Food insecurity, dietary quality and health in the Netherlands

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CHAPTER 6

Extending the theory of planned behavior for explaining dietary quality: The role of financial scarcity and food insecurity status

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Abstract

Objective: To examine whether an extended Theory of Planned Behavior (TPB) that included finance-related barriers better explained dietary quality.

Design: Cross-sectional survey.

Participants: 1033 participants were included from a Dutch independent adult panel.

Main Outcome: Dietary quality.

Analysis: Five TPB models were assessed: the traditional TPB; a TPB that included also direct associations between attitude and subjective norm with dietary quality; a TPB that additionally included financial scarcity or food insecurity; and a TPB that additionally included financial scarcity and food insecurity simultaneously. Structural relationships among the constructs were tested to compare the explanatory power.

Results: The traditional TPB showed poorest fit, the most extended TPB (including both financial scarcity and food insecurity) showed best fit. All 5 structure models explained ~42-43% of the variance in intention, however, the variance in dietary quality was better explained by the extended TPB models including food insecurity and/ or financial scarcity (~22%) compared to the traditional TBP (~7%), indicating that these models better explained differences in dietary quality.

Conclusions and Implications: These findings highlight the importance of taking into account finance-related barriers for healthy eating like financial scarcity or food insecurity for better understanding individual dietary behaviors in lower socioeconomic position groups.

Introduction

Poor dietary behavior is a major contributor to chronic disease morbidity and mortality worldwide (1) and dietary behavior is generally poorest amongst socioeconomically disadvantaged groups (2). Determinants of unfavorable dietary behavior amongst these groups remain poorly understood, however, and a better understanding is needed to achieve healthier dietary behavior and reduce diet-related disparities.

One of the most commonly used models for understanding health behaviors such as dietary behavior is the Theory of Planned Behavior (TPB) (3). According to the TPB, behavior is influenced by the intention to perform the behavior. This intention is influenced by the positive or negative evaluation of the behavior (i.e., attitude), the perceived social pressure and expectations to perform the behavior (i.e., subjective norm), and the perceived control over the behavior (i.e., perceived behavioral control). Besides the indirect influence of perceived behavioral control through intention, it can also directly influence the behavior. A more favorable attitude, subjective norm, and perceived behavioral control towards the behavior would lead to a stronger intention to perform the behavior. This intention in turn influences the likelihood that the behavior is actually performed (3, 4).

A systematic review conducted by McEachan et al. (2011) confirmed that the TPB is a suitable model for explaining intention and behavior across a range of health behaviors such as physical activity and sexual reproductive behavior (5). Dietary behavior, however, is complex because it is also driven by contextual factors such as perceived psychological stress (6). Indeed, the potential of the TPB to explain dietary behavior seems to be limited (4). This indicates that factors other than attitude, subjective norm, perceived behavioral control and intention may play an important role in motivating dietary behavior. Socioeconomically disadvantaged groups generally have poorer dietary quality (2), and studies that elaborate on this association show that financial resource-related matters influence the intention to eat a healthy diet as well as the actual eating behavior itself (7, 8). For example, financial stress, impaired mental health and perceived high costs of healthy food were mentioned as barriers for healthy eating (7)

Extending the TPB by including these factors may help to better explain dietary behavior and differences therein for people of different socioeconomic positions (SEPs). Differences in dietary quality that are related to SEP may be partially

explained by the generally higher costs of healthier diets and lower healthy food availability in low-SEP neighborhoods (2). Other factors, however, also constitute resource constraints and influence dietary behavior among low-SEP individuals (9). Following the conceptual framework proposed by Laraia et al. (2017), poverty indeed influences healthy food purchasing power, but also influences insecurities (including food insecurity) and biobehavioral mechanisms (including stress, sleep, and cognitive burden). Especially these insecurities trigger hormonal responses (i.e., stress-, appetite-, and hunger-regulating hormones) that shape eating behavior. These factors create a scarcity mindset, which (together with a poverty-induced reduced purchasing power) adversely influences dietary behavior and diet quality (9).

Food insecurity is a complex and multidimensional phenomenon, that reflects a limited or uncertain access to adequate food that meets dietary needs and food preferences for an active and healthy life (10). Food insecurity may for example include (anxiety and worries about) not having enough (healthy) foods, (perceived) social exclusion, and the inability to acquire food in socially acceptable way. Research shows that the impact of food insecurity on (mental) health and stress, may also lead to a tendency to consume unfavorable, highly palatable foods (9, 11). Indeed, both national and international research has shown that food insecurity is associated with poorer dietary quality (12, 13).

Financial scarcity can be defined as the subjective experience of having less financial resources than needed (14). Studies have shown that experienced financial scarcity can have negative psychological consequences. For example, it impedes executive functions (15) and increases depression and anxiety (16, 17). Moreover, having limited resources can lead to a self-reinforcing cycle between causes and consequences of poverty, also known as a "poverty trap" (18). When resources are scarce, (potential) problems loom larger and seize attention, and because of the greater engagement in trying to solve these problems, scarcity leads to neglect of other (potential) problems and longer-term goals including health (19, 20). Hence, experienced financial scarcity, and the uncertainties and stress that are associated with it, may impede cognitive control functions that are needed for healthy food choice. As described by Beenackers et al. (2017), financial strain is associated with unhealthy behavior, partially mediated by lower self-control (21). This helps explain the difficulty of eating healthy when experiencing financial scarcity.

Although perceived food insecurity and financial scarcity are closely related (22), they represent separate constructs. Financial scarcity reflects a perceived shortage of money in general and control over the financial situation, whereas food insecurity reflects a perceived inadequate access to food specifically, thereby also capturing psychosocial stress related to a perceived inadequate access to food. As both constructs are associated with unfavorable eating behavior, extending the TPB by including food insecurity and financial scarcity may be promising for better explaining dietary behavior and differences therein for people of different SEPs. Therefore, in the current study, we aim to assess whether extending the TPB with barriers related to financial scarcity and food insecurity better explains dietary quality.

Methods

Study Population and Data Collection

Data for this cross-sectional study were collected in December 2020 through online questionnaires sent to a Dutch independent panel that operates in line with ISO standards (23). We included adults living across the Netherlands including both rural and urban areas, with oversampling on a relatively low SEP: approximately four-fifth of the sample was selected to have a lower SEP. This was based on three combinations of their income and educational level: 1) below mode income + low educational level; 2) mode income + low educational level; or 3) below mode income + intermediate educational level. Questionnaires were available in the Dutch language. The study was reviewed by the Medical Ethics Committee of Leiden University Medical Center and confirmed not to be subject to the Medical Research Involving Human Subjects Act (WMO) (P17.164).

Variables and Measurements

Dietary intake and dietary quality.

Dietary intake was assessed using an adapted version of the Dutch Healthy Diet Food Frequency Questionnaire (DHD-FFQ) (24). Based on the dietary intake, adherence to the current dietary guidelines (25, 26) was assessed for the following components: vegetables; fruit; legumes; unsalted nuts; fish; grain products; dairy; tea; coffee; oils and fats; sugar containing beverages (SCBs); savory snacks; and sweet snacks. Each component was assigned a score ranging from 0 to 10, with higher scores indicating

better adherence to the dietary guidelines (**Supplemental Table 1**). All component scores were summed, resulting in a total dietary quality score with a theoretical range from 0 to 130 points.

Constructs of the theory of planned behavior.

Psychosocial factors related to dietary behavior were assessed based on the constructs of the TPB (3). Items were selected in a multiple step process. First, we selected general constructs based on the TPB (3). Second, we applied the specific health behavior of interest -dietary behavior- to these general constructs. For the construct subjective norm, we included items reflecting subjective norm regarding healthy eating in general. For the other constructs, we included items regarding healthy eating in general, and specifically regarding fruit and vegetable consumption and snack and fast-food consumption. For each construct, multiple items were included to reflect that particular construct. Specific items per construct are presented in **Supplemental Table 2**.

Attitude towards healthy eating; fruit and vegetable consumption; and snacks and fast-food consumption was assessed based on 24 items. Attitude was assessed using 7-point Likert scales ranging from positive to negative (e.g., I think healthy eating is… good for me (1 point), bad for me (7 points)). These scores were then reversed, so that higher scores indicate a more positive attitude towards the eating behavior in question.

Subjective norm regarding healthy eating was assessed based on 6 items (e.g., my family and/ or friends think it would be good if I eat healthy/ more healthy in the next 3 months) using 7-point Likert scales ranging from strongly disagree (1 point) to strongly agree (7 points), so that higher scores indicate a stronger perceived subjective norm regarding healthy eating.

Perceived behavioral control was assessed based on 8 items (e.g., I feel in control about eating healthy/ more healthy in the next 3 months) using 7-point Likert scales ranging from strongly disagree (1 point) to strongly agree (7 points), so that higher scores indicate a stronger perceived behavioral control.

Intention to eat healthy was assessed based on 5 items (e.g., I intend to eat healthy/ more healthy in the next 3 months) using 7-point Likert scales ranging from strongly disagree (1 point) to strongly agree (7 points), so that higher scores indicate a stronger intention to eat healthy.

Financial scarcity and food insecurity.

Financial scarcity was assessed based on the short version of the Psychological Inventory of Financial Scarcity (PIFS), a validated scale showing good validity and reliability (van Dijk, W., van der Werf, M., van Dillen L. *The Psychological Inventory of Financial Scarcity (PIFS): A Psychometric Evaluation*. 2021). The PIFS assesses experienced financial scarcity, and captures four aspects of this subjective experience: appraisals of insufficient financial resources and lack of control over one's financial situation, in addition to responses concerning financial rumination and worry, and a short-term focus. The scale included 5 statements (e.g., I am constantly wondering whether I have enough money) for which participants could indicate to what extent they agreed with the statements on 7-point Likert scales ranging from strongly disagree (1 point) to strongly agree (7 points), so that higher scores indicate a higher perceived experience of financial scarcity.

Food insecurity status was assessed using the 6-item United States Department of Agriculture Household Food Security Survey Module (USDA-HFSSM). This original survey was previously translated from the English to the Dutch language by Neter et al. (2014), using the translation and back-translation technique (27). Affirmative responses to questions addressing food insecurity-related conditions were summed, resulting in a food insecurity score ranging from 0 to 6. The food insecurity score was dichotomized into 'food secure' (0 affirmative responses: high food security) and 'food insecure' (1-6 affirmative responses: marginal, low and very low food security), according to current international recommendations to count marginal food insecurity as part of food insecurity (28).

Sociodemographic covariates.

Age, sex (male/ female), country of birth, marital status, educational level, employment status, income, smoking status, height, and weight were assessed. Body Mass Index (BMI, kg/m^2) of the participants was calculated from their self-reported weight and height, and classified into normal weight (BMI $<25\,kg/m^2$), overweight (BMI 25–30 kg/m^2) and obese (BMI $\geq 30\,kg/m^2$), using the WHO cut-off points (29). Country of birth was categorized into 'Netherlands' and 'other'. Educational level was categorized into low (upper secondary education or lower), intermediate (post-secondary – short cycle tertiary education), and high (Bachelor or higher education). Income was categorized into minimum income, below mode income, and mode income or higher (mode income refers to the income that is most commonly earned

in the Netherlands). Smoking status was dichotomized into current smoker (yes/ no). Employment status was dichotomized into currently employed (yes/ no). Further, we included the livability index (30) as a measure of the livability of the neighborhood ranging from poor (1) to outstanding (9). This index is based on 50 indicators which can be further divided into the following underlying six dimensions: housing stock; public space; level of facilities; (social/ economic) population composition; life structure and social cohesion of the population; inconvenience and safety (30). The livability index was linked to the dataset based on 4-digit postal code of the participants.

Statistical Analyses

Population characteristics for the total study population and split by food insecurity status and financial scarcity status were presented using descriptive statistics. Linear regression analyses were conducted to assess associations between food insecurity, financial scarcity, attitude, subjective norm, perceived behavioral control, intention, and dietary quality, both crude and adjusted for age, sex, income, educational level, employment status, marital status, country of birth, and livability index.

Exploratory factor analysis (EFA) was conducted to obtain the variable sets that best explained the underlying constructs (i.e., attitude, subjective norm, perceived behavioral control, intention, and financial scarcity). Items with component loadings above 0.3 were retained. For the EFA we used one-half of the dataset (n=517), for the CFA (described hereafter) we used the other half of the dataset (n=516). As described by Boateng et al. (2018), a sample size of over 500 is sufficient for factor analysis. They describe a sample size of 500 as very good for factor analyses, and suggest that, as a rule of thumb, the ideal ratio of respondents to items is 10:1 as, which is achieved in our study (31).

Five TPB models were assessed: the traditional TPB and 4 extended TPB models; a TPB that included also direct associations between attitude and dietary quality, and between subjective norm and dietary quality; a TPB that additionally included financial scarcity or food insecurity; and a TPB that additionally included financial scarcity and food insecurity simultaneously (**Supplemental Figure 1**). To compare the explanatory power of these models, structural relationships among the constructs were tested using structural models.

As recommended by Anderson and Gerbing, a two-step procedure with the maximum likelihood estimation method was applied (32). In the first step, Confirmatory

Factor Analysis (CFA) was conducted to assess the goodness-of-fit of the model, and the reliability and validity of the constructs (i.e., attitude, subjective norm, perceived behavioral control, intention, and financial scarcity). In the second step, the hypothesized structural relationships (i.e., paths) among the latent constructs were tested using structural equation models. All models were adjusted for age, sex, income, educational level, employment status, marital status, country of birth, and livability index. Model fit was assessed using absolute, parsimonious, and incremental indices: we assessed the Chi^2 to df ratio (Chi^2/ df), Comparative Fit Index (CFI), the root mean square error of approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR) (33). Model fit was deemed acceptable if Chi^2/ df $\leq$ 5; CFI $\geq$ 0.90; RMSE $\leq$ 0.10; and SRMR $\leq$ 0.080. Further, explained variance was assessed for intention, dietary quality, and the overall model.

CFA and path analyses were conducted using Stata version 16.1 (StataCorp,2015. Stata Statistical Software. College Station, TX:StataCorp LP). All other statistical analyses were performed using IBM SPSS statistics version 25.0 (IBM Corp., 2012, Armonk, NY). A two-sided p-value of 0.05 was considered statistically significant.

Results

Factor Analyses for Model Constructs

The variable sets that best explained the underlying constructs (i.e., attitude, subjective norm, perceived behavioral control, intention, and financial scarcity) following the EFA were retained, resulting in 14 items for attitude towards healthy eating and fruit and vegetables (2 items removed), 7 items for attitude towards snacks and fast-food (1 item removed), 4 items for subjective norm regarding healthy eating (2 items removed), 8 items for perceived behavioral control over healthy eating (no items removed), 5 items for intention to eat healthy (no items removed), and 5 items for financial scarcity (no items removed). Remaining items had a high internal consistency/ reliability, indicated by Cronbach's alpha ranging from 0.83 to 0.94 (**Supplemental Table 2**).

A Confirmatory Factor Analysis (CFA) was applied for the remaining items (i.e., the items that were not excluded following the EFA) within the constructs, showing moderate model fit (Chi^2/df = 3.74; CFI = 0.80, RMSEA (95%CI) = 0.094 (0.091; 0.098); SRMR = 0.086) and an explained variance of 99% for the overall model (**Supplemental Table 3**). In the analyses, we used the average scores of the remaining items for each construct.

Participant Characteristics

A total of n=1033 participants with oversampling on a relatively low SEP were included in the current study. Participants had a mean age of 55.5 (± 16.4), an approximately equal percentage of men and women were included, and the vast majority of participants was born in the Netherlands (96.7%) (**Table 1**). Most participants had an income below the mode Dutch income or lower (66.8%). Mean livability index was 6.7 (± 1.26) out of 9. Approximately one-quarter of participants were obese and mean dietary quality score was 70.3 (± 15.3) out of 130 (**Table 1**).

Participants generally did not perceive a strong subjective norm regarding healthy eating (4.3 ± 1.2). Participants overall showed a positive attitude towards healthy eating and fruit and vegetable consumption (4.8 ± 0.9) and a negative attitude towards snacks and fast-food consumption (2.9 ± 1.1). Participants generally felt confident about their ability to eat healthy, as reflected by a mean perceived behavioral control of 5.0 ± 1.0. Participants generally intended to eat healthy (4.7 ± 1.1) (**Table 1**).

Compared to participants not experiencing financial barriers, people experiencing food insecurity or financial scarcity generally reported a stronger perceived subjective norm regarding healthy eating, a less positive attitude towards healthy eating and fruit and vegetable consumption, and particularly food insecure participants reported a lower perceived behavioral control (**Supplemental Table 4**).

Table 1. Population characteristics for the total population (n=1033)

Characteristics	
Age (mean ± SD)	55.5 ±16.4
Age range (minimum-maximum)	18 - 88
Sex (n (%) male)	542 (52.5)
Country of birth (n (%) Netherlands)	999 (96.7%)
Marital status (n (%))	
Cohabiting with children	202 (19.6)
Cohabiting without children	408 (39.5)
Single with children	101 (9.8)
Single without children	285 (27.6)
Other	37 (3.6)
Educational level (n (%))	
Low (upper secondary education or lower)	469 (45.4)
Intermediate (post-secondary – short cycle tertiary education)	506 (49.0)
High (Bachelor or higher education)	58 (5.6)
Paid employment (n (%) yes)	429 (41.5)
Income (n (%))[1]	
Minimum	130 (12.6)
Below mode income	560 (54.2)
Mode income or higher	251 (24.3)
Don't know/ don't want to answer	91 (8.9)
Livability index (range1 (poor) to 9 (outstanding) (mean ± SD))[2]	6.7 ±1.26
Score 6 or lower	437 (42.4)
Score 7 or higher	594 (57.6)
Lifestyle factors	
Current smoker (n (%) yes)	183 (17.7)
BMI (mean ±SD)[3]	26.8 ±5.0
Weight status (n (%))	
Normal weight	404 (39.1)
Overweight	370 (35.8)
Obesity	259 (25.1)
Dietary quality (range 0-130) (mean ± SD)	70.3 ±15.3
TPB constructs (7-point Likert scales (mean ± SD))	
Subjective norm	4.3 ±1.2
Attitude healthy eating and fruit and vegetables	4.8 ±0.9
Attitude snacks and fast-food	2.9 ±1.1
Perceived behavioral control	5.0 ±1.0
Intention	4.7 ±1.1
Finance-related barriers	
Food insecurity score (range 0-6 (mean ±SD))	0.4 ±1.2
Financial scarcity (7-point Likert scale (mean ± SD))	2.6 ±1.5

TPB: Theory of Planned Behavior
[1] Income categories refer to the following amounts of annual gross income: Minimum <14.100 euro; Below mode income 14.100-36.500 euro; Mode income or higher >36.500 euro.
[2] Livability index: n=1031
[3] BMI (Body Mass Index): n=984

Associations Between Food Insecurity, Financial Scarcity, Attitude, Subjective Norm, Perceived Behavioral Control, Intention, And Dietary Quality

A higher food insecurity score (i.e., stronger experienced food insecurity) and a stronger experienced financial scarcity were associated with a lower dietary quality score (β = -1.51, 95%CI= -2,30; -0.73, p <0.001 and β = -1.60, 95%CI= -2,57; -0.94, p <0.001, respectively) after adjustment for sociodemographic variables (**Table 2**). Further, a more positive attitude towards healthy eating and fruit and vegetable consumption, a more negative attitude towards snacks and fast-food consumption; higher perceived behavioral control; and higher intention to eat healthy were associated with a higher dietary quality. No significant association was found between subjective norm and dietary quality. A more positive attitude towards healthy eating and fruit and vegetable consumption; a more negative attitude towards snacks and fast-food consumption; a higher perceived subjective norm; and a higher perceived behavioral control were associated with a higher intention to eat healthy. Experiencing financial scarcity or food insecurity were not significantly associated with intention. People experiencing food insecurity or financial scarcity had a less positive attitude towards healthy eating and fruit and vegetable consumption, perceived a stronger subjective norm for healthy eating, and perceived lower behavioral control (**Table 2**).

Table 2. Associations between food insecurity, financial scarcity, attitude, subjective norm, perceived behavioral control, intention, and dietary quality

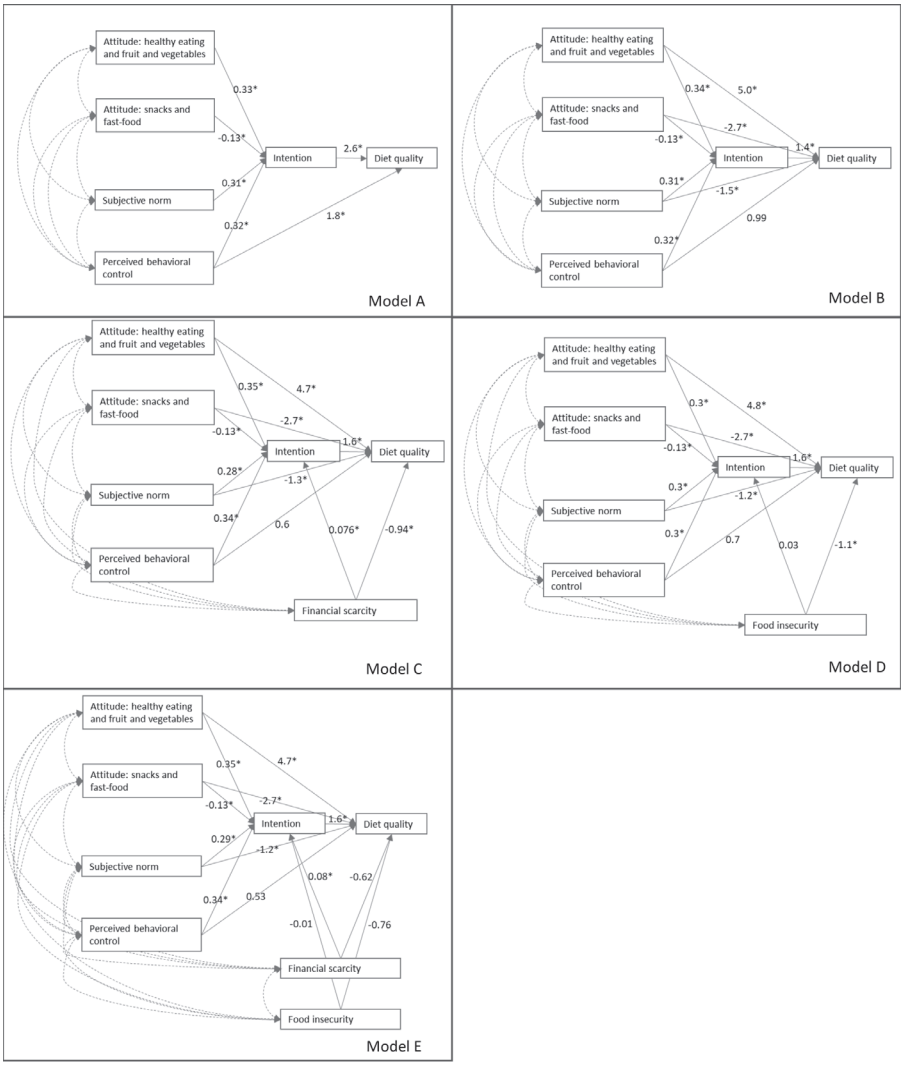
	Crude			Adjusted[2]		
	β	95%CI	p-value	β	95%CI	p-value
Outcome: dietary quality						
Food insecurity score	-1.94	-2.71; -1.18	0.000	-1.51	-2.30; -0.73	0.000
Financial scarcity	-1.81	-2.45; -1.18	0.000	-1.60	-2.27; -0.94	0.000
Subjective norm	-0.65	-1.44; 0.15	0.110	-0.069	-0.89; 0.76	0.870
Attitude healthy eating and fruit and vegetables[1]	6.56	5.58; 7.55	0.000	6.36	5.37; 7.35	0.000
Attitude snacks and fast-food[1]	-3.90	-4.72; -3.08	0.000	-3.05	-3.95; -2.15	0.000
Perceived behavioral control	3.25	2.35; 4.14	0.000	3.34	2.44; 4.24	0.000
Intention	3.24	2.41; 4.06	0.000	3.41	2.57; 4.24	0.000
Outcome: intention						
Food insecurity score	0.006	-0.050; 0.062	0.837	-0.015	-0.07; 0.04	0.610
Financial scarcity	0.001	-0.045; 0.047	0.957	-0.01	-0.06; 0.04	0.794
Subjective norm	0.37	0.31; 0.42	0.000	0.39	0.33; 0.45	0.000

Attitude healthy eating and fruit and vegetables[1]	0.54	0.47; 0.61	0.000	0.55	0.48; 0.62	0.000
Attitude snacks and fast-food[1]	-0.17	-0.23; -0.11	0.000	-0.21	-0.27; -0.14	0.000
Perceived behavioral control	0.50	0.44; 0.56	0.000	0.52	0.46; 0.58	0.000
	Outcome: attitude healthy eating and fruit and vegetables[1]					
Food insecurity score	-0.10	-0.14; -0.06	0.000	-0.10	-0.14; -0.05	0.000
Financial scarcity	-0.13	-0.16; -0.09	0.000	-0.12	-0.16; -0.08	0.000
	Outcome: attitude snacks and fast-food[1]					
Food insecurity score	0.013	-0.04; 0.07	0.648	-0.01	-0.07; 0.05	0.725
Financial scarcity	0.029	-0.02; 0.08	0.207	0.03	-0.02; 0.08	0.190
	Outcome: subjective norm					
Food insecurity score	0.18	0.12; 0.24	0.000	0.14	0.08; 0.20	0.000
Financial scarcity	0.13	0.08;0.18	0.000	0.10	0.05; 0.15	0.000
	Outcome: perceived behavioral control					
Food insecurity score	-0.14	-0.20; -0.09	0.000	-0.15	-0.21; -0.10	0.000
Financial scarcity	-0.16	-0.20; -0.12	0.000	-0.17	-0.22; -0.13	0.000

[1] Attitude scores were reversed (i.e., higher scores reflect a more positive attitude)
[2]Adjusted: adjusted for age, sex, income, educational level, employment status, marital status, country of birth, and livability index

The TPB And Extended TPB

Path analyses for the models explaining dietary quality showed that all associations between the constructs constituting the traditional TPB (Model A) were statistically significant ($p < 0.05$) and in the expected directions: a more positive attitude towards healthy eating and fruit and vegetable consumption; a more negative attitude towards snacks and fast-food consumption; a stronger perceived subjective norm; and a stronger perceived behavioral control were positively associated with a higher intention to eat healthy, and intention was positively associated with dietary quality (β=2.6, 95%CI = 1.62; 3.56, $p < 0.001$) (**Figure 1**). In the extended TPB, where financial scarcity and food insecurity score were added to the model (Model E), similar effect estimates were observed for most associations. Notably, a higher experienced financial scarcity was associated with a slightly higher intention (β = 0.08, 95%CI = 0.036; 0.12, $p <0.001$) and not statistically significantly associated with lower dietary quality (p = 0.086). A higher food insecurity score (i.e., stronger experienced food insecurity) was not significantly associated with intention nor with a lower dietary quality (p = 0.069) (**Figure 1**).



*p<0.05

Figure 1. Path analyses for the models explaining dietary quality. Double (dashed) arrows indicate correlations, single arrows indicate beta coefficients.

Model A: traditional TPB; Model B: Model A that included also direct associations between attitude and dietary quality, and between subjective norm and dietary quality; Model C: Model B that additionally included financial scarcity; Model D: Model B that additionally included food insecurity; Model E: Model B that additionally included financial scarcity and food insecurity

All models were adjusted for age, sex, income, educational level, employment status, marital status, country of birth, and livability index

Fit indices of the 5 models explaining dietary quality (outlined in **Supplemental Figure 1 and Figure 1**) showed poorest fit for the traditional TPB (Model A: Chi^2/ df = 11; CFI = 0.75; RMSEA (95%CI) = 0.10 (0.091; 0.12); SRMR = 0.049), and best fit for the most extended TPB including financial scarcity and food insecurity (Model E: Chi^2/ df= 3.3; CFI = 0.95; RMSEA (95%CI) = 0.050 (0.035; 0.065); SRMR = 0.018) (**Table 3**). All 5 structure models explained approximately 42-43% of the variance in intention, however, the variance in dietary quality was better explained by the extended TPB models including food insecurity and/ or financial scarcity (Model C, D and E: 21.6 - 21.9%) compared to the traditional TBP (Model A: 7.3%) (**Table 3**). The explained variance of the overall model (i.e., how much of the variance in included variables is explained by the total model) improved from 42.5% to 52.3% between model A and E (**Table 3**).

Table 3. Fit indices of models used to explain diet quality based on the theory of planned behavior (TPB).

	Model A*	Model B*	Model C*	Model D*	Model E*	Norm values
Fit index						
Chi^2 / df	11.09	3.84	3.42	3.49	3.31	≤ 5
CFI	0.749	0.941	0.950	0.948	0.953	≥0.90
RMSEA (95%CI)	0.104 (0.091; 0.117)	0.055 (0.041; 0.070)	0.051 (0.036; 0.066)	0.051 (0.037; 0.067)	0.050 (0.035; 0.065)	≤ 0.10
	P close=0.000	p close = 0.262	p close 0.437	P close=0.407	p close=0.490	
SRMR	0.049	0.022	0.019	0.019	0.018	≤ 0.080
Explained variance						
R^2 intention	0.418	0.418	0.427	0.419	0.427	
R^2 dietary quality	0.073	0.209	0.216	0.216	0.219	
R^2 overall model	0.425	0.510	0.522	0.515	0.523	

*Model A: traditional TPB;
*Model B: Model A that included also direct associations between attitude and dietary quality, and between subjective norm and dietary quality;
*Model C: Model B that additionally included financial scarcity;
*Model D: Model B that additionally included food insecurity;
*Model E: Model B that additionally included financial scarcity and food insecurity
All models were adjusted for age, sex, income, educational level, employment status, marital status, country of birth, and livability index

Discussion

Results of our study showed that dietary quality was better explained by the extended TPB including financial scarcity and/ or food insecurity compared to the traditional TPB: explained variance in dietary quality was approximately 7 percent for the traditional TPB, whereas the extended TPB showed an explained variance in dietary quality of 22 percent. The extended TBP thus accounts for more variance in dietary quality, indicating that this model better explains differences in dietary quality. However, based on our findings, including both food insecurity and financial scarcity simultaneously is not necessary for explaining differences in dietary quality. These findings highlight the importance of taking into account finance-related barriers for healthy eating like financial scarcity or food insecurity to better understand individual dietary behaviors in lower SEP populations.

Our results showed that the traditional TPB had a limited ability to explain dietary quality, a finding that has been confirmed by others as well (4). For example, previous research among Australian pregnant women, and a study among a sample of the general population in the UK, both showed that the TPB framework is well able to explain intention to eat healthy, but explains little variance in actual eating behavior (34, 35). Consistent with these findings, our results showed that the traditional TPB had a reasonable ability to explain intention to eat healthy, whereas the traditional TPB poorly explained dietary quality.

These observations may be explained by the underlying assumption of the TPB that dietary behavior is under an individual's volitional control, implying that dietary decisions are made willingly and rationally. This is partially accounted for by including perceived behavioral control over healthy eating in the TPB (36). However, clearly, dietary behavior is influenced by contextual factors and availability of resources, and the assumption of having volitional control over dietary behaviors does not hold for individuals experiencing finance-related barriers for healthy eating as reflected by food insecurity and financial scarcity. Additionally, previous studies show that factors such as attitude and subjective norm can also directly influence eating behavior (e.g. (37)). We therefore also explored including direct associations between attitude and subjective norm with dietary quality, and results of our path analyses showed that these direct associations were indeed significant and that including these direct associations improved the explained variance in dietary quality. Extending the traditional TPB by additionally including financial scarcity and/ or food insecurity,

further improved explained variance in dietary quality. The observed improvement in explained variance in dietary quality from 7 to 22 percent is considerable when taking into account the complex nature of dietary behavior (4).

Our regression analyses showed an association between experiencing food insecurity and poorer dietary quality, which is in line with previous studies (12). Our results indicate that food insecurity is directly associated with dietary quality, but not with intention to eat healthy, which is in line with a previous study reporting no differences in intention to eat healthy between food secure and food insecure individuals (38). This suggests that the generally poorer dietary quality among people experiencing food insecurity is not the result of a lack of intention to eat healthy, but may rather be induced by stress, psychosocial barriers, or financial barriers (9, 11).

Comparable to our findings on food insecurity, our regression analyses showed that experiencing financial scarcity was not significantly associated with intention. In contrast, our path analyses including all TPB constructs and food insecurity did indicate that experiencing financial scarcity was associated with a slightly higher intention to eat healthy. Based on literature, one would expect that (financial) scarcity has a negative impact on the ability to focus on longer-term goals, and thus would lead to a lower intention to eat healthy (19). Therefore, one the one hand, our path analyses results should be interpreted with caution as this association is not confirmed by theory nor by the results of the individual association. On the other hand, this contrasting finding may also be explained by the inclusion of the TPB constructs in the model. The model showed significant negative covariances for financial scarcity with attitude towards healthy eating and fruit and vegetable consumption and perceived behavioral control, and a positive covariance with subjective norm (data not shown). It may be speculated that other constructs related to subjective norms influence the positive association between financial scarcity and intention to eat healthy. For example, people living in poverty may have a higher intention to eat healthy to comply to social norms because of fear for social exclusion. Indeed, previous studies have shown that besides social norms, social exclusion is also an important determinant that needs to be taken into account when addressing health behavior (39).

In line with previous literature (12, 21), our findings indicate that experiencing financial scarcity or food insecurity is associated with a lower dietary quality in the regression analyses and path analyses, although in the path analyses of the most

extended TPB model including both financial scarcity and food insecurity we did not observe a significant association between these variables and dietary quality. A possible explanation for this finding is that food insecurity and financial scarcity are closely related, thereby each explaining part of the association of the other variable with dietary quality.

Although our results showed that the extended TPB improved the explained variance in dietary quality considerably, it should be noted that other factors that were not included in the current study expectedly also play an important role, as still a large part of the variance in dietary quality was not well explained by the extended TPB model in the current study. Nevertheless, the presented findings further our understanding on dietary behaviors and food choices, and underline the importance of taking finance-related barriers like financial scarcity and food insecurity into account when aiming to better understand dietary behavior or to improve dietary quality among lower-SEP populations.

The findings of the current study should be interpreted in light of its limitations. Firstly, all data were self-reported, which may have led to misclassification or biases such as recall bias and social-desirability bias (40). To validate our findings, more objective measures would be valuable, especially for the dietary intake assessment. Further, questionnaires were offered in the Dutch language only and no help could be provided as questionnaires were completed online and anonymously, thereby excluding non-Dutch speaking and illiterate people. This may explain the disproportionately high number of participants born in the Netherlands. This may have led to an underestimation of food insecurity prevalence in our study, as previous literature indicates that food insecurity prevalence is generally higher among ethnic minority groups (41). Also, the high number of participants born in the Netherlands, together with oversampling on lower SEP individuals, limits the generalizability of our results. It should further be noted that not all model fit statistics were above the norm values. Specifically, for the model that included the items within the constructs that remained after the EFA, we found a CFI of 0.8, whereas a norm of 0.9 or higher is considered in methodological literature (42). However, we found high internal consistency/ reliability for the constructs. Furthermore, our extended TPB models, which were the main focus of our study, all had CFI values above the norm values. Our study is further limited by its cross-sectional design, not suitable for drawing conclusions about causality. Also, no temporal order of the paths between the

TPB constructs could be confirmed in our study. We have partly overcome this by including the food insecurity status of before the COVID-19 pandemic, reflecting the food insecurity status preceding the dietary behavior. However, a longitudinal study design assessing dietary intake at al later timepoint than the other TPB constructs would have been preferred and would improve the ability to establish causal pathways leading to dietary quality.

Strengths of the current study include the relatively large sample size, and our inclusion of participants living across the Netherlands, including both rural and urban districts. Further, TPB constructs were assessed based on a large number of items and the retained items showed good validity and reliability. Further, financial scarcity and food insecurity were assessed based on validated scales.

In conclusion, our results indicate that variance in dietary quality is better explained by an extended TPB including financial scarcity and/ or food insecurity compared to the traditional TPB. These results highlight the importance of taking into account finance-related barriers for healthy eating like financial scarcity and food insecurity for better understanding individual dietary behaviors, and further our understanding on dietary quality and food choices especially in the context of lower SEPs. These findings may contribute to achieving healthier dietary behavior and reduce diet-related disparities.

Implications for research and practice

Dietary behavior is complex, and therefore the potential of the TPB to explain dietary behavior seems to be limited. Our results showed that including financial barriers such as financial scarcity or food insecurity in the extended TPB improved the explained variance in dietary quality considerably, however, our findings suggest that other factors that were not included in the current study expectedly also play an important role, as still a large part of the variance in dietary quality was not well explained by the extended TPB model in the current study. Therefore, future studies may consider including other potential important factors for explaining dietary quality in lower-SEP populations, or consider a mixed methods approach to better understand important factors determining dietary behavior from an individual perspective. All in all, the present findings underline the importance of taking into account finance-related barriers like financial scarcity or food insecurity when aiming to better understand dietary behavior or to improve dietary quality among lower-SEP populations.

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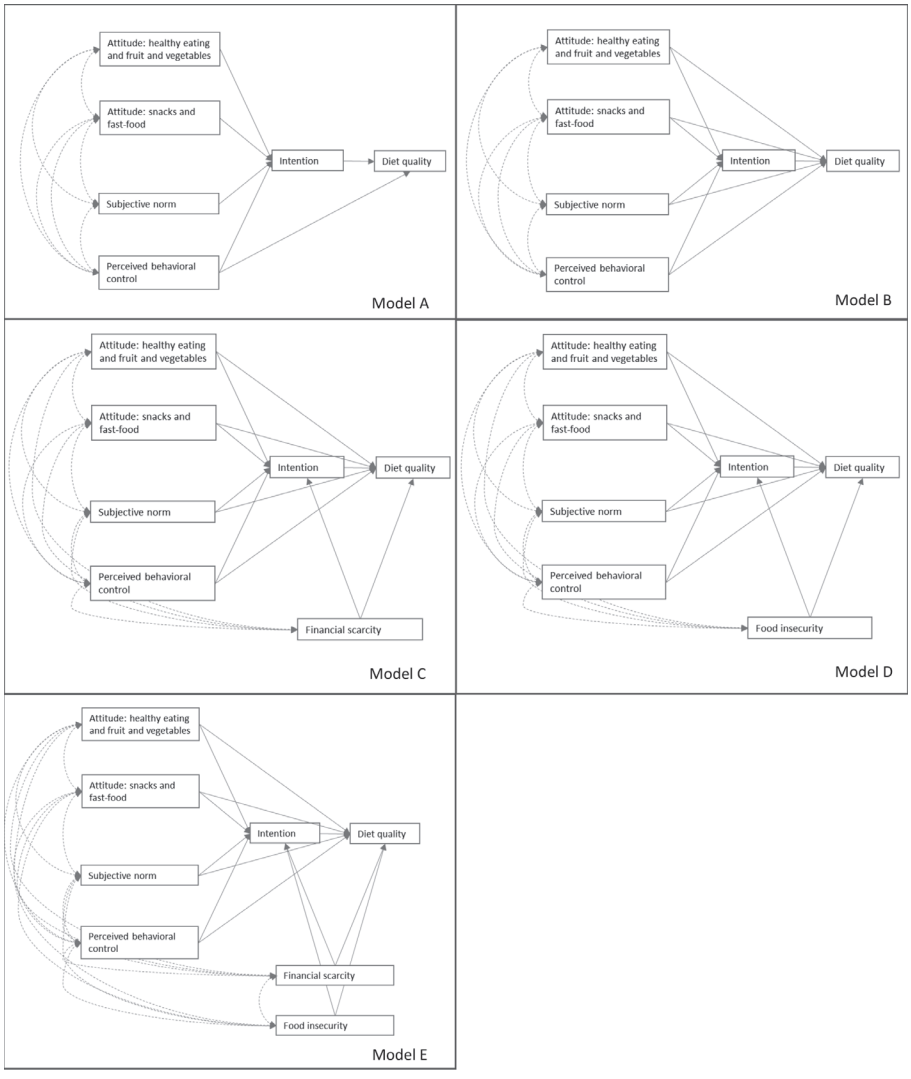
Additional material Chapter 6

Supplemental table 1 Dietary components with associated current national dietary recommendations, contribution percentages and scoring per component

Dietary component	Dietary recommendations by the Dutch Health Council and/or the Netherlands Nutrition Centre	% contribution to the dietary component score	Units	Dietary component score		
				Minimum score		*Maximum score*
				(=0 points)	*5 points*	*(=10 points)*
Vegetables	Consume at least 200 grams of vegetables daily	100	g/d	0	*Continuous*	≥200
Fruit	Consume at least 200 grams of fruit daily	100	p/d	0	*Continuous*	≥ 2
Legumes	Consume one serving legumes a week	100	g/w	0	*Continuous*	≥ 135[1]
Unsalted nuts	Consume at least 15 grams of unsalted nuts daily	100	g/d	0	*Continuous*	≥ 15
Fish	Consume one serving of fish weekly, preferably fatty fish	50	s/w	0	<1	≥ 1
		50	-	No fish consumed	Lean or both lean and fatty fish	Mostly fatty fish
Grain products	Consume at least 90 grams of whole grain products daily	50	g/d	0	*Continuous*	≥ 90
		50	-	Mostly refined	Both refined and whole grain	Mostly whole grain
	Replace refined grain products by whole grain products					
Dairy	Consume 2-3 servings of dairy daily	50	s/d	0	*Continuous*	≥ 2
			-	Full fat dairy products	Both whole dairy products and (semi)-skimmed dairy products	(Semi)-skimmed dairy products
		50				
Tea	Consume 3-4 cups of green/black tea a day	100	s/d	<1 **AND** mostly green/black tea <3 **AND** both herbal tea and green/black tea	1 to 2 **AND** mostly green/black tea ≥ 3 **AND** both herbal tea and green/black tea	≥ 3 **AND** mostly green/ black tea

			-	Not consumed		
				Mostly herbal tea		
Coffee	Replace unfiltered coffee by filtered coffee	100	-	Boiled coffee, cafetière coffee, Greek coffee, Turkish coffee	Vending-machine coffee[2], coffee from cups and espresso	Not consumed or filter coffee, coffee from pads and instant coffee
Oils and fats	Replace butter, hard margarines and cooking fats by soft margarines, liquid cooking fats, and vegetable oils	50		Butter, hard margarines		Oils and soft margarines
		50	-	Butter on bread or bread is not buttered at all	Semi-skimmed butter or hard margarine on bread	Diet margarine on bread
SCBs	Minimize consumption of sugar-containing beverages.	100	s/d	≥ 1	<1	0
Savory snacks	For products outside the Wheel of Five: consume an item from the daily selection no more than three to five times per day, and something from the weekly selection no more than three times a week	50	lrg s/w	≥ 3	<1 to 2	0
		50	sml s/d	> 3	*Continuous*	0
Sweet snacks	For products outside the Wheel of Five: consume an item from the daily selection no more than three to five times per day, and something from the weekly selection no more than three times a week	100	s/w	≥ 3	<1 to 2	0

Abbreviations: SCB, sugar-containing beverages; g/d, grams per day; p/d, pieces per day; s/w, servings per week; s/d, servings per day; lrg s/w, large servings per week; sml s/d, small servings per day.
[1]The Netherlands Nutrition Centre indicates that one serving of legumes corresponds to 135 grams of legumes
[2]Vending-machine coffee can be either filtered coffee or unfiltered coffee. Since the filter used by the vending- machine is not known, the cafestol level is assumed to be moderate



Supplemental Figure 1: Conceptual models used to explain diet quality based on the theory of planned behavior (TPB).
Model A: traditional TPB;
Model B: Model A that included also direct associations between attitude and dietary quality, and between subjective norm and dietary quality;
Model C: Model B that additionally included financial scarcity;
Model D: Model B that additionally included food insecurity;
Model E: Model B that additionally included financial scarcity and food insecurity

Supplemental Table 2. Internal consistency/reliability and factor loadings of model constructs (n=517)

	Factor loadings					
	1	**2**	**3**	**4**	**5**	**6**
Subjective norm (Cronbach's alpha=0.913)						
Most people who are important to me think it would be good if I eat healthy/ more healthy in the next 3 months.				0.900		
My child thinks / children think it would be good if I eat healthy/ more healthy in the next 3 months (if applicable).				0.861		
My family and / or friends think it would be good if I eat healthy/ more healthy in the next 3 months.				0.917		
It is expected of me to eat healthy/ more healthy in the next 3 months.				0.620		
Most people who are important to me eat healthy themselves						
Most people who are important to me, think healthy eating is important						
Perceived behavioral control (Cronbach's alpha= 0.909)						
I am convinced that I can eat healthy/ more healthy in the next 3 months if I want to.		0.635				
I feel in control about eating healthy/ more healthy in the next 3 months.		0.726				
I am convinced that I can eat healthy/ more healthy in the next 3 months, even if I have little money		0.693				
I am convinced that I can eat a lot of fruit and vegetables in the next 3 months, even if I have little money		0.695				
I am convinced that I can eat few snacks and/ or fast-food in the next 3 months, even if I have little money		0.731				
I am convinced that I can eat healthy/ more healthy in the next 3 months, even if I have little time		0.817				
I am convinced that I can eat a lot of fruit and vegetables in the next 3 months, even if I have little time		0.846				
I am convinced that I can eat few snacks and/ or fast-food in the next 3 months, even if I have little time		0.801				
Attitude healthy eating and fruit and vegetables (Cronbach's alpha= 0.944)						
I think eating healthy/ more healthy is: good for me – bad for me	0.697					
I think eating healthy/ more healthy is: easy – difficult	0.612					
I think eating healthy/ more healthy is: tasty – not tasty	0.682					
I think eating healthy/ more healthy is: important – not important	0.709					
I think eating healthy/ more healthy is: cheap-expensive						
I think eating healthy/ more healthy is: nice – stupid	0.634					
I think eating healthy/ more healthy is: possible - impossible	0.666	-0.386				
I think eating healthy/ more healthy is: positive - negative	0.694	-0.308				
I think eating fruits and vegetables is: good for me – bad for me	0.753					

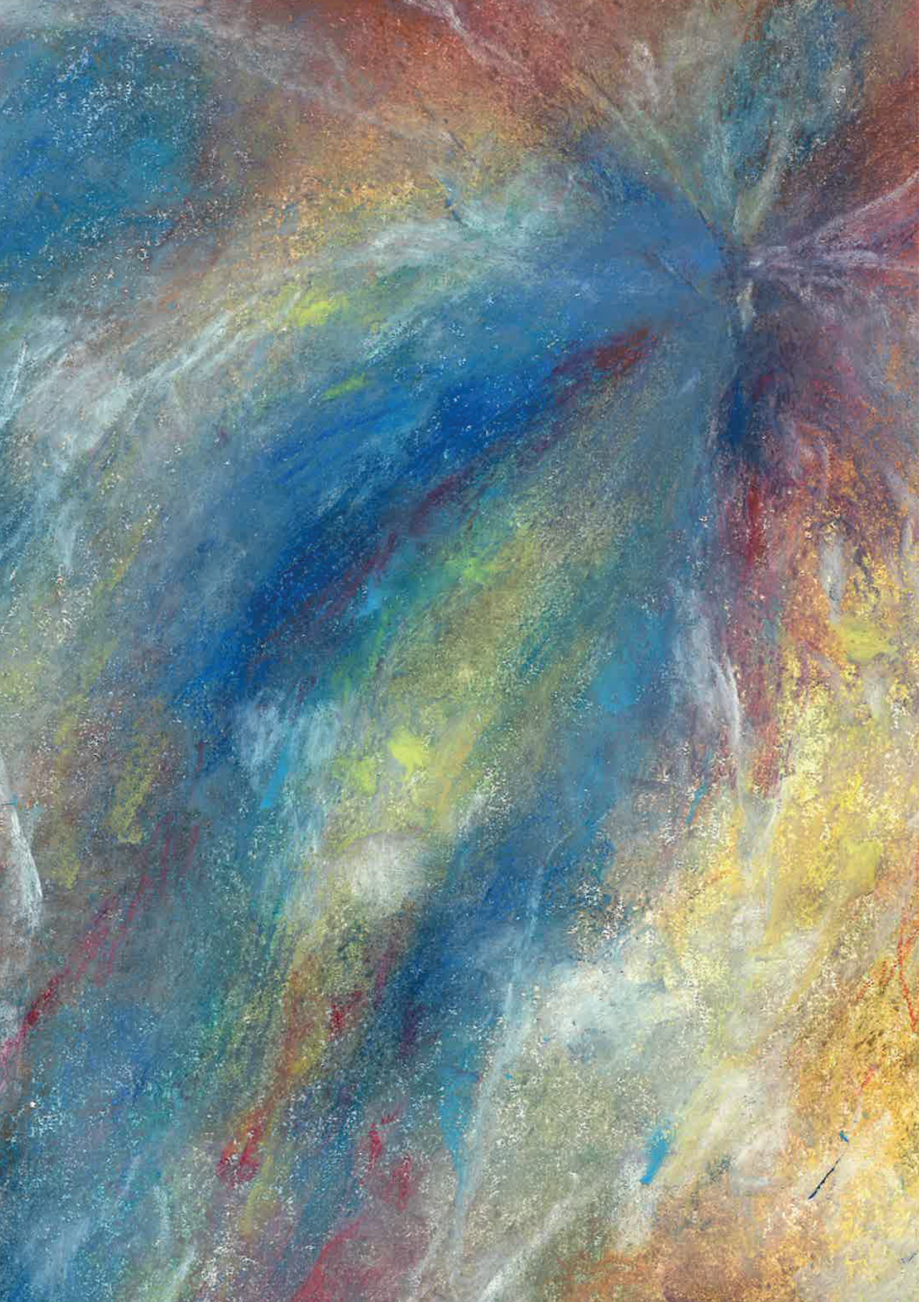
I think eating fruits and vegetables is: easy - difficult	0.726				
I think eating fruits and vegetables is: tasty – not tasty	0.806				
I think eating fruits and vegetables is: important – not important	0.837				
I think eating fruits and vegetables is: cheap – expensive					
I think eating fruits and vegetables is: nice – stupid	0.745				
I think eating fruits and vegetables is: possible - impossible	0.781				
I think eating fruits and vegetables is: positive - negative	0.831				
Attitude snacks and fast-food (Cronbach's alpha= 0.832)					
I think eating snacks and fast-food is: good for me – bad for me				0.413	
I think eating snacks and fast-food is: easy - difficult				0.662	
I think eating snacks and fast-food is: tasty – not tasty				0.862	
I think eating snacks and fast-food is: important – not important				0.475	
I think eating snacks and fast-food is: cheap- expensive					
I think eating snacks and fast-food is: nice – stupid				0.745	
I think eating snacks and fast-food is: possible - impossible				0.656	
I think eating snacks and fast-food is: positive - negative				0.586	
Intention (Cronbach's alpha= 0.900)					
I intend to eat healthy/ more healthy in the next 3 months		0.396			0.745
I intend to eat a lot of fruits and vegetables in the next 3 months	-0.307	0.429			0.627
I intend to eat few snacks and/ or fast-food in the next 3 months	-0.302	0.325		0.305	0.523
I really want to eat healthy/ more healthy in the next 3 months		0.315	0.324		0.757
I expect to eat healthy/ more healthy in the next 3 months		0.398			0.783
Financial scarcity (Cronbach's alpha= 0.944)					
I often don't have enough money.			0.899		
I am constantly wondering whether I have enough money.			0.896		
I worry about money a lot.			0.914		
I am only focusing on what I have to pay at this moment			0.862		
rather than my future expenses.					
I experience little control over my financial situation.			0.859		

Supplemental Table 3. Fit indices of the constructs subjective norm, attitude towards healthy eating and fruit and vegetables, attitude towards snacks and fast-food, perceived behavioral control, intention, and financial scarcity (n=516)

Fit index		**Norm**
Chi2 / df	3.74	≤ 5
TLI	0.790	≥0.90
CFI	0.803	≥0.90
RMSEA	0.094 (0.091; 0.098)	≤ 0.10
SRMR	0.086	≤ 0.080
Explained variance		
R^2 overall model	0.99	

Supplemental Table 4. Population characteristics for the total population and split by current food insecurity status and financial scarcity status

	Total population (n=1033)	**Food secure (n=890)**	**Food insecure (n=143)**	**No financial scarcity (Strongly disagree-neutral) (n=864)**	**Financial scarcity (somewhat agree- strongly agree) (n=169)**
Age (mean ± SD)	55.5 ±16.4	56.8 ±16.2	47.2 ±14.9	56.7 ±16.2	49.3 ±15.7
Age range (minimum-maximum)	18 - 88	18 - 88	20 - 82	18 - 88	20 - 85
Sex (n (%) male)	542 (52.5)	499 (56.1)	43 (30.1)	478 (55.3)	64 (37.9)
Country of birth (n (%) Netherlands)	999 (96.7%)	869 (97.6)	130 (90.9)	842 (97.5)	157 (92.9)
Marital status (n (%))					
Cohabiting with children	202 (19.6)	174 (19.4)	28 (19.6)	167 (19.3)	35 (20.7)
Cohabiting without children	408 (39.5)	376 (42.2)	32 (22.4)	363 (42.0)	45 (26.6)
Single with children	101 (9.8)	68 (7.6)	33 (23.1)	72 (8.3)	29 (17.2)
Single without children	285 (27.6)	240 (27.0)	45 (31.5)	232 (26.9)	53 (31.4)
Other	37 (3.6)	32 (3.6)	5 (3.5)	30 (3.5)	7 (4.1)
Educational level (n (%))					
Low (upper secondary education or lower)	469 (45.4)	414 (46.5)	55 (38.5)	411 (47.6)	58 (34.3)
Intermediate (post-secondary – short cycle tertiary education)	506 (49.0)	423 (47.5)	83 (58.0)	404 (46.8)	102 (60.4)
High (Bachelor or higher education)	58 (5.6)	53 (6.0)	5 (3.5)	49 (5.7)	9 (5.3)
Paid employment (n (%) yes)	429 (41.5)	381 (42.8)	48 (33.6)	365 (42.2)	64 (37.9)
Income (n (%))[1]					
Minimum	130 (12.6)	82 (9.2)	48 (33.6)	82 (9.5)	48 (30.2)
Below mode income	560 (54.2)	488 (54.8)	72 (50.3)	467 (54.1)	93 (58.5)
Mode income or higher	251 (24.3)	235 (26.4)	11 (11.2)	233 (29.8)	18 (11.3)
Don't know/ don't want to answer	91 (8.9)	85 (9.6)	7 (4.9)	82 (9.5)	10 (5.9)
Livability index (range1 (poor) to 9 (outstanding) (mean ± SD))[2]	6.7 ±1.26	6.75 ±1.24	6.36 ±1.34	6.7 ±1.2	6.5 ±1.4
Score 6 or lower	437 (42.4)	354 (39.9)	83 (58.0)	349 (40.5)	88 (52.1)
Score 7 or higher	594 (57.6)	532 (60.1)	60 (42.0)	513 (59.5)	81 (47.9)

Lifestyle factors					
Current smoker (n (%) yes)	183 (17.7)	133 (15.0)	50 (35.0)	140 (16.2)	43 (25.4)
BMI (mean ±SD)[3]	26.8 ±5.0	26.6 ±4.8	28.1 ±6.3	26.6 ±4.6	27.9 ±6.7
Weight status (n (%))					
Normal weight	404 (39.1)	354 (39.8)	50 (35.0)	335 (38.8)	69 (40.8)
Overweight	370 (35.8)	328 (36.9)	42 (29.4)	322 (37.3)	48 (28.4)
Obesity	259 (25.1)	208 (23.4)	51 (35.7)	207 (24.0)	52 (30.8)
Dietary quality (0-130) (mean ± SD)	70.3 ±15.3	71.2 ±15.1	64.3 ±15.2	70.9 ±15.2	66.8 ±15.5
TPB constructs (7-point Likert scales (mean ± SD))					
Subjective norm	4.3 ±1.2	4.2 ±1.1	4.9 ±1.3	4.2 ±1.1	4.7 ±1.3
Attitude healthy eating and fruit and vegetables	4.8 ±0.9	4.8 ±0.9	4.5 ±0.9	4.8 ±0.9	4.6 ±0.9
Attitude snacks and fast-food	2.9 ±1.1	2.9 ±1.1	3.0 ±1.1	2.9 ±1.0	3.0 ±1.2
Perceived behavioral control	5.0 ±1.0	5.0 ±0.97	4.6 ±1.2	5.1 ±1.0	4.9 ±1.3
Intention	4.7 ±1.1	4.7 ±1.1	4.8 ±1.2	4.7 ±1.1	4.8 ±1.2
Finance-related barriers					
Food insecurity score (range 0-6 (mean ±SD))	0.4 ±1.2	0 ±0	2.9 ±1.9	0.1 ±0.6	1.9 ±2.1
Financial scarcity (7-point Likert scale (mean ± SD))	2.6 ±1.5	2.3 ±1.2	4.6 ±1.2	2.2 ±1.0	5.0 ±0.7

[1] Income categories refer to the following amounts of annual gross income: Minimum <14.100 euro; Below mode income 14.100-36.500 euro; Mode income or higher >36.500 euro.
[2] Livability index: n=1031
[3] BMI: n=984