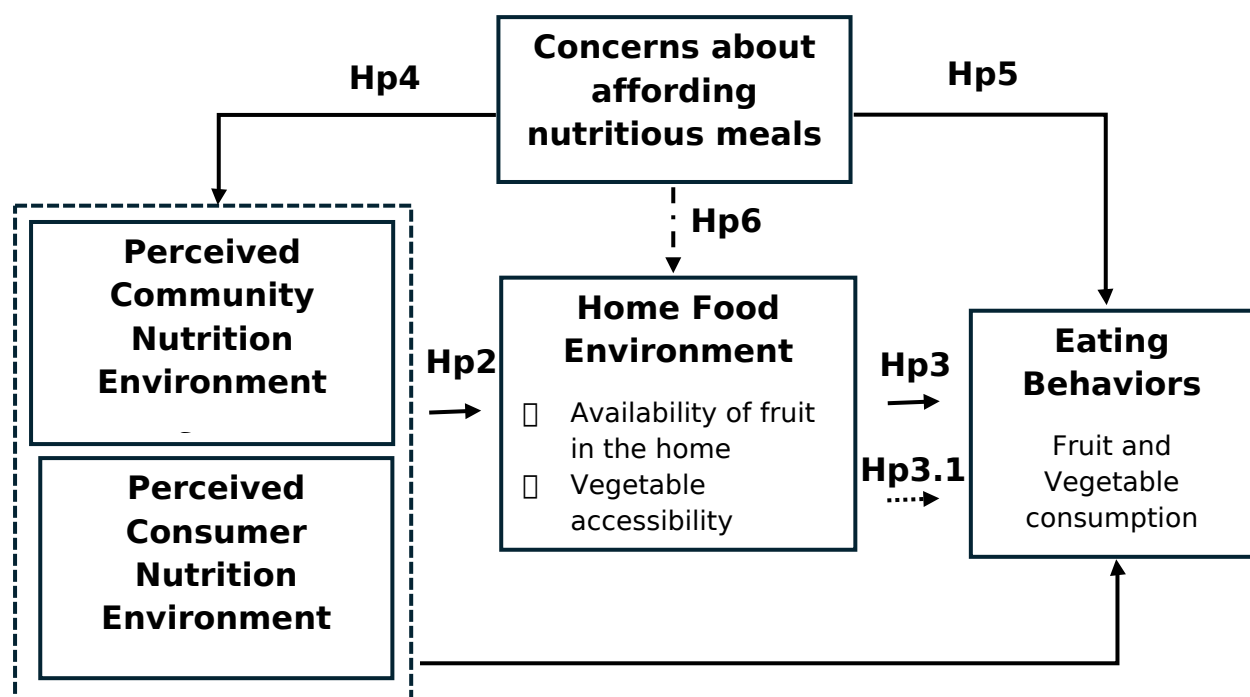
eating behaviour. In light of this, we examine how concerns about affording nutritious meals, which are particularly relevant in the context of this sample of single mothers, may negatively affect perceptions of the nutritional environment and the home food environment, and ultimately, fruit and vegetable consumption.

Hp4: Concern about affording nutritious meals is negatively associated with the perceptions of the Community and Consumer Nutrition Environments.

Hp5: Concern about affording nutritious meals is negatively associated with F&V consumption.

Moreover, in addition to the pathways indicated by the theoretical framework of Glanz and Green [46], we introduced a direct pathway between economic concerns and the home food environment, investigating its effect on all potential environments that contribute to shaping eating behaviours.

Hp6: Concern about affording nutritious meals is negatively associated with the Home Food Environment.



Hp1

Survey instrument

The Perceived Nutrition Environment Measures Survey (NEMS-P) was used [46]. In the current study, the original NEMS-P, developed to examine how the home food environment and perceived nutrition environments (Consumer and Community in store) influence healthy and unhealthy eating behaviours, was adapted to reflect the Hungarian dietary context.

Additionally, a pilot test involving 15 single mothers was conducted to revise and tailor the survey items accordingly. The Additional file 1 in the Supplementary Materials includes a comparison of the adapted items with those from the original version.

The revised survey retained 27 items of the adapted NEMS-P in the Hungarian context to test our conceptual framework.

The Community Nutrition Environment was assessed using 4 items that explored the mode of travel to the shop where most of the purchases are made ('Mode of travel to the store'), distance from home to the favourite shop ('Distance from home'), and whether the choice of a specific shop is motivated by its proximity to home and other frequently visited places ('Store access').

The Consumer Nutrition Environment was measured through 10 items addressing the Availability of F&V, Store motivation, Affordability, Placement/promotion of healthy items and nutrition information as defined by the theoretical framework [46]. Three items assessed the Availability of F&V, investigating the presence of good quality and selection of F&V in the neighbourhood. Store motivation included the importance of selection, quality, and price of food in deciding to shop at a specific grocery store, rated on a 5-point Likert scale from *Not at all important* to *Very important*. Affordability was measured by asking participants to rate the price of fruit and vegetables at the store where they did most of their grocery shopping. Placement/Promotion of healthy items and nutrition information' was assessed using items that evaluated the presence of signage, displays, adv promoting healthy options and discounts on F&V in the store. Participants responded using a 5-point Likert scale. Additionally, attention to nutrition labelling prior to purchase was measured.

The Home Food Environment was evaluated through 3 items measuring the availability and accessibility of both fruits and vegetables at home. Participants reported whether F&V were available at home using a 4-point

Likert scale from *I never have it at home* to *I typically have a large stockpile of it*.

Among the psychosocial dimension indicated in the theoretical framework, concern about affording nutritious meals was defined using 1 item, which asked if participants whether, in the past 12 months, they had ever worried about having enough money to buy nutritious meals. Responses were recorded on a 5-point Likert scale ranging from *Never* to *Almost all the time*, with an additional option of *Prefer not to say* to allow participants to opt out of responding.

The background characteristics to describe our sample included age, level of education, employment status (measured by working hours per week), monthly household income, BMI, number of children and household size, defined as the total number of people, including children, living in the household.

Finally, the eating behaviour of participants with regard to F&V was assessed based on the frequency with which they consumed these foods, as reported by the participants themselves. This was measured using a 6-point Likert scale ranging from 'Less than once a month' to 'Several times a day'.

Data collection

Data was collected using convenience sampling. In May 2023, a self-administered questionnaire was distributed among single parents registered in the Single Parent Center database. In total, 463 respondents answered the questionnaire. Informed consent was obtained from all participants in compliance with the Helsinki Declaration and the Hungarian data protection law (Act CXII of 2011 on Informational Self-Determination and Freedom of Information). The responses of participants who reported a male gender were excluded from the original dataset, allowing the analysis to focus exclusively on families headed by single mothers with children.

Data analysis

A range of statistical methods, including descriptive statistics, were used to analyse the collected data and provide a comprehensive overview of the socio-demographic characteristics of the single mothers in our sample and their self-reported F&V consumption.

In the first stage, a confirmatory factor analysis (CFA) was performed to identify the indicator items that define the constructs (Home Food Environment, Community and Consumer Nutrition Environments) theorised in the Model of Community Nutrition Environment defined by Glanz et al. [46]. The exclusion criteria adopted for identifying indicator items

describing the three theorised constructs were: 1) significant factor loadings ($p \leq 0.05$), and 2) exceeding the threshold value of 0.50 [67].

Cronbach's alpha was calculated to assess the internal reliability of the indicator items collected using the adapted version of the NEMS-P in the Hungarian context for the target group. We also assessed the composite reliability (CR) and average variance extracted (AVE) using the factor loadings of the significant indicator items resulting from the CFA for each construct.

Then, a structural equation model (SEM) was built to test the relationships outlined by the conceptual framework, both among the validated composite constructs and in relation to F&V consumption. The analysis identified the direct and indirect effects, enabling the mediating relationships between the composite constructs to be determined.

The primary dependent variables of interest were the mean of self-reported average consumption of F&V. Model fit was assessed using the comparative fit index (CFI), the Tucker-Lewis index (TLI), the standardized root mean squared residual (SRMR) and the root mean square error of approximation (RMSEA) and the R^2 to assess the overall explanatory power. The analysis was carried out using Stata 17.

Results

Descriptive statistics

From the original dataset of 463 participants, responses from single fathers ($N=8$; approximately 2% of the sample) were excluded, as well as cases where more than one household member was employed ($N = 24$; approximately 5% of the sample). Table 1 describes the socio-demographic and health characteristics of the 424 single-mothers. Most respondents were aged between 29–58 years (99% in total), while only 1% were between 21–28 years. The sample was relatively highly educated: the largest proportions had higher vocational qualifications (26%) or a master's degree or higher (24%), followed by high school diplomas (20%) and bachelor's degrees (16%). Only a small minority had primary education (4%) or a PhD/DLA (1%).

Most of the households reported a monthly household income concentrated in the low-middle categories. The largest group earned between €262– €786 per month (57% in total) followed by the group earning €1048–€1310 per month (11%). 13% of the sample preferred not to disclose their income, and few participants reported income below €262 per month (7%).

The majority of single mothers in the sample had one (57%) or two (27%) children, while larger families were less common. Household size was generally small, with 54% living in two-person households, and nearly 29% in three-person households.

Self-reported health status clustered around the middle to higher values of the scale: the majority rated their health as “Appropriate” (59%) or “Good” (20%), while only a small proportion reported “Very poor” (3%) or “Very good” (4%) health.

In terms of BMI, 40% of participants were of normal weight. However, a significant proportion were overweight or obese: 28% were categorised as pre-obese, while 27% were categorised as obese. Only 5% were underweight.

Overall, the sample is characterised by middle-aged adults who are relatively highly educated and predominantly from low-income households. Family sizes are generally small, self-perceived health is generally moderate, and the prevalence of participants with normal or pre-obese weights is high.

Tab. 1 Background characteristics of participants, descriptive statistics (N=424)

	N	%
Age		
21-28	6	1%
29-43	201	47%
44-58	217	51%
Level of Education		
1=Primary education	15	4%
2=Vocational school	41	10%
3=High school diploma	85	20%
4=Higher vocational qualification	110	26%
5=Bachelor's degree	68	16%
6=Master's degree or higher (5+ years)	101	24%
7=PhD, DLA	4	1%
Monthly Household Income		
1=between 0-100 000 HUF (0-262 EUR)	28	7%
2=between 100 000 - 200 000 HUF (262-524 EUR)	81	19%
3=between 200 000 - 300 000 HUF (524-786 EUR)	159	38%
4=between 300 000 - 400 000 HUF (786-1048 EUR)	37	9%
5=between 400 000 - 500 000 HUF (1048-1310 EUR)	48	11%
6=between 500 000 - 1 000 000 HUF (1310-2620 EUR)	17	4%
7=over 1 000 000 HUF (over 2620 EUR)	1	0%

8=Prefer not to answer	53	13%
Number of children		
1	240	57%
2	113	27%
3	57	13%
4	11	3%
5	3	1%
Household size		
2	227	54%
3	121	29%
4	54	13%
5	16	4%
6	6	1%
Self reported health status		
Very bad	12	3%
Bad	63	15%
Appropriate	249	59%
Good	84	20%
Excellent	16	4%
BMI		
Underweight (BMI<18.50)	20	5%
Normal range (18.50< BMI< 25.00)	170	40%
Overweight: Pre-obese (25.00<BMI< 30.00)	120	28%
Overweight: Obese (BMI>30.00)	113	27%
<i>Total</i>	424	

Note: average 2023 HUF/EUR exchange rate.

Participants' responses regarding the Consumer Nutrition Environment in their neighbourhood, indicated that there is high availability and quality of fruits and vegetables in their neighbourhood: respectively 61% and 43% totally agreed with the statement. However, perceptions of selection were slightly less positive (35%).

Participants' responses regarding the Community Nutrition Environment highlight the practical factors influencing food shopping behaviour. Proximity was a key motivator for store choice, with respectively 38% and 46% rating "close to home" and "close to other places where I spend time" as very important.

The descriptive statistics on the Home Food Environment refer to the accessibility and availability of F&V at home. Most respondents reported high availability of vegetables both on the kitchen counter and in the fridge, with 61% and 63% respectively indicating they typically have a large

stockpile. Fruit availability was also high, with 72% reporting a large stockpile at home.

A majority of respondents (72%) reported frequent concerns about affording nutritious meals.

All detailed descriptive statistics for the Consumer Nutrition Environment, Community Nutrition Environment, Home Food Environment, and economic concerns are provided in Additional File 2 of the supplementary materials (Tables S2.1–S2.4).

Table 2 summarises the frequency of F&V consumption among the 424 participants. 43% of participants reported consuming fruit daily or several times a day. Vegetable consumption was slightly lower, though still high: 44% consumed vegetables several times a week, while 24% consumed them daily or more.

Tab. 2 Eating behaviours, descriptive statistics (n=424)

Eating behaviour	Less often	Once a month	Once a week	Several times a week	On a daily basis	Several times a day
	% 95% CI	% 95% CI	% 95% CI	% 95% CI	% 95% CI	% 95% CI
Fruit consumption	8 [0.05-.11]	6 [0.04-.08]	1 [0.03-.16]	30 [0.25-.34]	2 [0.22-.30]	17 [0.13-.20]
Vegetable consumption	5 [0.03-.07]	6 [0.04-.09]	2 [0.10-.24]	44 [0.39-.04]	1 [0.12-.19]	8 [0.06-.11]

Confirmatory factor analysis

The first CFA was performed on the model including all the indicator items suggested by the theoretical framework for the 3 constructs Home Food Environment, Community Nutrition Environment and Consumer Nutrition Environment: 3 indicator items were modelled as a function of the construct Home Food Environment (HAvailability, HAccessibility1; HAccessibility2); 13 indicator items were modelled as a function of the Consumer Nutrition Environment (Avail1; Avail2; Avail3; SMotivation1; SMotivation2; SMotivation3; Placement1; Placement2; Placement3; Placement4; Promtion1; Promotion2; PPrice) and 4 indicator items were modelled as a

function of the Community Nutrition Environment (StoreAccess1, StoreAccess2; Mode of travel; DistanceT). The model 1 obtained an inadequate fit with an CFI of 0.57, TLI of 0.52, RMSEA of 0.112 and an SRMR of 0.131.

The factor loadings of the indicator items assessing the Store Motivation (SMotivation1, SMotivation2 SMotivation3); the Placement/Promotion of F&V in store and nutrition information (Placement1; Placement2; Placement3; Placement4; Promotion1; Promotion2) and the Price of fruits and vegetables in store (PPrice) as defined by Glanz and Green, were not significant (p -value >0.05) and were excluded in the structure of the Consumer Nutrition Environment construct. The factor loadings of the indicator items assessing the way of travel to the store (Mode of travel) and the distance from home to the store by walk (DistanceT) assessing Store access as defined by Glanz and Green, were not significant and were excluded in the structure of the Community Nutrition Environment (see Additional file 3 in Supplementary Material).

So a second CFA of the model excluding the 12 not significant indicator items indicated above, was performed (Model 2). The goodness of fit of Model 2 presented adequate indexes comparing to the first one with a CFI of 0.96, TLI of 0.93, RMSEA of 0.060 and SRMR of 0.065. (Table X)

Tab 3. Goodness of fit indices for Model 1 and 2.

	Model detail	RMSEA	CFI	TLI	SRMR
Model 1	Model including 20 indicator factors suggested by the theoretical framework	0.122	0.57	0.52	0.131
Model 2	Model including 8 indicators factors with the best fit	0.065	0.96	0.93	0.065

For each construct confirmed in Model 2, we assessed the internal consistency reliability of the indicator items by calculating the Cronback's alpha and the convergent validity by calculating the composite reliability (CR) and the average variance extracted (AVE) (Table 4).

Significant factor loadings ($p \leq 0.01$) were observed observed for all constructs. These loadings ranged from 0.59 to 0.90, exceeding the threshold value of 0.50 [65]

The Home Food Environment construct is defined by 3 indicator items: Availability of fruits in the home (HAvailability) with a positive and significant factor loading (0.5948) and Accessibility of Vegetables in the

home: HAccessibiliy1 with a positive and significant factor loading (0.7645); HAccessibiliy2 with a positive and significant factor loading (0.7534).

The Consumer Nutrition Environment construct is defined by 3 indicator items assessing the Availability of good quality and selection of F&V in the neighbourhood: Avail1 concerning the presence of shop withing walking distance where to buy fresh fruits and vegetables, with a positive and significant factor loading (0.7928); Avail2 concerning the quality of fruits and vegetables withing walking distance with a positive and significant factor loading (0.9097) and Avail3 concerning the selection of fruits and vegetables in the neighbourhood with a positive factor loading (0.7894).

The Community Nutrition Environment construct is defined by 2 indicator items assessing the Store Access: StoreAccess1, which concerns the importance of the proximity of the store where most food is bought to participants' homes, has a positive and significant factor loading (0.7537). StoreAccess2, which concerns the importance of the proximity of the store where most food is bought to places where participants spend most of their time, also has a positive and significant factor loading (0.7537).

The composite reliability value (CR) of the three constructs was equal or above the recommended value of 0.60 [68]: Home food environment (0.749), Consumer Nutrition Environment (0.871) and Community Nutrition Environment (0.871). The average variance extracted values (AVE) of the three constructs were above the value recommended of 0.50 [68]: Home Food Environment (0.502); Consumer Nutrition environment (0.693) and Community Nutrition Environment (0.574). The internal consistency reliability (Cronbach's alpha) above the recommended value of 0.70 [69]: Home food environment (0.749); Consumer Nutrition Environment (0.871) and Community Nutrition Environment (0.733).

Tab. 4 Indicator Items description, factor loading, composite reliability (CR), average variance extracted (AVE) and Cronbach's alpha(α) of the three composite constructs: Home Food Environment; Consumer Nutrition Environment; Community Nutrition Environment.

Composite item/ Latent variables	Survey item(s)	Item scale	No. of items	Factor loading	CR	AVE	α
Home Food Environment					0.749	0.502	0.779
1) Availability of fruits in the home	How often do you find the following foods in your home? - Fruits -HAvailability	1-4	3	0.5948**			
2) Accessibility of vegetables in the home	How often do you find the following foods in your home? - Vegetables exposed (in sight, within easy reach) - HAccessibiliy1			0.7645**			
	Fresh vegetables in the fridge -: HAccessibiliy2			0.7534**			
Consumer Nutrition Environment					0.871	0.693	0.882
Availability of good quality and selection of F&V in the neighbourhood	How much do you agree with the following statements? -There is a shop within walking distance where I can buy at least some varieties of fresh fruits and vegetables -Avail1	1-5	3	0.7928**			

	Fresh fruits and vegetables within walking distance are of good quality -Avail2			0.9097* **			
	There is a wide choice of fresh fruits and vegetables in my area -Avail3			0.7894* **			
Community Nutrition Environment							
Store Access	How important are the following factors to you when deciding where to buy? -Close to where I live -StoreAccess1	1-5	2	0.7537* **	0.73 3	0.57 4	0.807
	-Is it on the way or close to other places where you spend time -StoreAccess2			0.7537* **			

*** = $p < 0.001$, ** = $p < 0.01$, * = $p < 0.05$

Structural equation model

The structural equation model (SEM) used to examine the direct and indirect effects of the Perceived Consumer and Community Nutrition Environment, the Home Food Environment and affordability concerns on F&V consumption demonstrated a strong fit to the data. Although the Tucker-Lewis Index (TLI = 0.83) falls below the commonly recommended threshold of 0.90, the model's overall fit remains robust. The Root Mean Square Error of Approximation (RMSEA = 0.065) indicates excellent model parsimony, while the Comparative Fit Index (CFI = 0.98) reflects an excellent fit. Additionally, the Standardized Root Mean Square Residual (SRMR = 0.021) supports the adequacy of the model. The model showed an overall explanatory power, R^2 values ranging from 0.05 to 0.19 across the endogenous constructs. Prior research has emphasized that model evaluation should consider multiple indices in combination rather than relying on any single indicator [70]. Several scholars have argued that a model can be deemed acceptable when at least three or four fit indices meet their respective criteria, particularly when the overall theoretical and empirical justification is strong [71], [72]. Accordingly, the present model is considered to have an acceptable and theoretically meaningful fit.

The results highlight that F&V consumption was significantly influenced by several direct and indirect relationships as indicated in Figure 2.

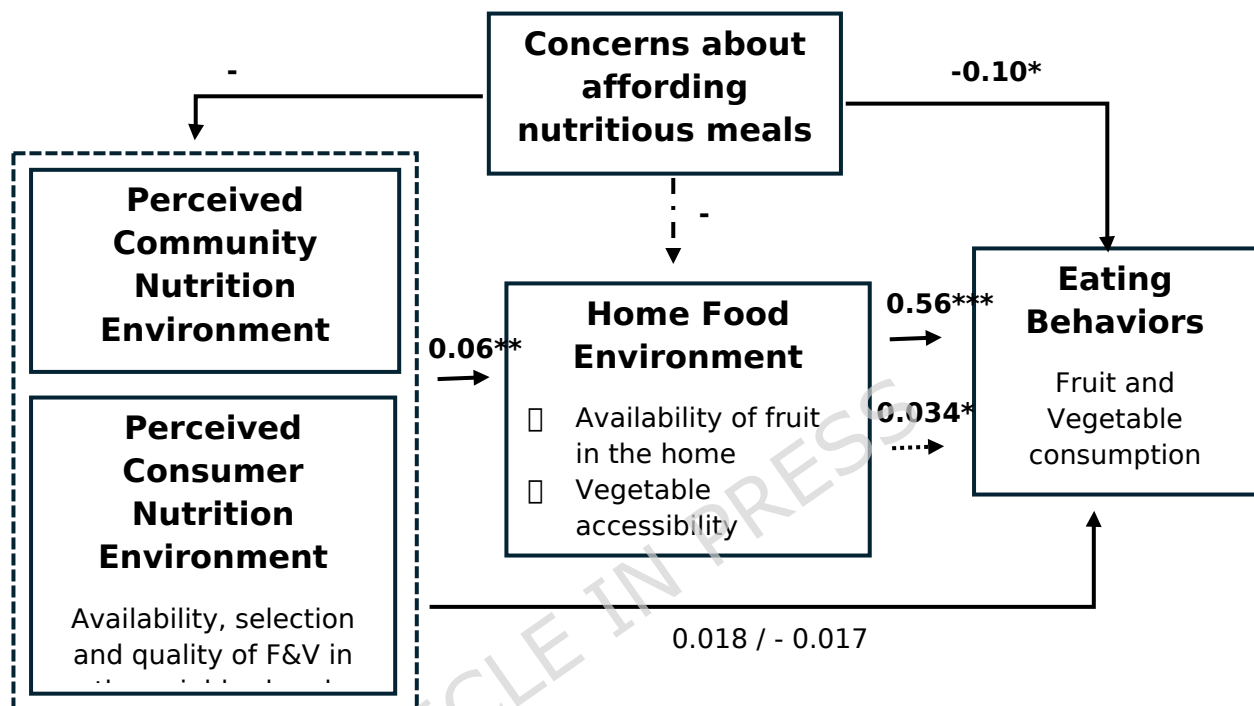
The Home Food Environment has the strongest direct positive effect on F&V consumption ($\beta = 0.568$, $p < 0.001$), and mediates the impact of the Consumer Nutrition Environment (indirect $\beta = 0.034$, $p = 0.048$). These results allow us to confirm the indirect relationship proposed in the theoretical framework between the Consumer Nutrition Environment and F&V consumption, mediated by the Home Food Environment, and emphasizing the crucial role it plays in shaping eating behaviour. However, unlike what is suggested by the Model of the Perceived Nutrition Environments, in our sample, both the Consumer Nutrition Environment ($\beta = 0.018$, $p = 0.623$) and Community Nutrition Environment ($\beta = -0.017$, $p = 0.739$) do not have a direct influence on F&V consumption among Hungarian single mothers.

The concerns about affording healthy meals has a direct effect ($\beta = -0.10$, $p = 0.048$) and an indirect effect mediated by the home food environment ($\beta = -0.08$, $p = 0.000$) on eating behaviour. Moreover, as hypothesized in our conceptual framework, this factor has a strong and direct negative influence on the availability and accessibility of F&V at home ($\beta = -0.14$, $p < 0.000$).

The Consumer Nutrition Environments has a significant direct effect on the Home Food Environment ($\beta = 0.06$, $p = 0.043$) while the Community

Nutrition Environment does not exert any effect on the construct. Moreover, how single mothers perceived fruits and vegetables are made available in the neighbourhood is negatively influenced by affordability concerns ($\beta = 0.182$, $p < 0.000$). While contrary to the theory, the perception of the Community Nutrition Environment is not affected by it in our sample ($\beta = 0.016$, $p < 0.719$).

Fig. 2 Structural equation modelling



*** = $p < 0.001$, ** = $p < 0.01$, * = $p < 0.05$

Note: the not significant pathways are not in bold

$- \cdot - \blacktriangleright$ = pathway not theorized by Model of the Perceived Nutrition Environment but introduced in this study

$\cdots \blacktriangleright$ = indirect effect of Consumer nutrition environment on eating behaviours mediated by the Home Food Environment

Discussion

This study aims to assess the influence of the perceived food environments (Community and Consumer Nutrition Environment) and the Home Food Environment and along with affordability concerns, on F&V consumption among single mothers in Hungary. Using structural equation modelling, we tested a conceptual framework based on the Model of the Perceived Nutrition Environments developed by Green and Glanz [46] through an adapted version of NEMS-P to the Hungarian context. Prior testing of our conceptual framework, a validation of the perceived nutrition environments

and home food environment constructs was performed through Confirmatory Factor Analysis (CFA). The CFA results enabled the identification of the indicator items that best define the three constructs theorised. Compared with the theoretical model, the Consumer Nutrition Environment is defined by the availability of a good selection and high quality of fruits and vegetables in the neighbourhood. The Community Nutrition Environment is defined by two store accessibility variables (proximity to home and proximity to where most time is spent), while the Home Food Environment is defined by the same variables as the theory: the availability and accessibility of fruits and vegetables at home.

With these validated constructs, we then tested the conceptual framework, which differs from the theoretical model also by the introduction of an additional relationship between Concerns about affording nutritious meals and the Home Food Environment, in order to assess the magnitude of its influence in our sample.

To our knowledge, this is one of the few studies to measure in a quantitative way the relationships between perceptions of Community, Consumer and Home Food Environments, and F&V consumption. It is also the first study to focus on single mothers in a Hungarian context.

The most significant finding was the strong and positive direct effect of the Home Food Environment on F&V consumption (**Hp3**). This finding aligns with several studies that have demonstrated that high availability of F&V at home is associated with higher F&V consumption [59], [60], [61], [62], [63]. Since most food is consumed at home [62], the home food environment is crucial in shaping dietary behaviours [59], [61], [62], [73]. The presence of children and the responsibility of being the sole adult providing healthy food may further explain this finding. Previous studies have shown that mothers play a central role in shaping the healthier dietary practices for their children [19],[20],[21],[25]. For instance, research indicates that single mothers are more likely to cook meals at home and include fruit and vegetables in daily meals [18],[19],[21],[22]. Evidence from Hungary also supports this, showing that families headed by women place a high value on eating regular family meals together, avoiding ready-to-eat foods and cooking locally-produced fruit and vegetables [71], [72].

This behavioural pattern encourages mothers to shop in stores offering a wide selection of high quality fruit and vegetables. This explains the positive perception of the Consumer Nutrition Environment, as well as the positive relationship measured between the Consumer Nutrition Environment and the Home Food Environment (**Hp2**). Similar mechanisms have been reported in other studies where positive perceptions of Consumer Nutrition Environments have been associated with healthier food availability at home

[26],[33],[35],[36] that in turn have a positive effect also on the eating behaviour of mothers (**Hp3.1**).

It is also important to note that the participants in our study reported medium to high daily consumption of fruit and vegetables. Moreover, the theoretical model proposed by Glanz et al. [46] suggests that the relationship between the Home Food Environment and F&V intake is bidirectional: higher F&V availability at home not only promotes consumption, but individuals who habitually consume higher amounts of F&V also tend to ensure greater availability of these foods at home [63], [76].

Notably, single mothers in our sample reported having a relatively high level of education and it may indicate a higher level of nutritional awareness and knowledge, leading them to prioritise a healthy diet despite economic constraints.

Furthermore, participants self-reported their health status as fair to good. A large body of literature has shown that higher educational level and a better perceived health status are both associated with more conscious, health-oriented food choices [23], [24],[35]. These factors may explain why the Community Nutrition Environment did not significantly affect either F&V consumption (**Hp1**) or the Home Food Environment (**Hp2**): participants may already have the motivation and knowledge to maintain healthy dietary practices, regardless of community environmental constraints.

However, as demonstrated by our analyses, concerns about affording nutritious meals had a clear negative influence on F&V consumption (**Hp5**), the Home Food Environment (**Hp6**), and perceptions of the Consumer Nutrition Environment (**Hp4**). This finding is consistent with previous literature showing that when mothers feel overwhelmed by financial constraints related to their food budget, they may perceive external food environments as hostile or unsupportive, even when objective measures suggest otherwise [30],[41],[61],[62],[63].

Interestingly, perceptions of the Community Nutrition Environment were not influenced by affordability concerns (**Hp4**). This may be explained by the descriptive statistics, which show that 59% of participants reported to have access to the store where they do most of their grocery, in under 20 minutes. Since proximity was identified as the main factor influencing store choice, it is likely that participants live in neighbourhoods characterised by a relatively high density of store offering a good quality and selection of fruit and vegetables.

Conclusions

This study contributes to the growing body of research investigating the impact of perceived food environments on dietary behaviours, focusing specifically on Hungarian single mothers. Moreover, this study validates some of the relationships proposed by the Model of the Perceived Nutrition Environment, confirming the interplay between exogenous and endogenous food environments and their influence on eating behaviour.

This study showed that positive perceptions of the Consumer Nutrition Environment are associated with greater availability and accessibility of F&V at home, although they do not directly translate into higher F&V consumption. In contrast, economic concerns had a significant negative impact on F&V consumption, the Home Food Environment, and perceptions of the Consumer Nutrition Environment within our sample.

These findings highlight that, for this particularly vulnerable group of consumers, policies aimed at improving the availability, quality, affordability, and accessibility of healthy foods within external environments must be grounded in a comprehensive understanding of the economic constraints experienced by these families, even when such constraints are primarily perceived rather than objectively measured. Furthermore, effective interventions should go beyond addressing structural barriers to access and incorporate social support interventions capable of alleviating the economic and social pressures that ultimately shape food choices and dietary behaviours.

A natural progression of this work is to integrate and test the additional pathways theorized by the Model of the Perceived Nutrition Environment, including shopping behaviour, background characteristics, and other psychosocial determinants that shape food choices.

Further research is needed to develop models that incorporate additional factors at individual, interpersonal and macro-policy levels. This will provide a comprehensive understanding of the interaction between the subjective components of food environments that describe each consumer, and the objective environments shaped by other actors in the food system.

This will help to identify specific leverage points within food environments that can support the development of effective interventions for different target groups of consumers, based on what is available within each specific context.

Limitations

Our results have certain limitations. First, the study relies on self-reported measures, which are subject to potential biases such as social desirability. Second, while the adapted NEMS-P survey was piloted and refined, further validation across diverse Hungarian populations is necessary to ensure its

reliability and cultural relevance. The relatively modest R^2 values of our model may be partly explained by the fact that the NEMS-P questionnaire, although previously validated in other countries, was applied for the first time in the Hungarian context.

Furthermore, as our study employs a cross-sectional design, it can identify associations but cannot establish causal relationships.

Supplementary Information

Supplementary Information is available for this article and contains additional files (1-3), presented in the main text.

Declarations

Ethics approval

The study was conducted in compliance with the Declaration of Helsinki (revised in 2000). According to Hungarian regulations and GDPR, no separate ethics committee approval was required for this type of voluntary research. The data processing was carried out by ESSRG Nonprofit Kft. in line with the Hungarian data protection law (Act CXII of 2011 on Informational Self-Determination and Freedom of Information) and the organisation's internal data protection policies. The Ethical Committee of the HUN-REN Centre for Economic and Regional Studies in Hungary granted ethical approval *for the study* (Ref. No. 1Főig/20-1/2025).

Consent to participate

All participants gave informed consent before taking part in the study. Specifically, before beginning the survey and other research activities, participants received two documents: 1. Information about the project and data management explaining the aims of the PLAN'EAT project, the voluntary nature of participation, the activities involved, potential risks and benefits, data confidentiality, and the right to withdraw at any time without consequences; 2. Informed consent form, where participants confirmed their agreement to participate.

Consent to publish

All participants provided informed consent to participate in the study and to allow the publication of the results.

Clinical trial number

Not applicable

Availability of data and materials

The datasets analysed during this study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

FV and EM conceived and designed the study. KV, VP, DS, and AE were responsible for data acquisition, including participant engagement, survey refinement and data processing, resulting in the original dataset. FV conducted the statistical analyses, interpreted the findings, and drafted the manuscript with substantial intellectual input. EM and BZ critically revised the manuscript for intellectual content. All authors read and approved the final version of the manuscript.

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