Food Quality and Preference 116 (2024) 105145

Contents lists available at ScienceDirect

Food Quality and Preference

journal homepage: www.elsevier.com/locate/foodqual

Differences in drivers of healthy eating and nutrition app preferences across motivation-based consumer groups

Muriel C.D. Verain [a,*], Ireen Raaijmakers [a], Saskia Meijboom [b], Sandra van der Haar [b]

[a] Wageningen University & Research, Wageningen Economic Research, P.O. Box 35, 6700 AA Wageningen, the Netherlands
[b] Wageningen University & Research, Wageningen Food & Biobased Research, P.O. Box 17, 6700 AA Wageningen, the Netherlands

ARTICLE INFO

Keywords:
Nutrition apps
Mobile health (mHealth)
Health-related motive orientation
App properties
Consumer segments
Motivation

ABSTRACT

The aim is to explore whether and how different consumer groups, based on health motivations, differ in their drivers to adopt a healthy diet and their preferences for nutrition app properties. Four groups were identified: Health-motivated, Moderately-motivated, Body-motivated and Mind-motivated consumers. All groups are motivated to consume a healthy diet, although the Moderately-motivated less than the other groups. In addition, all groups feel sufficiently able to consume a healthy diet. Most differences were found regarding the perceived opportunity to consume a healthy diet. Although the perceived financial opportunity and the eating context are barriers to all groups, physical opportunity (lack of availability) is only perceived as a problem by the Moderately-motivated group. Worries about data protection is an issue to all groups, except for the Body-motivated group. Finally, social acceptance is not perceived as a barrier. Since different health motivations (e.g. physical health) can be related to different properties of nutrition apps (e.g. positive feedback), differences in app preferences were researched, but groups showed little differences in their preferences. For all groups easy navigation and a complete and reliable food database are important requirements for a nutrition app. In conclusion, this study suggests that consumer groups based on health motivations need different approaches to support them in healthy eating, but there is no clear need to adapt properties of nutrition apps to these groups. In the future, it could be interesting to study app preferences for other types of consumer segments e.g. based on socio-economic status or body mass index.

1. Introduction

Dietary intake of a majority of consumers in developed countries is suboptimal, and is associated with non-communicable diet-related diseases such as cardiovascular disorders, certain forms of cancer and diabetes type II (Afshin et al., 2019; Phillips et al., 2019). Therefore, there is an urgent need to stimulate and support consumers to shift their diets towards more healthy intake levels. This can take several forms, such as generic nutritional campaigns, targeted interventions or the development of supporting tools such as smartphone apps. Information campaigns and educational measures are traditionally used to incite consumers towards more healthy diets. However, popularity of mobile health applications (mHealth apps), including nutrition apps, to support health behavior change is increasing rapidly (IQVIA, 2021; Materia & Smyth, 2021).

Up till now, nutrition campaigns have had modest success in shifting consumers' diets (Brambila-Macias et al., 2011; Capacci et al., 2012; Snyder, 2007), possibly because of the one-size-fits all approach (Geeroms, Verbeke, & Kenhove, 2008b; Kazbare, van Trijp, & Eskildsen, 2010). A one-size-fits-all approach is unlikely to be effective, since important characteristics such as motivations and needs differ across individuals (Raaijmakers, Sijtsema, Labrie, & Snoek, 2018). The importance of tailoring in designing effective health interventions is widely acknowledged already for several decades (Noar, Benac, & Harris, 2007; Slater, 1996; Snyder, 2007; Wedel & Kamakura, 2000; Wilson, 2007). In a *meta*-analysis of web-delivered tailored health behavior change interventions, Lustria and colleagues concluded that a tailored approach is beneficial over non-tailored approaches (Lustria et al., 2013). It remains challenging, though, to identify homogeneous subgroups in the population with regards to key characteristics that are important to consider when tailoring health interventions.

In addition to nutrition campaigns, nutrition apps can be effective

* Corresponding author.
E-mail addresses: muriel.verain@wur.nl (M.C.D. Verain), ireen.raaijmakers@wur.nl (I. Raaijmakers), saskia.meijboom@wur.nl (S. Meijboom), sandra.vanderhaar@wur.nl (S. van der Haar).

https://doi.org/10.1016/j.foodqual.2024.105145
Received 12 May 2023; Received in revised form 22 December 2023; Accepted 16 February 2024
Available online 21 February 2024

tools to support dietary changes. Several studies have shown the effectiveness of nutrition apps in stimulating healthy dietary habits and in supporting weight loss (DiFilippo, Huang, Andrade, & Chapman-Novakofski, 2015; Patel, Wakayama, & Bennett, 2021; Schoeppe et al., 2016; Villinger, Wahl, Boeing, Schupp, & Renner, 2019; Zhao, Freeman, & Li, 2016). A study by Wang and colleagues showed that also in the perception of users, nutrition apps are effective tools in achieving dietary change (Wang, Egelandsdal, Amdam, Almli, & Oostindjer, 2016). Similarly to nutrition campaigns, nutrition apps are likely to be more effective when tailored to the motivations and needs of population subgroups. A recent systematic review by König and colleagues identified several barriers for consumers to use nutrition apps and concluded that there is no 'one-size-fits-all' approach that fits everyone (König, Attig, Franke, & Renner, 2021). Moreover, an experimental study by Materia and Smyth (2021) showed the added value of tailored (as opposed to generic) features in mHealth interventions on amongst others the perceived utility and the likelihood of participation. Finally, Chen and colleagues concluded from a review that it is important to customize digital nutrition interventions, including apps, to the target population (Chen, Perez-Cueto, Giboreau, Mavridis, & Hartwell, 2020).

In short, tailoring to the needs of specific population subgroups seems promising in order to increase engagement and make long-lasting behavior change towards more healthy diets more likely (Materia & Smyth, 2021). But the question remains what key characteristics are crucial in identifying homogeneous subgroups that are a promising basis for tailored interventions and tools. Subgroups can be identified based on a wide range of factors (Slater, 1995; Wedel & Kamakura, 2000). The COM-B model, developed by Michie and colleagues (Michie, Atkins, & West, 2014), is a relevant behavioural framework in this respect and is frequently used in food research to understand the drivers of food choices (e.g. Graça, Godinho, & Truninger, 2019; Sijtsema, Dagevos, Nassar, van Haaster de Winter, & Snoek, 2021). This model is widely used to explain and study behaviour change and states that in order for behaviour change to occur, a person must feel Capable, have the Opportunity and must be Motivated to perform the desired Behaviour. Capability (having the necessary knowledge and skills) and motivation are internal mechanisms for change, whereas opportunity is an external factor and has to do with one's social and physical environment. Materia and Smyth (2021) underpin the importance of willingness (motivation) and capability of users in successfully engaging with a mHealth tool or app.

To address the motivational component, an effective tailoring strategy is aligned with personal motivations and preference. Motivational subgroups are useful in the development of effective communications, because of the cognitive insights they provide (Wedel & Kamakura, 2000). In general, health motivations are important drivers for health behaviours, as for example shown in the successful application of self-determination theory (in which motivation is a central concept) in achieving positive health outcomes in general, and positive dietary changes more specifically (Ryan, Patrick, Deci, & Williams, 2008).

Health is a multidimensional concept though, and can have different meanings for different (groups of) consumers, ranging from the absence of disease and physical well-being to mental health and social well-being (Geeroms, Verbeke, & Kenhove, 2008a), which is in line with the definition of health used by the World Health Organisation (WHO): "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (Guillemin et al., 2016). Food-related wellbeing, a closely related concept, is similarly related to multiple dimensions, such as physical health, body functioning and emotional state (Ares et al., 2015).

This multidimensionality of health is captured in the Health-Related Motive Orientation (HRMO) scale designed by Geeroms and colleagues (2008a). This scale investigates the psychological meanings that individuals associate with health and that motivate their food choice behaviour. Based on these different health meanings, consumers can be grouped into five subgroups: Energetic Experimenters, Harmonious Enjoyers, Normative Carers, Conscious Experts and Rationalists (Geeroms et al., 2008a; Geeroms et al., 2008b). The groups differ in their food consumption, for example with regard to protein consumption (Sijtsema, Raaijmakers, Onwezen, & Doets, 2019), ready-to-eat meals and fruit and vegetable consumption (Raaijmakers et al., 2018), but differ also in their perceptions of food attributes and meal functionalities (Raaijmakers et al., 2018; Sijtsema et al., 2019) and in how they react to advertising messages (Geeroms et al., 2008b). Therefore, segmenting the general population into subgroups based on health motivations, as a basis for tailoring nutrition interventions and tools, seems promising. Maybe even more so, since the contribution of food products to health differs along the health dimensions (e.g. chocolate may be perceived as beneficial to mental health, but undesirable when focussing on weight loss) (Ares, et al., 2016; Puska & Luomala, 2016), which suggests that optimal dietary advise depends on one's health goal. The work by Ares and colleagues (2015; 2016) also shows the importance of considering wellbeing as a multidimensional construct, when studying the link between wellbeing goals and food products.

Several recent papers have shown the relevance of personalized health goals and motivations in nutrition app usage. Van der Haar and colleagues (Van der Haar, Raaijmakers, Verain, & Meijboom, 2023) found that a clear purpose is important in the start phase of nutrition app usage, and motivation and personalization of goals are important when it comes to long-term usage of a nutrition app. Also König and colleagues (2021) described in their review on nutrition apps that it is important to tailor app features to individual needs and goals. Similarly, Szinay and colleagues (Szinay, Jones, Chadborn, Brown, and Naughton, 2020) concluded from their metareview that personalized goals are an important factor in app engagement.

Taking the above one step further, it is likely that preferences for app requirements depend on these personal health goals and motivations. A reliable database with accurate nutrition information seems for example most relevant when talking about physical health, positive feedback may be beneficial for mental health and social media and communication features are most likely to be relevant when focussing on social well-being (Van der Haar et al., 2023). Therefore, in this paper we will research the differences in app requirements of consumer groups based on health motivations.

To summarize, tailoring seems important in the development of effective nutrition interventions and tools. So far, insight are limited in key consumer characteristics that form a useful basis for tailoring, but motivation seems an important factor. Therefore, the objective of the current paper is to study whether and how different consumer groups, based on their health motivations, differ in their capability, perceived opportunity and motivation to eat healthily and second, to research differences in needs and preferences regarding nutrition app properties related to these health motivations.

2. Methods

2.1. Procedure and respondents

An online survey was conducted to collect the data in June 2020 by a professional market research agency (MSI-ACI Europe BV). Participants were approached by email to fill out an online survey and received an incentive consisting of credits for a personal saving system. All participants provided written informed consent to participate in the survey. Ethical clearance was obtained from the Social Ethics Committee of Wageningen University & Research (09215846).

The aim of the survey was twofold. First, it aimed to quantify the results that were obtained in an earlier qualitative study (N = 44), in which nutrition app functionalities were identified. For more information on the focus group discussions and the quantification of the app elements we refer to a recently published paper by van der Haar and colleagues (Van der Haar et al., 2023). The second aim of the survey was

to gain insights in differences across consumer groups with regard to healthy eating motivations, explore their drivers for healthy eating and their needs and preferences regarding nutrition apps. The identification and description of these consumer groups form the core of the current paper.

The survey was completed by a national representative sample of the Dutch adult population in terms of their gender and age. Familiarity with using smartphones and smartphone apps were used as inclusion criteria. The initial dataset consisted of 1,500 participants. The dataset was cleaned by removing 80 participants who showed zero dispersion in their ratings of app properties, suggesting that they did not take the survey seriously. After cleaning, 1,420 participants remained eligible for analysis. The final dataset included 49 % males and 51 % females, with a mean age was 44 years, ranging from 18 to 82. Fifteen percent had a low level of education, 44 % a middle level of education and 41 % a high level of education.

2.2. Measures

2.2.1. Segmentation variables

Health motivations. Respondents were assigned to a subgroup based on their explicit health motivations. For this purpose, the 13-item explicit subscale of the Health-Related Motive Orientation scale (HRMO) was used. The HRMO-scale was developed by Geeroms and colleagues (2008a, 2008b) and identifies meanings that people attribute to health and that motivate health behaviour. The original scale includes 34 statements: a 13-item subscale that explicitly addresses the meanings that respondents attribute to health, or their reasons to strive for good health and a 21-item subscale with implicit items that focus on perceived consequences of bad health. We disregarded the implicit subscale for our purpose, since we were interested in conscious health motivations and these are reflected by the explicit health meanings, and not by the implicit items on possible consequences of bad health. Respondents were asked to respond to the statement 'For me, health is mainly about…'. Example items were: 'keeping the body in good condition', 'taking time to relax and to enjoy life' and 'staying slim'. The respondents rated all 13 motives on 7-point Likert scales, ranging from 'completely disagree (1)' to 'completely agree (7)'. The original factors have been computed and reliability was checked with Cronbach's Alpha. The item "Health is about following the advice of expert such as doctors and dieticians' has been removed for reasons of reliability. The remaining subscales were: HRMO-energy (3-items; $\alpha = 0.850$), HRMO-emotional wellbeing (3-items; $\alpha = 0.648$), HRMO-social responsibility (2-items; $\alpha = 0.728$), HRMO-physical wellbeing (2-items; $\alpha = 0.680$) and HRMO-outward appearance (2-items; $\alpha = 0.706$).

2.2.2. Descriptor variables

Capability. Capability to consume a healthy diet was operationalised by assessing *one's self-efficacy to eat healthy*. Seven items from The Healthy Eating and Weight Self-Efficacy scale (HEWSE) (Wilson-Barlow, Hollins, & Clopton, 2014) were used that relate to healthy eating ($\alpha = 0.882$). The items on weight self-efficacy were disregarded for our purpose. An example statement is: 'I am able to modify recipes to make them healthier'. Participants had to rate all statements on 7-point scales ranging from 'completely disagree (1)' to 'completely agree (7)'. The statement 'I am able to consume fruits and vegetables in most of my meals' was split into two items, one item focussing on fruits and one on vegetables, resulting in eight items in total. In addition to self-efficacy, *subjective knowledge* regarding healthy eating was included to capture another aspect of capability. Subjective knowledge was assessed by a two-item measure of Flynn and Goldsmith (1999) ($\alpha = 0.785$). The included statement were: 'I know quite a lot about healthy nutrition' and 'In my circle of friends I am one of the 'experts' in the field of healthy eating'. Both items were rated on 7-point scales, ranging from 'not at all (1)' to 'completely (7)'. Last, the participants' *experiences in using novel technologies* were assessed, based on Norman and Skinner's eHealth Literacy Scale Norman and Skinner (2006). All eight items of the questionnaire were used ($\alpha = 0.953$), but instead of statements on health, we transformed them to nutrition. Example statements are: 'I know how to find helpful nutrition resources on the internet' and 'I feel confident in using information from the internet to make good decisions on nutrition'. All items were rated on 7-point scales, ranging from 'completely disagree (1)' to 'completely agree (7)'.

Opportunity. Physical opportunity to eat healthy was assessed by four statements ($\alpha = 0.741$) (e.g. 'Compared to high-caloric foods, low-caloric foods are available in too few varieties') and *financial opportunity* was assessed by four statements ($\alpha = 0.713$) (e.g. 'Compared to high-caloric foods, low-caloric foods are too expensive). Both opportunity scales were adapted from Bos, van der Lans, Rijnsoever, and van Trijp (2016). In addition, perceived barriers to the adoption of personalised nutrition were assessed by making use of the questionnaire by Stewart-Knox et al. (2016). This scale is composed of three subscales of barriers: *data protection* (7-items; $\alpha = 0.955$); *eating context* (8-items; $\alpha = 0.850$); and *social acceptance* (3-items; $\alpha = 0.847$). Examples of barriers are: 'Worries about how my personal data might be used by insurance companies' (data protection), 'Difficulties in maintaining healthy eating habits when eating at other people's houses' (Eating context), 'My family rejecting the adoption of personalised nutrition' (societal acceptance). We added an extra item to the factor that measures the eating context barriers: 'I find it difficult to replace food products in what I am currently used to eat at home'. All items were rated on 7-point scales, ranging from 'completely disagree (1)' to 'completely agree (7)'.

Motivation. Motivation to apply healthy eating strategies was assessed by means of the 17-item Openness to Healthy Eating Strategies (OHES) questionnaire (Verain, Bouwman, Galama, & Reinders, 2022). This questionnaire includes a range of healthy eating behaviours such as eating less red meat, eating more vegetables and choosing light products. Participants were asked how willing they were to perform these behaviours. Each item was assessed on a 7-point scale ranging from 'not at all (1)' to 'very much (7)'. The original four dimensions of the OHES-scale were computed: Increasing healthy foods (6-items; $\alpha = 0.770$), limiting unhealthy foods (6-items; $\alpha = 0.811$), moderation (2-items; $\alpha = 0.568$) and light products (3-items; $\alpha = 0.716$).

Intention. Intention to consume a healthy diet was measured with three items (e.g. 'I intend to (continue to) eat healthy') ($\alpha = 0.864$), adapted from Bouwman, Bolderdijk, Onwezen and Taufik (2022) and Onwezen, Van 't Riet, Dagevos, Sijtsema and Snoek (2016). Each item was assessed on a 7-point scale ranging from 'completely disagree (1)' to 'completely agree (7)'.

Nutrition apps. Usage of nutrition apps was measured by asking respondents to indicate whether they make or made use of one or more nutrition apps (Yes / No). Depending on the answer, respondents were subsequently asked about usage frequency and their reason to use nutrition apps (e.g. "Gain insights into diet"), or their reason for not using one (e.g. "I don't need insights into what I eat"). Respondents could select multiple options from a pre-defined list of reasons or fill in an open answer. Subsequently, importance of *nutrition app properties* was assessed. The nutrition app properties that resulted from the focus groups (Meijboom, Raaijmakers, Verain, van der Haar, & Doets, 2020) were operationalised into 46 single items. Participants were asked to rate the importance to include in a nutrition app of each of the 46 elements on a 7-point scale ranging from 'very unimportant' to 'very important'. Items belonging to the same user-centric app aspect were averaged into one score. Cronbach's Alpha was checked to assess reliability. The item on privacy did not form a reliable scale with the other social media and communication items and was therefore included as a separate item. The other user-centric aspects formed reliable scales: *purpose* (3-items; $\alpha = 0.793$), *introduction* (2-items; $\alpha = 0.740$), *personalization* (7-items; $\alpha = 0.859$), *user-friendly interface* (7-items; $\alpha = 0.856$), *database* (5-items; $\alpha = 0.887$) *education & information* (5-items; $\alpha = 0.878$), *progress & monitoring* (4-items; $\alpha = 0.836$), *feedback & support* (5-items; $\alpha = 0.829$), *social media & communication* (2-items; $\alpha = 0.754$),

privacy (single item) and *motivations & continuous usage* (5-items; α = 0.876).

Demographics. Age, gender, education level, income, household composition and BMI were included to profile the consumer segments on socio-demographic characteristics.

An overview of the included statements can be found in the supplementary materials.

2.3. Data analysis

Preparatory analyses were conducted to make the variables suitable for further analyses. Constructs were computed by taking the average of the individual items. Reliability of the resulting scales was assessed with Cronbach's Alpha. The results are described under "Measures". Subsequently, several steps were taken to identify and describe the consumer groups (see Fig. 1 for an overview of the steps). First, a cluster analysis was performed to group respondents into consumer segments based on their HRMO. To control for answering tendencies the centred scales were used in the cluster analysis, by subtracting the individual's average scale score from the individual's raw scale scores. Although the centred scale values were used in the cluster analysis, for reasons of interpretability the uncentered mean scores are reported. Hierarchical agglomerative cluster analysis was applied with Ward's method and Euclidean distance measure. The number of segments was determined based on inspection of the dendrogram and interpretability of the segments.

Second, the resulting groups were described based on their socio-demographic characteristics, their intentions to consume a healthy diet, the COM-B elements and their app preferences. Analyses of variance (ANOVA) with post-hoc Tukey comparisons of mean scores were used to analyse differences in age, household size and BMI and cross tabulations with post hoc comparisons (Z-test with Bonferroni correction) were used for gender, level of education and income category. Additionally, analyses of variance (ANOVA) with post-hoc Tukey comparisons of mean scores were used to test for significant differences across the identified segments in terms of their intention, capability, opportunity and motivation to consume a healthy diet. Finally, ANOVAs with post-hoc Tukey comparisons of mean scores were used to test for significant differences across segments in their preferences for app properties belonging to the ten identified user-centric aspects.

3. Results

3.1. Four HRMO-based consumer groups

On the level of the total sample, physical wellbeing is the most important HRMO, followed by emotional wellbeing and energy. Outward appearance is considered to be the least important aspects of health. The final cluster solution resulted in four consumer segments (Table 1), that differ in their HRMO. Although physical wellbeing is the most important aspect to all groups, we found significant differences across the groups for each of the five HRMO. All HRMO-dimensions have a large effect size (Table 1), except for energy, which has a medium effect size. The F-values (Table 1) show that social responsibility, followed by outward appearance, are most important in determining the consumer groups.

Segment 1 is labelled as 'Health-motivated' and is the largest segment with 43 % (N = 611) of the sample. Compared to the other segments, this segments scores relatively high on all health motivations (Table 1). This segment consists of 48 % males, is relatively old mean age of 49 years, and has a relatively high percentage of lower educated respondents and a relatively low percentage of respondents with a low income (Table 2).

Segment 2 is labelled as 'Moderately-motivated' and consists of 32 % (N = 486) of the sample. In comparison to the other groups, this segment does not score high on any of the included health motivations, but is particularly characterized by a relatively low score on energy, emotional wellbeing and physical wellbeing. This segment consists of 55 % males, with a mean age of 43 and relatively high percentage of respondents with a low income (Table 2).

Segment 3 is labelled as 'Body-motivated' and consists of 14 % (N = 196) of the sample. This segment is characterized by a relatively low score on social responsibility and on emotional well-being, but in contrast scores relatively high on energy, physical wellbeing and outward appearance (Table 1). Also in absolute terms, this segment scores very low on social responsibility, indicating that health is not a social concept to them. This segment consists of 39 % males, is relatively young with a mean age of 41, and has a relatively low percentage of lower educated respondents and a relatively high percentage of respondents with a low income. This segment has a significantly lower BMI than the other segments (Table 2).

Segment 4 is labelled as 'Mind-motivated' and is the smallest segment consisting of 9 % (N = 127) of the sample. This segment is characterized by a relatively high score on emotional wellbeing, social responsibility and physical wellbeing, and a relatively low score on energy and outward appearance. Also in absolute terms, this segment scores very low on outward appearance, indicating that to them, health is not about looks (Table 1). This segment consists of 50 % males and is relatively older with a mean age of 50 (Table 2).

3.2. HRMO-based segments differ in their capability, ability and motivation to consume a healthy diet

Intentions to consume a healthy diet are high in all four HRMO-based consumer segments and do not differ. The segments, do, however, differ

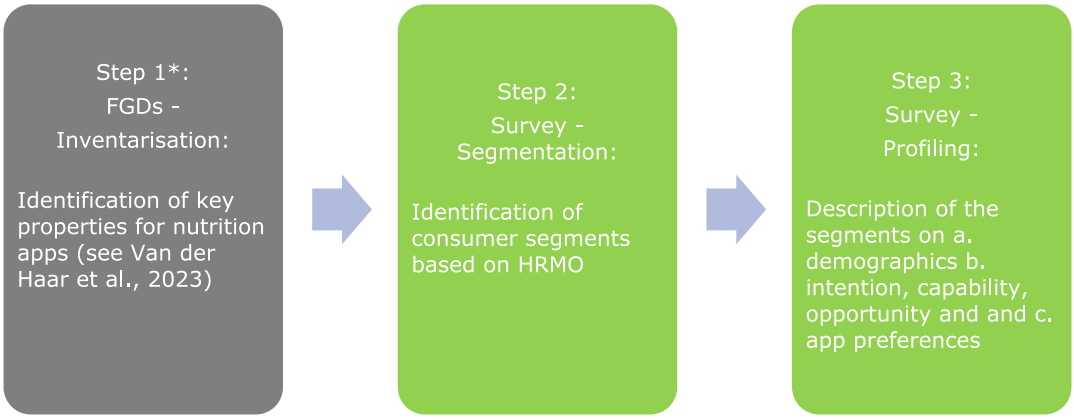

Fig. 1. Overview of the steps taken, combining qualitative (step 1) and quantitative results (steps 2 and 3). **Note.* Step 1 has been published elsewhere. Steps 2 and 3 (in green) form the core of this paper.

Table 1
Mean scores on the Health-Related Motive Orientations per segment.

	Health motivated	Moderately motivated	Body motivated	Mind motivated	Total sample	η^2
N	611	486	196	127	1420	
Segment size (%)	43.0	32.2	13.8	8.9	100	
HRMO – Energy***	5.45[a]	4.94[b]	5.73[c]	5.05[b]	5.28	0.071
HRMO – Emotional wellbeing***	5.84[a]	4.93[b]	4.98[b]	5.76[a]	5.40	0.197
HRMO – Social responsibility***	5.74[a]	4.63[b]	3.40[c]	5.56[a]	5.02	0.384
HRMO – Physical wellbeing***	5.94[a]	5.00[b]	5.93[a]	5.90[b]	5.62	0.181
HRMO – Outward appearance***	5.20[a]	4.63[b]	5.42[a]	2.80[c]	4.82	0.300

Note. HRMO-Energy $F(3, 1416) = 36{,}305$, $p < .001$; HRMO-Emotional Wellbeing $F(3, 1416) = 115{,}567$, $p < .001$; HRMO-Social Responsibility $F(3, 1416) = 294{,}711$, $p < .001$; HRMO-Physical Wellbeing $F(3, 1416) = 104{,}055$, $p < .001$; HRMO-Outward Appearance $F(3, 1416) = 202{,}025$, $p < .001$.
Note. Asterisks indicate that means differ significantly across the consumer segments.
Note. Measured on a 7-point Likert scale ranging from 'completely disagree (1)' to 'completely agree (7)'.
*p <.05, **p <.01, ***p <.001.
[a -c] Different superscripts across rows indicate significant different means.

Table 2
Socio-demographic characteristics of the segments.

	Health motivated	Moderately motivated	Body motivated	Mind motivated	Total sample
Male (%)	47.6[a,b]	54.7[a]	38.8[b]	49.6[a,b]	49.0
Age (Mean)	48.67[a]	42.50[b]	41.23[b]	50.12[a]	45.66
Household size	2.51[a,b]	2.59[a]	2.19[b]	2.46[a,b]	2.49
Education (%)					
Low (%)	18.3[a]	12.6[a,b]	7.7[b]	16.5[a,b]	14.7
Middle (%)	43.0[a]	45.5[a]	45.9[a]	40.9[a]	44.1
High (%)	38.1[a]	41.8[a]	45.4[a]	42.5[a]	40.8
Income (%)					
<€1.500 (%)	9.7[a]	12.8[b]	18.4[b]	12.6[a,b]	12.2
€1.500-€3.000 (%)	37.0	31.7[a]	31.1[a]	40.2[a]	34.6
€3.000-€7.500 (%)	30.0[a]	32.9[a]	31.6[a]	22.0[a]	30.5
>€7.500 (%)	3.1[a]	3.5[a]	1.5[a]	3.9[a]	3.1
BMI	25.63[a]	25.58[a]	24.09[b]	26.64[a]	25.49

Note. 20% of the participant did not report their income level.
[a -b] Different superscripts across rows indicate significant different means.

in terms of their capability, opportunity and motivation to consume a healthy diet (Table 3), although effect sizes are small. None of the segments seems to perceive the capability to eat healthily as a barrier. However, small differences across segments were found. Only subjective knowledge to what constitutes a healthy diet is higher for the Moderately-motivated as compared to the other segments, but healthy eating self-efficacy does not differ across the segments.

In general, a lack of financial opportunity forms the most important barrier to consume healthy products, whereas the social context is not perceived as a barrier. Although social context does not form a barrier in any of the segments, interestingly, this is the only determinant with a medium effect size (other effect sizes should be interpreted as small (Cohen & Cohen, 1983). But segments differ in their perceived opportunity to consume a healthy diet and to follow a personalized dietary advice, except for the eating context, which is somewhat perceived as a barrier by all segments. Physical opportunity is perceived as significantly lower by the Moderately-motivated compared to the other segments. In addition, financial opportunity is lowest for the Mind-motivated and highest for the Health-motivated. The Body-motivated perceive data protection issues more as a barrier compared to the other segments. Furthermore, although the social context does not form a barrier to any of the groups, the Moderately-motivated rate this barrier higher than the Body-motivated and Mind-motivated. In short, Moderately-motivated perceive most barriers, whereas Body-motivated

Table 3
Segment description on capability, opportunity and motivation to follow a healthy diet.

	Health motivated	Moderately motivated	Body motivated	Mind motivated	Total sample	η^2
Intentions	5.59[a]	5.64[a]	5.81[a]	5.64[a]	5.64	0.004
Capability						
Subjective knowledge***	4.13[a]	4.68[b]	4.28[a]	4.30[a]	4.36	0.031
Healthy eating self-efficacy*	4.97[a]	5.12[a]	4.95[a]	5.14[a]	5.03	0.006
Opportunity						
Physical opportunity***	3.72[a]	4.22[b]	3.83[a]	3.85[a]	3.91	0.047
Financial opportunity**	4.49[a]	4.65[a,b]	4.70[a,b]	4.78[b]	4.60	0.010
Data protection barrier***	4.46[a]	4.55[a]	4.00[b]	4.55[a]	4.44	0.014
Eating context barrier*	4.39[a]	4.39[a]	4.24[a]	4.13[a]	4.35	0.006
Social context barrier***	3.24[a]	3.74[b]	2.72[c]	2.66[c]	3.29	0.068
Motivation						
OHES – increasing healthy foods***	5.64[a]	5.29[b]	5.62[a]	5.61[a]	5.51	0.027
OHES – decreasing unhealthy foods***	5.49[a]	5.23[b]	5.50[a]	5.45[a,b]	5.40	0.012
OHES – moderation**	5.47[a,b]	5.23[a]	5.48[a,b]	5.53[b]	5.53	0.011
OHES – light products*	5.08[a]	4.87[a,b]	5.03[a,b]	4.75[b]	4.75	0.007

Note. Intention $F(3, 1416) = 2{,}035$, $p < .107$; Subjective Knowledge $F(3, 1416) = 14{,}985$, $p < .107$; Healthy Eating Self-Efficacy $F(3, 1416) = 3{,}005$, $p < .107$; Physical Opportunity $F(3, 1416) = 23{,}163$, $p < .107$; Financial Opportunity $F(3, 1416) = 4{,}646$, $p < .107$; Data protection barrier $F(3, 1416) = 6{,}920$, $p < .107$; Eating context barrier $F(3, 1416) = 2{,}665$, $p < .107$; Social context barrier $F(3, 1416) = 34{,}247$, $p < .107$; OHES-Increasing healthy foods $F(3, 1416) = 12{,}955$, $p < .107$; OHES-Decreasing unhealthy foods $F(3, 1416) = 5{,}802$, $p < .107$; OHES-Moderation $F(3, 1416) = 5{,}364$, p <.107; OHES-Light products $F(3, 1416) = 3{,}392$, $p < .107$.
Note. Asterisks indicate that means differ significantly across the consumer segments: *$p < .05$, **$p < .01$, ***$p < .001$.
Note. Measured on 7-point Likert scales, ranging from [1]'completely disagree (1)' to 'completely agree (7)', [2] 'not at all (1)' to 'completely (7)' or [3]'not at all (1)' to 'very much (7)'.
[a -c] Different superscripts across rows indicate significant different means.

perceive least barriers.

Finally, increasing the amounts of healthy foods is the most popular healthy eating strategy. Overall, Moderately-motivated are least motivated to apply healthy eating strategies, except for the consumption of light products.

3.3. Segments show small differences in their preferences for nutrition app properties

Twenty-two percent of the respondents makes use of nutrition apps. The main reasons for using such apps are to gain insight in own dietary pattern, to loose weight and to maintain body weight. In contrast, the main reasons for not using a nutrition app are no need for insights in own food consumption, not seeing the added value and unawareness of the existence of nutrition apps.

Among the Moderately-motivated, nutrition app usage is highest, with 29 % of respondents using or having used nutrition apps. This percentage is significantly higher than for the Health-motivated (17 %) and Mind-motivated (16 %) segments. Body-motivated respondents score in between with 26 %. The reasons for not using a nutrition app do not differ across the groups, and for the reasons to use a nutrition app the only difference is found for 'maintain one's body weight', with the Body-motivated mentioning this more frequently as a reason to use a nutrition app than the Moderately-motivated.

The final step was to describe the segments in terms of their preferences for nutrition app properties, combined into the ten user-centric aspects (Table 4). On the sample level, privacy, a complete and reliable database and a clear introduction including a tutorial are the most important app elements, but the segments show some differences in their preferences. A similar pattern can be found for *purpose, introduction, personalisation, user-friendly interface, database, education & information, privacy and motivation & continuous usage*, with the Moderately-motivated segment attaching less importance to these user-centric aspects than the Mind-motivated segment (and for most aspects also the Health-motivated segment). The Body-motivated segment scores somewhere in between. For the importance of *progress & monitoring*, no significant differences are found across groups. *Feedback & support* shows a different pattern, with the Body-motivated segment valuing this aspect less than the Health-motivated segment. Finally, for *social media & communication*, the Moderately-motivated segment values this aspect more than the Body-motivated segment. When looking at the ranking of the user-centric aspects, the differences are small, with a *reliable database* and *privacy* as the most important aspects for all four segments. *Introduction* ranks third for the health-motivated, body-motivated and mind-motivated groups, whereas a *user-friendly interface* ranks third for the moderately-motivated group. *Feedback & support* and *social media & communication* are ranked as two least important user-centric app aspects for all groups.

4. Discussion and conclusion

4.1. HRMO-based consumer groups differ in their health motivations

Using data from a large nationally representative sample of the Dutch adult population, we identified four distinct consumer groups based on their HRMO: Health-motivated, Moderately-motivated, Body-motivated and Mind-motivated consumers. These segments largely overlap with the segments identified by Geeroms and colleagues (Geeroms et al., 2008b), both in HRMO and in demographic characteristics, with the Health-motivated showing resemblance with Rationalists, the Moderately-motivated with Energetic Experimenters, the Body-motivated with Conscious Experts and the Mind-motivated with Harmonious enjoyers. Geeroms' group of Normative carers, with a strong focus on social responsibility, is lacking in our sample. An important difference between both studies is that in our sample, respondents in all groups are primarily involved with physical health, whereas the groups identified by Geeroms and colleagues differ in their primary health dimension. This may suggest that in the Netherlands, health is more narrowly perceived – with a strong focus on physical health problems – than it is in Belgium. Several other survey studies in Dutch samples point in the same direction: main motivations for eating healthily are often linked to physical health, disease and healthy aging (Dijkstra et al., 2014; Sialino et al., 2023) or to weight concerns and concerns about the diet-health link (de Ridder et al., 2014).

An alternative explanation would be that the difference may be the result of the limited set of items that has been used in this study, including only the explicit HRMO-items and excluding the more implicit items that focus on perceived consequences of bad health. In other words, when people are explicitly asked about the meaning of health, they primarily mention physical health problems, but when they think about health consequences, people may show differences in their responses on what they think would be particularly undesirable. Further research is needed to confirm this hypothesis.

The identification of these distinct groups underpins the relevance of

Table 4
Segment differences in user-centric app aspects.

	Health motivated	Moderately motivated	Body motivated	Mind motivated	Total sample	η^2
Start						
1. Purpose***	5.25[a]	4.94[b]	5.19[a,b]	5.31[a]	5.14	0.015
2. Introduction***	5.37[a,b]	4.96[c]	5.22[a,c]	5.56[b]	5.22	0.028
3. Personalisation**	4.92[a,b]	4.75[a]	4.82[a,b]	5.06[b]	4.86	0.008
Usage						
4. User-friendly interface***	5.25[a]	4.97[b]	5.20[a,b]	5.31[a]	5.16	0.016
5. Database***	5.48[a]	5.11[b]	5.65[a]	5.70[a]	5.40	0.035
6. Education & Information *	5.03[a,b]	4.86[a]	4.99[a,b]	5.14[b]	4.98	0.006
7. Progress & Monitoring	4.77[a]	4.72[a]	4.65[a]	4.87[a]	4.74[a]	0.002
8. Feedback & Support*	4.50[a]	4.45[a,b]	4.19b	4.38[a,b]	4.43	0.007
9a. Social Media & Communication ***	3.87[a,b]	4.10[a]	3.35[c]	3.65[b,c]	3.86	0.024
9b. Privacy***	5.69[a,b]	5.11c	5.35a,c	5.87[b]	5.46	0.036
End or continuation						
10. Motivation & continuous usage**	5.02[a,b]	4.78[a]	5.03[a,b]	5.08[b]	4.94	0.010

Note. Purpose $F(3, 1416) = 7{,}390$, $p < .001$; Introduction $F(3, 1416) = 13{,}504$, $p < .001$; Personalisation $F(3, 1416) = 3{,}895$, $p = .009$; User-friendly interface $F(3, 1416) = 7{,}3624$, $p < .001$; Database $F(3, 1416) = 16{,}991$, $p < .001$; Education & Information $F(3, 1416) = 2{,}733$, $p < .042$; Progress & Monitoring $F(3, 1416) = 1{,}022$, $p < .382$; Feedback & Support $F(3, 1416) = 3{,}190$, $p < .023$; Social Media & Communication $F(3, 1416) = 11{,}510$, $p < .001$; Privacy $F(3, 1416) = 17{,}705$, $p < .001$; Motivation & continuous usage $F(3, 1416) = 4{,}911$, $p < .002$.

Note. Asterisks indicate that means differ significantly across the consumer segments: *$p < .05$, **$p < .01$, ***$p < .001$.

Note. Measured on a 7-point Likert scale, ranging from 'very unimportant' to 'very important'.

Note. Underlined numbers are the top 3 most important user-centric app aspects per segment.

[a-c] Different superscripts across rows indicate significant different means.

considering health as a multidimensional concept and suggests that in health and nutrition interventions, it is important to take this multidimensionality into account, although a focus on physical health would be relevant to all groups. In their review, Hughner and Kleine (2004) underpin the importance of understanding how consumers think about health and wellness, since the way they look at health influences their health-related behaviour.

4.2. HRMO-based consumer groups mainly differ in their perceived opportunities

The current paper adds to the literature by investigating differences in barriers to adopt a healthy diet across the identified HRMO-based consumer groups. While the groups differ in HRMO, they all equally intent to consume a healthy diet. Although capability and motivations to consume healthy diets show some differences across segments, motivation and capability seem sufficient in all groups. In contrast, all groups encounter barriers in the perceived opportunity to consume a healthy diet. The eating context causes a barrier to follow-up a personalized dietary advice in all segments, which is in agreement with Reinders and colleagues who also pointed out the importance of eating contexts as a barrier to follow up personalized dietary advice (Reinders, Bouwman, van den Puttelaar, & Verain, 2020). Also the financial opportunity poses a barrier to all segments, but particularly for the Mind-motivated consumers. Price being an important factor for food choice is a common finding (Steenhuis et al., 2011; Markovina et al., 2015; Sautron et al., 2015). In addition, concerns about data protection and privacy cause a barrier to the Moderately-motivated, the Health-motivated and the Mind-motivated segments to engage in personalized nutrition services. Privacy barriers are known from the literature. Berezowska et al. (2015) for example suggested that consumers feel that disclosing certain private data is not worth the risk compared to the benefits of receiving personalized nutrition advice. Also Szinay et al. (2021a) discuss data protection concerns as a barrier for the uptake of health and well-being apps. And finally, the physical opportunity (availability) is an additional barrier to Moderately-motivated consumers to select healthy food products. This finding is in accordance with a review by Mackenbach et al. (2019) on socioeconomic differences in the association between food environments and dietary behaviors, in which they conclude that several studies focussing on economics and food environments found a stronger association for populations with a low socio-economic status. Since the Moderately-motivated consumers are characterized by a relative low income, a parallel can be drawn. In addition, Poelman et al. (2023) recently showed that the Dutch food environment indeed leaves much to be desired when it comes to healthy food offerings in retail and in the food catering industry. Interestingly, the social context – rejection by family members or friends – does not pose a problem in following a personalized dietary advice to any of the groups. The literature suggests otherwise. In a systematic review and *meta*-analysis on the effectiveness of app-based nutrition interventions, Villinger and colleagues (2019) conclude that social support is an important building block. The reason for this discrepancy could be the way social context was measured in our study, namely by asking the extent to which the social environment disapproves personalized nutrition advice. Questioning the social support that participants perceive to consume a healthy diet may have led to other results, more in accordance with the literature. In short, this makes clear that although consumers are motivated and feel able to consume a healthy diet, the perceived opportunity to do so forms a barrier in all segments, although in different degrees and in different ways for the different groups. In current literature there is limited and inconclusive support for education-based intervention programmes (de Ridder et al., 2017), which may be explained by our finding, as nutrition campaigns are mainly an instrument to foster capabilities (knowledge, self-efficacy) and motivations, but not to increase the opportunity. Our work shows that opportunity is the main barrier for healthy eating. A nutrition app is also mainly suitable to stimulate motivation and increase the ability to consume a healthy diet, and may therefore not be the right instrument to achieve behaviour change, since opportunity is the main barrier. Otherwise, one can also argue that such interventions and tools should be designed in such a way that they motivate and enable to overcome the perceived (contextual) barriers. More concrete, (personalized) dietary advice should consider the price of foods and come up with healthy, affordable, easily available options. Additionally, the eating context should be taken into account when designing dietary advice: different options can be advised for different setting. Szinay et al. (2021b) also identified tailoring, peer support and embedded professional support as important factors that enhance user opportunities to engage in nutrition apps. Moreover, privacy should be ensured, for example when developing nutrition apps. Finally, other types of instruments, that are suitable to change the opportunity to consume a healthy diet, should get more attention. One can think of subsidies and taxes that can make healthy options financially more attractive, and regulations or guidelines that help increase the offer in healthy options in supermarkets, canteens, restaurants and other types of food outlets (see Løvhaug et al., 2022, for an overview of the potential of food environment policies in relation to healthy diets).

4.3. Moderately-motivated have the most distinct app preferences: Implications for nutrition app development

Finally, the current paper adds to the literature by investigating differences in preferences for nutrition app properties across consumer groups that differ in health motivation. Previous studies indicate that tailoring mHealth, including nutrition apps, seems a promising strategy to increase compliance and engagement with these type of tools (Chen et al., 2020; Materia & Smyth, 2021). Almost all user-centric app aspects (Van der Haar et al., 2023) were rated as important by all segments, but some interesting differences were found. The Moderately-motivated values most user-centric app aspect less than the Mind-motivated consumers, but for social media and communication the opposite was found. A reliable database and ensuring privacy are the top two most important user-centric aspects to all groups, and are therefore prerequisites for nutrition apps in general. This is in agreement with the work by Holzmann and colleagues, who also point to the prerequisites of reliable (evidence-based) information and transparency with regard to data protection (Holzmann, Pröll, Hauner, & Holzapfel, 2017). Additionally, an inaccurate database is also the main barrier for professionals to recommend nutrition apps to clients or patients (Vasiloglou et al., 2020). A user-friendly interface is the third most-important user-centric app aspect for the Moderately-motivated segment, whereas for the other segments, clarity on how to use the app (introduction) ranks third. The recent review by König and colleagues (2021) even identified usability as the most important barrier for using nutrition apps. Social media and communication is the only user-centric app aspects that is not rated as important on the sample level, but the Moderately-motivated do attach some importance to this aspect. This finding is in contrast with the work by Szinay et al. (2021b), who found that embedded social support is an important factor in engagement with health and wellbeing apps. Our study suggests that this is particularly true for a specific subsample of the population (Moderately-motivated). A recent review on E-Health and M−Health interventions focussing on those with a lower socio-economic position found that social support functionalities, such as discussion for a, are rarely used in such interventions (Ronteltap et al., 2022), which may be a missed opportunity to engage the Moderately-motivated.

These findings suggest that, although the consumer groups largely agree in their app preferences, the preferences of the Moderately-motivated deviate most. Although our study does not provide strong support that a tailored approach is needed based on one's HRMO, we find some indications that it may be useful to develop an app, or a version of an app, that is specifically tailored to Moderately-motivated consumers. This app should be particularly user-friendly and should give the opportunity to link to social media platforms. Our

recommendation to tailor an app is in agreement with the work of König and colleagues (2021) who advice against a one-size-fits all.

4.4. Limitations and future research

This study has several limitations that need to be addressed in future research. Respondents were asked to assess app properties on 7-point scales, instead of having consumers choose between app properties. This has resulted in a long list of app elements that are all rated as important to consumers. A follow-up study could use a choice experiment in which several app versions – that vary on several dimensions – are presented, and where respondents have to choose their preferred option. This would make it possible to study trade-offs between certain app elements. Although our study provides some insights in the most important app elements, we are unable to pinpoint the key characteristics that are decisive in whether or not consumers are likely to start and maintain using a nutrition app.

Furthermore, we included both users and non-users of nutrition apps in our study. For participants who never made use of a nutrition app, it might have been more difficult to rate certain app properties (even though we guided them through how nutrition apps work in the survey). Future studies could select respondents that already have some experience with nutrition apps and can give their insights on what works and what does not, for them.

Also the measures that were used, have some limitations. First, HRMO was measured with the 13-item explicit subscale and not with the full 34-item scale. This 13-item subscale has not been validated as a stand-alone scale, and the choice for using only the explicit subscale is likely to be the reason that two of the HRMO-dimensions (emotional and physical wellbeing) show questionable reliability. Since the reliability is just slightly below the acceptable level of 0.7 (Field, 2004), the items are taken from the validated HRMO-scale and the resulting segments show a lot of resemblance with the HRMO-segments as identified by Geeroms and colleagues (2008a), Geeroms and colleagues (200b), the findings can still be considered to be relevant, but including the full HRMO-scale in future studies is recommended to confirm our findings. Second, preferences and behaviors were all self-reported. In order to validate these self-reported findings, an experimental intervention with an app, targeting and measuring actual behavior should be the next step. Referring back to the introduction section, in which we state that a tailored approach is important but that little is known on what characteristics are important to tailor on, we can conclude that our results are not convincing on the added value to tailor nutrition apps to different HRMO-based consumer groups. Since we only found minor differences in nutrition app preferences between the consumer segments based on HRMO, a final recommendation for the future is to study other types of consumer groups in this context. Especially consumers with a lower socio-economic status, or obesity, might benefit most from improving the quality of their diet with the support of nutrition apps. Motivations and preferences of such subgroups need further studying, to be able to conclude whether nutrition apps targeted at certain subgroups may be effective.

4.5. Conclusion

This study shows that four consumer groups can be identified based on their Health-Related Motives Orientations: Health-motivated, Moderately-motivated, Body-motivated and Mind-motivated consumers. These groups differ in their capability, perceived opportunity and motivation to consume healthy diets, although differences are small. In general, we can conclude that all four groups are sufficiently motivated and feel able to consume a healthy diet, but the perceived opportunity forms a barrier to translate intentions into behaviour. Particularly the financial opportunity and the eating context form barriers in all consumer groups. In addition, concerns about data protection, such as the storage and use of personal data, are a barrier to the Health-motivated, Moderately-motivated and Mind-motivated groups for using services that can provide personalized nutrition advice. Moreover, the physical opportunity (availability) is a barrier for the Moderately-motivated group. This suggests that in terms of perceived opportunity, tailoring interventions to the different group is advisable. In their preferences for nutrition app functionalities, the differences between the groups are subtle. Privacy aspects, a reliable and complete food database and clarity on the goal and usage of the app are important requirements for all segments, but a link to social media platforms and the user-friendliness are aspects that need tailoring. Further research is needed to identify and investigate other consumer groups in relation to their needs in nutrition apps that can support them in achieving their healthy eating goals.

Ethical statement

Ethical approval for the involvement of human subjects in this study was granted by the Social Ethics Committee of Wageningen University & Research, Reference number 09215846, 04/01/2020. Participants were recruited by a professional market research agency (MSI-ACI Europe BV). Participants gave informed consent where an affirmative reply was required to enter the survey. They were able to withdraw from the survey at any time without giving a reason. The study was explained to consumers in the online questionnaire. They were informed that only the research team would have access to their anonymized data. Participants were approached by email to fill out an online survey and received an incentive consisting of credits for a personal saving system.

CRediT authorship contribution statement

Muriel C.D. Verain: Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Ireen Raaijmakers:** Conceptualization, Methodology, Writing – review & editing. **Saskia Meijboom:** Conceptualization, Methodology, Project administration, Writing – review & editing. **Sandra van der Haar:** Conceptualization, Methodology, Project administration, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgements

Funding: This work was supported by the Dutch Ministry of Agriculture, Nature and Food Quality, under the research programme KB-37 Healthy and Safe Food System. The funder had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodqual.2024.105145.

References

Afshin, A., Sur, P. J., Fay, K. A., Cornaby, L., Ferrara, G., Salama, J. S., & Collaborators, G. B. D. D. (2019). Health effects of dietary risks in 195 countries, 1990–2017: A systematic analysis for the Global Burden of Disease Study 2017. *The Lancet, 393*(10184), 1958–1972. https://doi.org/10.1016/S0140-6736(19)30041-8

Ares, G., Giménez, A., Vidal, L., Zhou, Y., Krystallis, A., Tsalis, G., & Deliza, R. (2016). Do we all perceive food-related wellbeing in the same way? Results from an exploratory cross-cultural study. *Food Quality and Preference, 52*, 62–73. https://doi.org/10.1016/j.foodqual.2016.03.014

Ares, G., de Saldamando, L., Giménez, A., Claret, A., Cunha, L. M., Guerrero, L., . . . Deliza, R. (2015). Consumers' associations with wellbeing in a food-related context: A cross-cultural study. *Food Quality and Preference, 40*, 304-315. dio: 10.1016/j.foodqual.2014.06.001.

Berezowska, A., Fischer, A. R., Ronteltap, A., van der Lans, I. A., & van Trijp, H. C. (2015). Consumer adoption of personalised nutrition services from the perspective of a risk–benefit trade-off. *Genes & nutrition, 10*, 1–14. https://doi.org/10.1007/s12263-015-0478-y

Bos, C., van der Lans, I. A., van Rijnsoever, F. J., & van Trijp, H. C. M. (2015). Heterogeneity in barriers regarding the motivation, the opportunity and the ability to choose low-calorie snack foods and beverages: Associations with real-life choices. *Public Health Nutrition*. https://doi.org/10.1017/s1368980015002517

Bouwman, E. P., Bolderdijk, J. W., Onwezen, M. C., & Taufik, D. (2022). "Do you consider animal welfare to be important?" activating cognitive dissonance via value activation can promote vegetarian choices. *Journal of Environmental Psychology, 83*, Article 101871. https://doi.org/10.1016/j.jenvp.2022.101871

Brambila-Macias, J., Shankar, B., Capacci, S., Mazzocchi, M., Perez-Cueto, F. J. A., Verbeke, W., & Traill, W. B. (2011). Policy interventions to promote healthy eating: A review of what works, what does not, and what is promising. *Food and Nutrition Bulletin, 32*(4), 365–375. https://doi.org/10.1177/156482651103200408

Capacci, S., Mazzocchi, M., Shankar, B., Brambila Macias, J., Verbeke, W., Pérez-Cueto, F. J., & D'Addesa, D. (2012). Policies to promote healthy eating in Europe: A structured review of policies and their effectiveness. *Nutrition Reviews, 70*(3), 188–200. https://doi.org/10.1111/j.1753-4887.2011.00442.x

Chen, Y., Perez-Cueto, F. J. A., Giboreau, A., Mavridis, I., & Hartwell, H. (2020). The Promotion of Eating Behaviour Change through Digital Interventions. *International Journal of Environmental Research and Public Health, 17*(20). https://doi.org/10.3390/ijerph17207488

Cohen, J., & Cohen, P. (1983). *Applied multiple regression/correlation analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

DiFilippo, K. N., Huang, W.-H., Andrade, J. E., & Chapman-Novakofski, K. M. (2015). The use of mobile apps to improve nutrition outcomes: A systematic literature review. *Journal of Telemedicine and Telecare, 21*(5), 243–253. https://doi.org/10.1177/1357633x15572203

De Ridder, D., Adriaanse, M., Evers, C., & Verhoeven, A. (2014). Who diets? Most people and especially when they worry about food. *Appetite, 80*, 103–108. https://doi.org/10.1016/j.appet.2014.05.011

De Ridder, D., Kroese, F., Evers, C., Adriaanse, M., & Gillebaart, M. (2017). Healthy diet: Health impact, prevalence, correlates, and interventions. *Psychology & health, 32*(8), 907–941. https://doi.org/10.1080/08870446.2017.1316849

Dijkstra, S. C., Neter, J. E., Brouwer, I. A., Huisman, M., & Visser, M. (2014). Motivations to eat healthily in older Dutch adults-a cross sectional study. *International Journal of Behavioral Nutrition and Physical Activity, 11*, 1–12. https://doi.org/10.1186/s12966-014-0141-9

Field, A. (2004). *Discovering statistics using SPSS*. London: Sage Publications Ltd.

Flynn, L. R., & Goldsmith, R. E. (1999). A Short, Reliable Measure of Subjective Knowledge. *Journal of Business Research, 46*(1), 57-66. dio: 10.1016/S0148-2963(98)00057-5.

Geeroms, N., Verbeke, W., & Van Kenhove, P. (2008). Consumers' health-related motive orientations and ready meal consumption behaviour. *Appetite, 51*(3), 704–712. https://doi.org/10.1016/j.appet.2008.06.011

Geeroms, N., Verbeke, W., & Kenhove, P. V. (2008). Health advertising to promote fruit and vegetable intake: Application of health-related motive segmentation. *Food Quality and Preference, 19*(5), 481–497. https://doi.org/10.1016/j.foodqual.2008.02.004

Graça, J., Godinho, C. A., & Truninger, M. (2019). Reducing meat consumption and following plant-based diets: Current evidence and future directions to inform integrated transitions. *Trends in Food Science & Technology, 91*, 380–390. https://doi.org/10.1016/j.tifs.2019.07.046

Guillemin, I., et al. (2016). "How French subjects describe well-being from food and eating habits? Development, item reduction and scoring definition of the Well-Being related to Food Questionnaire (Well-BFQ©)." *Appetite, 96*, 333-346. doi: /10.1016/j.appet.2015.09.021.

Holzmann, S. L., Pröll, K., Hauner, H., & Holzapfel, C. (2017). Nutrition apps: Quality and limitations. An explorative investigation on the basis of selected apps. *Ernaehrungs. Umschau, 64*(5), 80–89. https://doi.org/10.4455/eu.2017.018

Hughner, R. S., & Kleine, S. S. (2004). Views of health in the lay sector: A Compilation and Review of How individuals think about health. *Health, 8*(4), 395–422. https://doi.org/10.1177/1363459304045696

IQVIA Institute for human data science (2021). *Digitial Health Trends 2021: Innovation, evidence, regulation, and adoption*.

Kazbare, L., van Trijp, H. C. M., & Eskildsen, J. K. (2010). A-priori and post-hoc segmentation in the design of healthy eating campaigns. *Journal of Marketing Communications, 16*(1–2), 21–45. https://doi.org/10.1080/13527260903342712

König, L. M., Attig, C., Franke, T., & Renner, B. (2021). Barriers to and Facilitators for Using Nutrition Apps: Systematic Review and Conceptual Framework. *JMIR mHealth and uHealth, 9*(6), e20037.

Løvhaug, A. L., Granheim, S. I., Djojosoeparto, S. K., Harrington, J. M., Kamphuis, C. B., Poelman, M. P., & Terragni, L. (2022). The potential of food environment policies to reduce socioeconomic inequalities in diets and to improve healthy diets among lower socioeconomic groups: An umbrella review. *BMC Public Health, 22*(1), 433. https://doi.org/10.1186/s12889-022-12827-4

Lustria, M. L. A., Noar, S. M., Cortese, J., Van Stee, S. K., Glueckauf, R. L., & Lee, J. (2013). A Meta-Analysis of Web-Delivered Tailored Health Behavior Change Interventions. *Journal of Health Communication, 18*(9), 1039–1069. https://doi.org/10.1080/10810730.2013.768727

Mackenbach, J. D., Nelissen, K. G., Dijkstra, S. C., Poelman, M. P., Daams, J. G., Leijssen, J. B., & Nicolaou, M. (2019). A systematic review on socioeconomic differences in the association between the food environment and dietary behaviors. *Nutrients, 11*(9), 2215. https://doi.org/10.3390/nu11092215

Markovina, J., Stewart-Knox, B. J., Rankin, A., Gibney, M., de Almeida, M. D. V., Fischer, A., … Frewer, L. J. (2015). Food4Me study: Validity and reliability of Food Choice. *Questionnaire in 9 European countries. Food quality and preference, 45*, 26–32.

Materia, F. T., & Smyth, J. M. (2021). Acceptability of intervention design factors in mHealth Intervention research: Experimental Factorial Study. *JMIR mHealth and uHealth, 9*(7), e23303.

Meijboom, S., Raaijmakers, I., Verain, M. C. D., Haar, S., & Doets, E. L. (2020). *Prerequisites for nutrition apps to engage consumers in long-term usage*. https://library.wur.nl/WebQuery/wurpubs/fulltext/539901.

Michie, S., Atkins, L., & West, R. (2014). *The behaviour change wheel. A guide to designing interventions*. 1st ed. Great Britain: Silverback Publishing, 1003-1010.

Noar, S. M., Benac, C. N., & Harris, M. S. (2007). Does tailoring matter? Meta-analytic review of tailored print health behavior change interventions. *Psychological Bulletin, 133*(4), 673. https://doi.org/10.1037/0033-2909.133.4.673

Norman, C. D., & Skinner, H. A. (2006). eHEALS: The eHealth Literacy Scale. *Journal of Medical Internet Research, 8*(4), e27.

Onwezen, M. C., Van 't Riet, J., Dagevos, H., Sijtsema, S. J., & Snoek, H. M. (2016). Snacking now or later? Individual differences in following intentions or habits explained by time perspective. *Appetite, 107*, 144–151. https://doi.org/10.1016/j.appet.2016.07.031

Patel, M. L., Wakayama, L. N., & Bennett, G. G. (2021). Self-monitoring via digital health in weight loss interventions: A systematic review among adults with overweight or obesity. *Obesity, 29*(3), 478–499. https://doi.org/10.1002/oby.23088

Phillips, C. M., Chen, L.-W., Heude, B., Bernard, J. Y., Harvey, N. C., Duijts, L., & Suderman, M. (2019). Dietary inflammatory index and non-communicable disease risk: A narrative review. *Nutrients, 11*(8), 1873. https://doi.org/10.3390/nu11081873

Poelman, M. P., Dijkstra, S. C., Djojosoeparto, S. K., Winkel, D., Linnebank, C., Seidell, J. C., ... Kamphuis, C. B. M. (2023). Monitoring the healthiness of food environments in supermarkets and out-of-home settings. *European Journal of Public Health, 33* (Supplement_2), ckad160-1021. doi :10.1093.

Puska, P., & Luomala, H. T. (2016). Capturing qualitatively different healthfulness images of food products. *Marketing Intelligence & Planning, 34*(5), 605-622. dio: 10.1108/MIP-06-2015-0119.

Raaijmakers, I., Sijtsema, S., Labrie, C., & Snoek, H. (2018). Consumer segmentation based on health-related motive orientations and fruit and vegetable consumption. *British Food Journal*. https://doi.org/10.1108/BFJ-02-2018-0098

Reinders, M. J., Bouwman, E. P., van den Puttelaar, J., & Verain, M. C. D. (2020). Consumer acceptance of personalised nutrition: The role of ambivalent feelings and eating context. *PLoS One, 15*(4), e0231342.

Ronteltap, A., Bukman, A. J., Nagelhout, G. E., Hermans, R. C., Hosper, K., Haveman-Nies, A., ... & Bolman, C. A. (2022). Digital health interventions to improve eating behaviour of people with a lower socioeconomic position: a scoping review of behaviour change techniques. *BMC nutrition, 8*(1), 1-13.

Ryan, R. M., Patrick, H., Deci, E. L., & Williams, G. C. (2008. Facilitating health behaviour change and its maintenance: Interventions based on self-determination theory. *European Health Psychologist, 10*(1), 2-5.

Sautron, V., Péneau, S., Camilleri, G. M., Muller, L., Ruffieux, B., Hercberg, S., & Méjean, C. (2015). Validity of a questionnaire measuring motives for choosing foods including sustainable concerns. *Appetite, 87*, 90–97. https://doi.org/10.1016/j.appet.2014.12.205

Schoeppe, S., Alley, S., Van Lippevelde, W., Bray, N. A., Williams, S. L., Duncan, M. J., & Vandelanotte, C. (2016). Efficacy of interventions that use apps to improve diet, physical activity and sedentary behaviour: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 13*(1), 127. https://doi.org/10.1186/s12966-016-0454-y

Sialino, L. D., Wijnhoven, H. A. H., van Oostrom, Picavet, H. S. J., Verschuren, W. M. M., … Schaap, L. A. (2023). Perspectives of older women in the Netherlands: identifying motivators and barriers for healthy lifestyles and determinants of healthy aging. *BMC Public Health, 23*(1), 1–11.

Sijtsema, S. J., Dagevos, H., Nassar, G., van Haaster de Winter, M., & Snoek, H. M. (2021). Capabilities and Opportunities of Flexitarians to Become Food Innovators for a Healthy Planet: Two Explorative Studies. *Sustainability, 13*(20), 11135. https://doi.org/10.3390/su132011135

Sijtsema, S. J., Raaijmakers, I., Onwezen, M. C., & Doets, E. (2019). Exploring health-related motive orientations among Dutch seniors. *British Food Journal, 122*(11), 3499–3512. https://doi.org/10.1108/BFJ-03-2019-0192

Slater, M. D. (1995). Choosing audience segmentation strategies and methods for health communication. In E. Maibach & R. L. Parrott (Eds.), *Designing health messages: Approaches from communication theory and public health practice* (pp. 186–198). Thousand Oaks, CA:Sage.

Slater, M. D. (1996). Theory and Method in Health Audience Segmentation. *Journal of Health Communication, 1*(3), 267–284. https://doi.org/10.1080/108107396128059

Snyder, L. B. (2007). Health Communication Campaigns and Their Impact on Behavior. *Journal of Nutrition Education and Behavior, 39*(2, Supplement), S32-S40. doi: 10.1016/j.jneb.2006.09.004.

Steenhuis, I. H., Waterlander, W. E., & De Mul, A. (2011). Consumer food choices: The role of price and pricing strategies. *Public Health Nutrition, 14*(12), 2220–2226. https://doi.org/10.1017/S1368980011001637

Stewart-Knox, B. J., Markovina, J., Rankin, A., Bunting, B. P., Kuznesof, S., Fischer, A. R. H., & Frewer, L. J. (2016). Making personalised nutrition the easy choice: Creating policies to break down the barriers and reap the benefits. *Food Policy, 63*, 134–144. https://doi.org/10.1016/j.foodpol.2016.08.001

Szinay, D., Jones, A., Chadborn, T., Brown, J., & Naughton, F. (2020). Influences on the uptake of and engagement with health and well-being smartphone apps: Systematic review. *Journal of Medical Internet Research, 22*(5), e17572.

Szinay, D., Perski, O., Jones, A., Chadborn, T., Brown, J., & Naughton, F. (2021a). Influences on the uptake of health and well-being apps and curated app portals: Think-aloud and interview study. *JMIR mHealth and uHealth, 9*(4), e27173.

Szinay, D., Perski, O., Jones, A., Chadborn, T., Brown, J., & Naughton, F. (2021b). Perceptions of factors influencing engagement with health and well-being apps in the United Kingdom: Qualitative interview study. *JMIR mHealth and uHealth, 9*(12), e29098.

van der Haar, S., Raaijmakers, I., Verain, M. C., & Meijboom, S. (2023). Incorporating Consumers' Needs in Nutrition Apps to Promote and Maintain Use: Mixed Methods Study. *JMIR mHealth and uHealth, 11*(1), e39515.

Vasiloglou, M. F., Christodoulidis, S., Reber, E., Stathopoulou, T., Lu, Y., Stanga, Z., & Mougiakakou, S. (2020). What Healthcare Professionals Think of "Nutrition & Diet" Apps: An International Survey. *Nutrients, 12*(8). https://doi.org/10.3390/nu12082214

Verain, M. C. D., Bouwman, E. P., Galama, J., & Reinders, M. J. (2022). Healthy eating strategies: Individually different or context-dependent? *Appetite, 168*, Article 105759. https://doi.org/10.1016/j.appet.2021.105759

Villinger, K., Wahl, D. R., Boeing, H., Schupp, H. T., & Renner, B. (2019). The effectiveness of app-based mobile interventions on nutrition behaviours and nutrition-related health outcomes: A systematic review and meta-analysis. *Obesity Reviews, 20*(10), 1465–1484. https://doi.org/10.1111/obr.12903

Wang, Q., Egelandsdal, B., Amdam, G. V., Almli, V. L., & Oostindjer, M. (2016). Diet and Physical Activity Apps: Perceived Effectiveness by App Users. *JMIR mHealth and uHealth, 4*(2), e33.

Wedel, M., & Kamakura, W. (2000). *Market Segmentation: Conceptual and methodological foundations* (2nd ed.). Boston: Kluwer Academic Publishers.

Wilson, B. J. (2007). Designing Media Messages About Health and Nutrition: What Strategies Are Most Effective? *Journal of Nutrition Education and Behavior, 39*(2, Supplement), S13-S19. doi: 10.1016/j.jneb.2006.09.001.

Wilson-Barlow, L., Hollins, T. R., & Clopton, J. R. (2014). Construction and validation of the healthy eating and weight self-efficacy (HEWSE) scale. *Eating Behaviors, 15*(3), 490–492. https://doi.org/10.1016/j.eatbeh.2014.06.004

Zhao, J., Freeman, B., & Li, M. (2016). Can Mobile Phone Apps Influence People's Health Behavior Change? An Evidence Review. *Journal of Medical Internet Research, 18*(11), e287.