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Preferences and willingness to pay for personalized nutrition interventions: Discrete choice experiments in Europe and the United States

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ABSTRACT

This study gives insight into what intervention-related factors are crucial for using personalized nutrition (PN) interventions, as well as what the general population is willing to pay for PN. This was done by focusing on two different types of PN (i.e., PN advice and personalized meals) in two discrete choice experiments (DCEs). The DCEs were conducted in four European countries and the United States, including at least 500 respondents per country aged 18–65 years. Panel mixed multinomial logit models were used to evaluate the preferences. Results show that for both types of PN in all countries, the total expenditure on nutrition was the most crucial factor when choosing a PN intervention. The participation rate for specific hypothetical scenario's varied but was considered high overall (maximum 81 % for 'PN advice' and 87 % for 'personalized meals' in Spain). Moreover, highest willingness to pay estimates were found for six kilograms of weight loss. For example, Polish respondents were willing to spend an extra 25.78 euros per week for 'personalized meals' for a 4-month period to lose six kilograms. Our models showed preference heterogeneity between, but also within, the different countries. In conclusion, this study showed that people seem willing to pay for and participate in PN interventions. Since PN interventions may improve health outcomes, policymakers should consider subsidizing some of the costs, financially incentivizing PN interventions or introducing commitment lotteries to encourage uptake. More research is needed to study heterogeneity in preferences.

1. Introduction

Globally, 41 million people die each year from noncommunicable diseases (NCDs), which is equivalent to 74 % of all deaths (WHO, 2022). Many types of NCDs, such as cardiovascular diseases, cancers, and diabetes, occur because of a combination of genetic, physiological, environmental, and behavioral factors. Behavioral factors are oftentimes modifiable and include tobacco use, alcohol use, physical activity, and an unhealthy diet, which increase the risk of NCDs and thereby increase the number of deaths. For example, there are yearly 1.8 million deaths attributed to excess salt/sodium intake, since over usage could lead to high blood pressure and cardiovascular disease (Global Burden of Disease Collaborative Network, 2020). Among most NCDs, a diet is a common risk factor and therefore attracts attention and effort to find effective strategies for providing healthy food (Budreviciute et al., 2020). One of these strategies may be personalized nutrition (PN).

PN has no agreed definition, but it can be seen as an approach that uses individual characteristics, such as genetic, phenotypic, medical, nutritional, and other relevant information to develop targeted nutritional advice, products, or services (Ordovas et al., 2018) with the overall goal to preserve or improve health. Since advice, products or services are more relevant for a specific person when personalized, this can in turn lead to a higher compliance to a specific PN intervention (Adams et al., 2020; Brug et al., 2003). This personalized way of providing nutrition interventions has been shown in previous research to be more effective than generic nutrition interventions, although there is not yet consistency in evidence of effectiveness (Brug et al., 2003; Celis-Morales et al., 2017; Shyam et al., 2022).

Several studies have demonstrated that there is a high degree of interest in PN, and that there might even be a market for PN (Pérez-Troncoso et al., 2021; Szakály et al., 2021). PN is explained by Ordovas et al., 2018 who make a distinction between a biological/medical basis

Abbreviations: BMI, body mass index; DCE, Discrete choice experiment; IQR, Interquartile range; MIXL, panel mixed multinomial logit; MNL, multinomial logit model; NCD, noncommunicable diseases; PN, Personalized Nutrition; SDs, standard deviations; UK, United Kingdom; US, United States; WTP, Willingness to pay.

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(i.e., different responses to foods because of genotypic or phenotypic characteristics) and the behavioral/psychological basis of nutrition (Dijksterhuis et al., 2021). Combining these two creates a 'high level' of personalization of nutrition. New interventions developed in different projects, such as PREVENTOMICS (Empowering consumers to PREVENT diet-related diseases through OMICS sciences, Horizon 2020: No.818318), can be viewed as PN with both biological/medical information and behavioral/psychological information (i.e., high level of PN) (Keijer et al., 2023). During the PREVENTOMICS project a platform was developed, including a decision support system, which was integrated into three interventional studies. The focus of two of these studies was on PN advice and one of these studies delivered personalized meals. Moreover, a behavioral change program was included in all of the interventional studies (see website for more information (PREVENTOMICS, 2022)). The PREVENTOMICS project showed promising results of effectiveness but with uncertainty surrounding the effects (Aldubayan et al., 2022; Del Bas, 2022). Besides the effectiveness, there might be several intervention-related factors that affect individual's willingness and ability to use a PN intervention. Gaining insights in what factors of different high-level PN interventions individuals found important is relevant for the developers and designers of PN interventions (Yang et al., 2020). With this, a PN intervention can be tailored to the needs of an individual, which in turn might lead to more satisfaction, better uptake, better health, and more efficient interventions (Ostermann et al., 2017).

There are methods available to quantify people's preferences regarding different characteristics of interventions (Bridges et al., 2011; Ryan, 2004). In this, 'preferences' could be defined as 'qualitative or quantitative assessments of the relative desirability or acceptability to patients of specified alternatives or choices among outcomes or other attributes that differ among alterative health interventions' (U.S. Department of Health and Human Services Food and Drug Administration et al., 2016).' One method to elicit individuals' preferences that is increasingly being used in health care and public health (Soekhai et al., 2019) and often used in food research as well (Lizin et al., 2022) is a discrete choice experiment (DCE). In a DCE, respondents are asked to state their preferences by evaluating several hypothetical interventions, which are shown to respondents in a series of questions called choice tasks (Bridges et al., 2011; Ryan, 2004). These interventions have several characteristics (i.e., attributes) that vary (i.e., attribute levels). It is possible to study the relative importance of attributes and levels to one another with statistical methods. These methods underline the random utility theory in which each option that is considered has latent utility and the choice alternative with the greatest utility to the respondent will be chosen (Hensher et al., 2015; Louviere et al., 2000; McFadden, 1973; Ryan et al., 2008). Moreover, statistical methods can be used to elicit marginal rates of substitution such as the willingness to pay (WTP) (Hensher et al., 2015); which reflects the amount users would be willing to pay in order to gain something else such as health. Since users of PN interventions are expected to pay at least a part of the intervention costs out-of-pocket, it is important to estimate this WTP (Ryan et al., 2008; Veldwijk et al., 2013). Although the aim of this study is not to explain heterogeneity in preferences by identifying factors that influence preferences, it is crucial to explore how WTP varies across income levels. This exploration is motivated by previous research suggesting that (1) price might be an important factor for (dis)utility associated with meal choices (Livingstone et al., 2021) and could therefore potentially be a barrier to participate in PN interventions and (2) income could be correlated to this (Livingstone et al., 2021). This information can be valuable when making decisions about the implementation and reimbursement of PN interventions. Moreover, it is important to know if the preferences and WTP differ between countries, since culture differences might lead to different flavors, meal patterns, meal cycles (Kittler et al., 2016) and thereby potential differences in preferences about PN.

To our knowledge, no preference study has ever investigated people's preferences regarding the characteristics of different types of high-level PN interventions and the WTP of PN interventions. However, preferences of respondents for specific interventions will be increasingly important for health technology assessment bodies as supportive evidence (van Overbeeke et al., 2021). Therefore, the aim of this study was to determine which intervention-related factors are crucial for people when deciding to participate in PN interventions as well as how much the general population in Europe and the United States (US) is willing to pay for PN interventions. Additionally, we aimed to calculate the population level participation rate for different hypothetical PN interventions and to investigate if and to what extent the outcomes differ between countries (while accounting for heterogeneity in preferences of respondents within and between countries). The PN interventions that we studied were 'PN advice' and 'personalized meals'. Based on the outcomes, recommendations can be made on what characteristics of PN interventions would most likely be preferred by the potential users. These recommendations can be considered when developing PN interventions to prevent NCDs, thus increasing their reach, and hence their public health benefit.

2. Methods

2.1. Discrete choice experiment

This study used an online questionnaire containing two different DCE's to elicit people's preferences for attributes of PN interventions. These two DCE's consisted of two hypothetical PN interventions primarily based on the interventional studies from the PREVENTOMICS project: DCE1: 'PN advice' and DCE2: 'personalized meals' (Keijer et al., 2023; PREVENTOMICS, 2022).

2.2. Study sample and recruitment

For the DCEs in this study, a study sample of individuals aged 18–65 years were recruited from the general population representing the US and all wind directions of Europe: the Netherlands (west), the United Kingdom (UK) (north), Spain (south) and Poland (east) (United Nations, 2023). These countries were chosen for different reasons. First, literature showed that central/northern European countries have different meal patterns than Mediterranean countries, which involves a reason to include these variety of European countries (Huseinovic et al., 2016). Second, the US was included as well, since this might show interesting differences due to differences in food consumption patterns and culture (Kittler et al., 2016; Mitchell, 2004). The general population was chosen since PN might be useful for preserving health and preventing diseases.

Respondents were required to provide informed consent to participate in the study and were recruited via a commercial survey sampling company Dynata, Rotterdam, Netherlands. These respondents received a small financial compensation when the questionnaire was completed. Data was collected in the UK and in the Netherlands in May 2022 and in Poland, Spain, and the US in September 2022. Recruitment in each country was continued until at least 500 respondents completed the questionnaire. The study was approved by the internal ethical review board of the Erasmus School of Health Policy & Management [IRB 20-15].

2.3. Case study, attributes, and levels

In this study, two different DCEs involving two different types of PN interventions were performed. These types were (1) PN advice and (2) personalized meals. These types were primarily chosen because of interventional studies that took place as part of the PREVENTOMICS project. Moreover, a recent literature review of the cost-effectiveness of PN interventions, showed that PN advice was the most frequently assessed type of PN intervention when cost and effects of PN were investigated (Galekop et al., 2021).

For both DCEs, attributes and levels were derived (independently for both DCEs) by several consecutive steps. These included a literature review, focus group studies with the general population and expert interviews. First, a list of different characteristics of PN interventions was compiled, following previous published literature (Church et al., 2018; Galekop et al., 2021; Ryan et al., 2015; Shyam et al., 2022; Wang & Hu, 2018). This resulted in the first draft of attributes and levels. Second, to ensure that all different characteristics of PN interventions were included, three focus group studies were conducted with a total of 18 participants from the Netherlands. An additional aim of the focus groups was to gain information about the different levels for the attributes. The focus group studies were conducted following the guideline of Krueger (Krueger, 2002). We had no reason to believe that other important attributes had come up if focus groups were conducted in more countries. See Appendix A for more details about the focus groups methods and a summary of the results. Third, the attributes and levels created were presented to different nutrition intervention experts (i.e., different partners in the PREVENTOMICS project) and choice modelling experts, during a meeting with the Erasmus Choice Modelling Centre. This was done to ensure that the attributes and levels were clinically relevant, suited the PREVENTOMICS project and fulfilled the properties of a rigorous DCE. Lastly, they were finalized by the research team. These three steps resulted in six different attributes with different levels for the two DCEs. Tables 1 and 2 show the attributes and levels.

2.4. DCE design and questionnaire

The questionnaire that included the two DCEs was developed and designed following good research practices (Bridges et al., 2011; Soekhai et al., 2019). A draft questionnaire was assessed in a pre-testing session with ten respondents in the Netherlands. Furthermore, seven think-aloud sessions were held to obtain more insight into how people approached answering the questionnaire (Bridges et al., 2011). This draft questionnaire was comparable to the final questionnaire, as respondents indicated that the questionnaire was clear, and that the length was manageable. Only minor changes were made in the formulation of attributes, levels, and some questions. After pre-testing, the questionnaire was translated into English by the researchers and a pilot with the final questionnaire was done in the Netherlands and the UK with approximately 10 % of the total study sample in the Netherlands and the UK. The set-up of the questionnaire is explained later in this paragraph.

Table 1
Attributes and levels of discrete choice experiment 1 (DCE1) 'PN advice' in the Netherlands.[a]

Attribute*: explanation*	Attribute Level
Type of personalized nutrition advice*: given via an app on people's mobile phone.*	Advice on recipes via app
	Advice on food products via app
Number of dietician appointments*: face-to-face or online consultations for extra support/ monitoring.*	0 per month
	1 per month
	2 per month
	3 per month
Number of behavioral reminders*: personalized messages sent via an app to motivate people for stepping out of the comfort zone and to try new behaviors that contribute to a healthy lifestyle.*	0 per week
	1 per week
	3 per week
	1 per day
Total expenditure on nutrition*: amount people spend on everything related to nutrition and consisted of two components: (1) the attribute level* (i.e., *the extra amount people spend because of the PN intervention) and (2) respondents' current expenditure. The summed amount of these two components was shown to the respondent.*	0 euros per week
	31 euros per week
	63 euros per week
	94 euros per week
Use of time*: the time people spend compared to their current eating pattern, by getting PN advice* (e.g., *time for blood sampling or dietician appointments).*	5 min more per day
	15 min more per day
	30 min more per day
	60 min more per day
Expected outcomes*: health outcomes of the intervention.*	Longer life expectancy and weight loss of up to 0 kg after 4 months
	Longer life expectancy and weight loss of up to 2 kg after 4 months
	Longer life expectancy and weight loss of up to 4 kg after 4 months
	Longer life expectancy and weight loss of up to 6 kg after 4 months

Note: [a] The attributes and levels are the same for all other countries, but 'total expenditure on nutrition' was converted with the purchasing power parity to relevant currencies and amounts.

Table 2
Attributes and levels discrete choice experiment 2 (DCE2) 'personalized meals' in the Netherlands.[a]

Attribute	Attribute Level
Meals provided	Personalized dinner
	Personalized lunch and dinner
	Personalized breakfast and dinner
	Personalized breakfast, lunch, and dinner
Number of dietician appointments	0 per month
	1 per month
	2 per month
	3 per month
Number of behavioral reminders	0 per week
	1 per week
	3 per week
	1 per day
Total expenditure on nutrition	0 euros per week
	81 euros per week
	163 euros per week
	244 euros per week
Use of time	5 min more per day
	15 min more per day
	30 min more per day
	60 min more per day
Expected outcomes	Longer life expectancy and weight loss of up to 0 kg after 4 months
	Longer life expectancy and weight loss of up to 2 kg after 4 months
	Longer life expectancy and weight loss of up to 4 kg after 4 months
	Longer life expectancy and weight loss of up to 6 kg after 4 months

Note: [a] The attributes and levels are the same for all other countries, but 'total expenditure on nutrition' was converted with the purchasing power parity to relevant currencies and amounts.

In reference to the DCEs included in this questionnaire, it was not possible to present all combinations of attributes and levels to the respondent, since this would result in an unfeasible number of combinations of alternatives. Therefore, a subset of alternatives was selected using a Bayesian D-efficient design, which is increasingly used in food DCEs (Lizin et al., 2022), generated with NGene 1.2.1 software (ChoiceMetrics, 2018; Johnson et al., 2013). For the pilot study beta priors were based on best guesses with uniform distributions. These distributions and beta priors were updated based on the pilot data in the Dutch setting (n = 52) (Johnson et al., 2013). Attributes that showed significance, were updated accordingly assuming a normal distribution, other attributes were updated while maintaining uniform distributions. In the other four countries, the same updated design (i.e., updated priors) as in the Netherlands was used to eliminate possible between-country differences in preference outcome resulting from the design (Visser et al., 2021). No other changes were made to the questionnaire after the pilot study and data collection was completed in the Netherlands and the UK. Partners from the PREVENTOMICS project translated the questionnaires to Polish and Spanish using backward and forward translation, after which the pilot and final data collection was done in those remaining countries including the US.

Both DCEs consisted of 24 choice tasks that were divided into three blocks of eight choice tasks per block, each containing two alternatives. This was done to reduce the burden for the respondent. The design forced respondents to choose between the two alternatives (i.e., types of PN interventions), but after each choice task, respondents were asked whether they would actually choose the intervention they had selected or if they would rather choose their own current eating pattern (i.e., opt-out) (Veldwijk et al., 2014). This opt-out option was included as in real life people may also want to stick by their current eating pattern and not want to choose a PN intervention (Bøgelund et al., 2011). The opt-out showed people's actual current eating pattern (based on previous asked questions), because literature shows that respondents use their current choices as a reference for ranking hypothetical alternatives (Ben-Akiva et al., 1992). An example of a choice task for 'PN advice' can be found in Figs. 1 and 2. The DCE for 'personalized meals' had the same form as 'PN advice'.

Before the choice tasks were shown to the respondents, the questionnaire started with an introductory text and the request for informed consent. The remainder of the questionnaire was divided into seven sections. The first section contained questions regarding some general respondent characteristics, such as age, gender, height, and weight. The second section included questions about respondents' current eating style, by asking several questions about the use of (personalized) nutrition interventions and expenditure behavior. The aim of these questions was twofold: a) to get more insight in people's use of nutrition interventions and expenditure behavior and b) to use the answers to these questions as input for the opt-out option in the DCEs. Third, people were given a detailed explanation of all attributes and levels, followed by instructions on how to complete a choice task with an example. Fourth, the respondents were shown the first eight choice tasks ('PN advice'), where every choice task started with the question: 'Imagine having the choice between two different personalized nutrition advice. Which of the options below (1 or 2) would you prefer?'. In the next step, the following question was asked: 'Suppose you have to choose between your previous choice for personalized nutrition advice (1) and your current eating pattern. Which option would you prefer? Personalized nutrition advice (1) or your current eating pattern?'. The fifth section contained some general questions, such as marital status, household size, nationality, educational status, work, and income. Sixth, respondents were shown another extensive explanation about the meaning of the next attributes and levels and continued with the next eight choice tasks ('personalized meals'), where every choice task started with the question: 'Imagine having the choice between two different personalized meal interventions. Which of the options below (1 or 2) would you prefer?'. Followed by asking them again to choose between their previous choice and their current eating pattern. The sixth section contained some lifestyle related questions based on questions set up by Dieteren et al., 2020 where we asked respondents about their experiences with health, allergy, eating habits, exercise patterns and health goals (Dieteren et al., 2020). Finally, we closed with questions about the perceived difficulty of the questionnaire and the option for the respondent to provide feedback or ask questions about the study. The questionnaire was designed using Sawtooth Software Lighthouse Studio 9.8.0.

2.5. *Statistical analyses*

The choices that respondents made in the DCEs were used to analyze which trade-offs respondents were willing to make regarding different PN intervention attributes. The data were analyzed separately in every country in both DCEs. Data was handled as if respondents had three options to choose from.

As a starting point for model specification, a main effects multinomial logit model (MNL) was used. We tested for linearity of the numeric levels and included two alternative specific constants to correct for (1) the first presented alternative (left bias) and (2) the last presented alternative (the opt-out) (i.e., left–right bias). Attributes were considered categorical if in at least one country the slopes of the levels of one attribute were unequal (Hauber et al., 2016). This was the case for all attributes in both DCEs and so these attributes were dummy coded. However, 'the total expenditure on nutrition' was analyzed as a continuous variable since this allows us to calculate respondents' marginal WTP (Revelt & Train, 1998). The alternative specific constant for left bias was excluded in the end, since in both DCEs this constant was not significant ($p > 0.05$) in any country. Finally, panel mixed multinomial logit (MIXL) models were used to allow preference heterogeneity and to adjust for the multilevel structure of the data (each respondent answered eight choice tasks) (Fiebig et al., 2010). Based on the significance of the estimates of the standard deviations (SDs), it was decided which attributes to include as random parameters (with normal distribution) due to significant preference heterogeneity ($p < 0.05$). This was done for each country and DCE separately and attributes were included as random if the SDs of at least one level of the attribute was statistically significant ($p < 0.05$). The equations for the final main effect models that were used to estimate the utility of either 'PN advice' or 'personalized meals' can be found in Appendix B.

Parameter estimates (β) from the analyses were used to indicate the relative importance of attributes and their levels. If the coefficients were statistically significant at alpha = 0.05 this indicated that respondents considered the attribute important in making their choices concerning PN. The sign of the parameter estimates reflects whether the attribute

Fig 1. Example of a choice task of 'PN advice' in the UK. Respondents had to choose between these alternatives and select their preference.

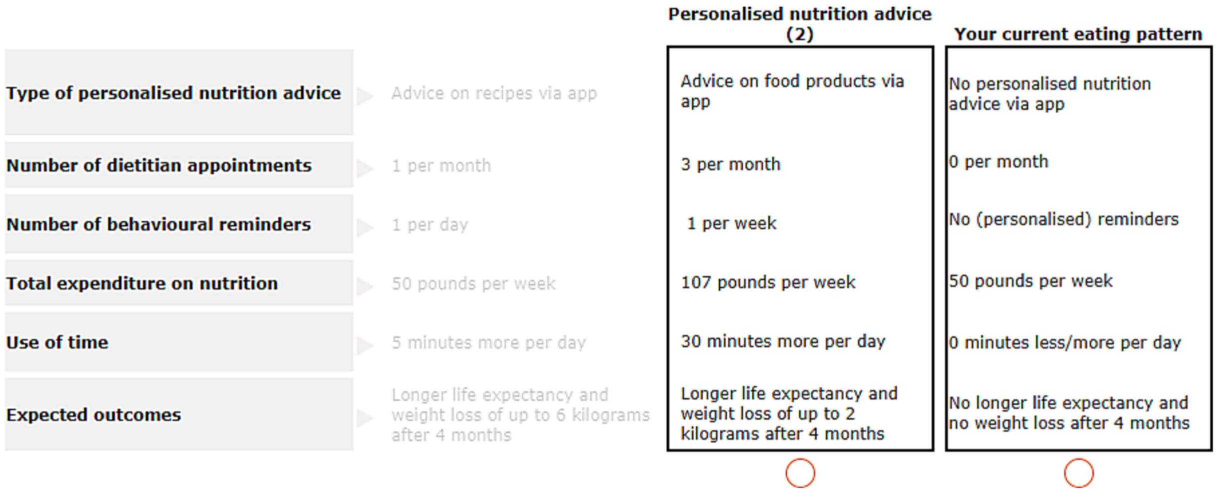

Fig 2. Example of a choice task of 'PN advice' in the UK. Respondents were shown the chosen PN intervention from the first step and were asked to compare this with their current eating pattern and select their preference.

level had a negative or positive effect on utility. The size of these coefficients was further used to examine the relative importance of the attributes. The relative importance of attributes was assessed by first taking the difference between the most and least desirable attribute level in each attribute. Second, this difference was divided by the sum of differences of all attributes (Gonzalez, 2019). The larger this value, the larger the relative importance of an attribute. Moreover, we calculated how many respondents always chose the opt-out option, and how many respondents who chose a PN intervention in all choice tasks, always chose the PN intervention with the lowest cost level. These calculations were performed for each country separately, including the distinction between 'PN advice' and 'personalized meals'.

Moreover, as described earlier in this section 2.5, the coefficients were used for calculating the WTP (Revelt & Train, 1998; Ryan et al., 2008). This was done to calculate the amount of money an individual is willing to spend to lose weight. The 'total expenditure on nutrition' and 'expected outcomes' were used as a proxy for this. As stated before (section 2.3), 'the total expenditure on nutrition' consisted of two components, of which the attribute level was used for WTP calculations. The WTP can been seen as the ratio of the attribute coefficients of 'expected outcomes' to the cost coefficient (Revelt & Train, 1998). Since the 'expected outcome' is not linear, the WTP is consequently not fixed in each country and instead differs per change in level of the 'expected outcome'. The difference in individual coefficients between two levels was thus divided by the individual coefficient of 'total expenditure on nutrition' to calculate the WTP. Individual coefficients were used since both attributes were included as random parameters in the analyses (Louviere et al., 2000; Ryan et al., 2008). Additionally, since only one component (i.e., the attribute level) was used as a proxy for the cost component, we studied whether the WTP varied when the other component (i.e., current expenditure on nutrition) was low or high. A distinction between low and high current expenditure was based on the median, where respondents with an expenditure above the median were labeled as 'high'.

To calculate the uptake or participation rate for the different PN interventions, four alternative scenarios were chosen. This was done for (1) the least preferred scenario, (2) the most preferred scenario, and (3–4) PREVENTOMICS interventions. The last two scenarios included attribute levels that were assumed to resemble the interventions studied during the PREVENTOMICS project. These scenarios were all compared to having no PN intervention, and thus with the current eating pattern. Uptake was predicted by taking the exponent of the utility for the intervention scenario under evaluation divided by the sum of the intervention scenario utility's exponent and the no treatment utility's exponent (Hensher et al., 2015). Again, the choice probabilities could not be calculated directly since attributes were included as random parameters, and therefore individual estimates were used. The mean participation rates of all respondents were calculated by taking the average of all participation rate probabilities.

Since we compared the attribute level estimates of five countries, the role of the scale parameter needs to be considered (Swait & Louviere, 1993). This is because the coefficients that are estimated in models are a ratio of the true parameter estimates and a scale parameter (i.e., inverse variance) (Swait & Louviere, 1993; Veldwijk et al., 2019). However, since variances might differ between countries (i.e., data sets), the attribute level estimates cannot be compared directly between countries before scale factor differences (differences in variance) between the models are ruled out. We used the Swait and Louviere test for this purpose. Details about the applied Swait and Louviere test can be found in the study by (Veldwijk et al., 2013). All analyses were done using Stata 17 software.

3. Results

3.1. Respondents' characteristics

In total, 513 respondents completed the questionnaire in the Netherlands, 525 in the UK, 516 in the US, 501 in Spain and 501 in Poland after the inclusion criteria were met and informed consent was provided. The respondents had a median age ranging from 39 years in Poland to 48 years in the Netherlands. In all countries, there were slightly more females than males. The median body mass index (BMI) of respondents in the Netherlands, the UK, Spain, and Poland was very close to being overweight (BMI > 25 kg/m2) and the median BMI of respondents in the US just passed the BMI minimum of overweight; this is supported by the percentages of respondents in the overweight and obese weight category (NHS, 2022). Most of the respondents in all countries rated their health as 'very good' or 'good' and the Netherlands had the biggest proportion of respondents that indicated having a healthy diet (40.2 %) and to be physical active (47.8 %). Lastly, approximately one-quarter to one-third of respondents reported having a chronic disease, ranging from 24.4 percent in the UK to 35.3 percent in Poland. See Appendix C for more details about the respondents' characteristics.

3.2. Preference heterogeneity and relative importance

Table 3 shows the results of the panel MIXL model for 'PN advice'

Table 3
Preferences for PN advice interventions (DCE1) based on a panel MIXL stratified by country.

Attributes	Level	The Netherlands		UK		US		Spain		Poland	
		Coefficient	Std. err.	Coefficient	Std. err.	Coefficient	Std. err.	Coefficient	Std. err.	Coefficient	Std. err.
Constant (opt-out)		−0.774**	0.187	−0.796**	0.157	−0.416*	0.166	−1.079**	0.188	−0.458*	0.183
Type of personalized nutrition advice	Advice on recipes via app (ref)	0.000	x	0.000	x	0.000	x	0.000	x	0.000	x
	Advice food products via app	−0.015	0.069	−0.104	0.058	0.023	0.061	0.110	0.062	0.005	0.064
Number of dietician appointments	0 per month (ref)	0.000	x	0.000	x	0.000	x	0.000	x	0.000	x
	1 per month	0.083	0.109	0.041	0.086	−0.024	0.089	0.290**	0.093	0.263**	0.094
	2 per month	0.011	0.107	0.060	0.090	−0.195*	0.093	0.011	0.096	0.050	0.098
	3 per month	−0.170	0.097	−0.089	0.083	−0.286**	0.088	0.036	0.091	−0.001	0.091
Number of behavioral reminders	0 per week (ref)	0.000	x	0.000	x	0.000	x	0.000	x	0.000	x
	1 per week	0.130	0.097	0.004	0.085	−0.067	0.092	0.252**	0.091	0.204*	0.090
	3 per week	0.056	0.098	0.065	0.082	0.145	0.086	0.234**	0.088	0.208*	0.091
	1 per day	0.239*	0.102	0.059	0.084	0.239**	0.087	0.300**	0.092	0.238*	0.094
Total expenditure on nutrition		−0.055**	0.004	−0.035**	0.003	−0.018**	0.002	−0.040**	0.003	−0.015**	0.001
Use of time	5 min more per day (ref)	0.000	x	0.000	x	0.000	x	0.000	x	0.000	x
	15 min more per day	−0.173	0.105	−0.090	0.086	0.158	0.089	−0.078	0.093	−0.099	0.093
	30 min more per day	−0.207*	0.091	−0.074	0.078	0.122	0.082	0.030	0.083	−0.236**	0.085
	60 min more per day	−0.627**	0.111	−0.258**	0.093	−0.128	0.100	−0.328**	0.106	−0.397**	0.104
Expected outcomes	Longer life expectancy and weight loss of up to 0 kg after 4 months (ref)	0.000	x	0.000	x	0.000	x	0.000	x	0.000	x
	Longer life expectancy and weight loss of up to 2 kg after 4 months	0.509**	0.107	0.097	0.087	0.254**	0.096	0.456**	0.097	0.568**	0.101
	Longer life expectancy and weight loss of up to 4 kg after 4 months	0.777**	0.095	0.368**	0.078	0.603**	0.089	0.672**	0.087	0.916**	0.089
	Longer life expectancy and weight loss of up to 6 kg after 4 months	0.779**	0.108	0.465**	0.093	0.788**	0.106	0.897**	0.105	1.037**	0.108
SD											
Constant (opt-out)		2.513**	0.151	2.102**	0.124	2.187**	0.135	2.538**	0.162	2.517**	0.152
Type of personalized nutrition advice	Advice on recipes via app (ref)										
	Advice food products via app										
Number of dietician appointments	0 per month (ref)	0.000	x								
	1 per month	−0.624**	0.215								
	2 per month	0.084	0.279								
	3 per month	−0.076	0.280								
Number of behavioral reminders	0 per week (ref)			0.000	x	0.000	x	0.000	x		
	1 per week			−0.392*	0.178	−0.516**	0.171	−0.434*	0.183		
	3 per week			−0.012	0.197	0.276	0.283	0.026	0.234		
	1 per day			0.061	0.228	−0.029	0.202	−0.095	0.283		
Total expenditure on nutrition		0.051**	0.003	−0.041**	0.003	0.025**	0.002	−0.045**	0.003	0.016**	0.001
Use of time	5 min more per day (ref)	0.000	x					0.000	x		
	15 min more per day	−0.650**	0.161					0.337	0.241		
	30 min more per day	−0.065	0.232					0.034	0.192		
	60 min more per day	−0.080	0.242					0.488**	0.177		
Expected outcomes	Longer life expectancy and weight loss of up to 0 kg after 4 months (ref)	0.000	x	0.000	x	0.000	x	0.000	x	0.000	x
	Longer life expectancy and weight loss of up to 2 kg after 4 months	0.395	0.257	0.059	0.191	0.615**	0.169	0.544**	0.189	0.482*	0.225
	Longer life expectancy and weight loss of up to 4 kg after 4 months	−0.053	0.217	0.007	0.217	0.668**	0.144	−0.335	0.233	0.291	0.240
	Longer life expectancy and weight loss of up to 6 kg after 4 months	0.708**	0.159	0.730**	0.132	1.123**	0.134	0.959**	0.142	0.963**	0.140

* Significant at $P < 0.05$. ** Significant at $P < 0.01$.

stratified by the countries. The cost attribute (i.e., total expenditure on nutrition) showed statistically significant estimates in similar direction in all countries; meaning that all respondents preferred lower cost levels over higher cost levels. The negative coefficient of the opt-out option (i.e., current eating style) means that people a priori preferred one of the 'PN advice' options over their current eating pattern (i.e., the opt-out), all else being equal. Moreover, all respondents preferred a longer life expectancy and a weight loss in kilograms after four months over zero kilograms of weight loss. These estimates were statistically significant in all countries. Significant preference heterogeneity was shown for the cost attribute, the expected outcomes, and the opt-out option as can be seen by the significant SDs reported for these attributes (levels). Additionally, preference heterogeneity was shown for the behavioral reminder attribute in the UK, the US and Spain and for the use of time attribute in the Netherlands and Spain and preference heterogeneity was shown for the number of dietician appointments in the Netherlands.

Table 4 shows the results of the panel MIXL model for 'personalized meals', stratified by the countries. The cost attribute (i.e., total

Table 4
Preferences for personalized meals (DCE2) based on a panel MIXL stratified by country.

Attributes	Level	The Netherlands		UK		US		Spain		Poland	
		Coefficient	Std. err.	Coefficient	Std. err.	Coefficient	Std. err.	Coefficient	Std. err.	Coefficient	Std. err.
Constant (opt-out)		−2.250**	0.244	−1.325**	0.192	−1.184**	0.189	−1.712**	0.211	−1.081**	0.194
Meals provided	Personalized dinner	0.000	x	0.000	x	0.000	x	0.000	x	0.000	x
	Personalized lunch and dinner	0.074	0.116	0.183	0.099	0.069	0.094	0.367**	0.104	0.151	0.099
	Personalized breakfast and dinner	−0.004	0.128	0.080	0.116	0.132	0.106	0.179	0.114	0.133	0.105
	Personalized breakfast, lunch, and dinner	−0.347**	0.117	0.085	0.098	−0.011	0.095	0.355**	0.105	−0.044	0.098
Number of dietician appointments	0 per month (ref)	0.000	x	0.000	x	0.000	x	0.000	x	0.000	x
	1 per month	−0.604**	0.146	−0.382**	0.124	−0.123	0.108	−0.219	0.113	−0.007	0.104
	2 per month	0.126	0.110	0.026	0.095	−0.043	0.092	0.145	0.097	0.134	0.094
	3 per month	0.006	0.126	−0.047	0.106	0.049	0.106	0.319*	0.125	0.251*	0.113
Number of behavioral reminders	0 per week (ref)	0.000	x	0.000	x	0.000	x	0.000	x	0.000	x
	1 per week	−0.005	0.130	−0.007	0.123	−0.015	0.107	0.260*	0.121	0.136	0.111
	3 per week	−0.071	0.118	0.231*	0.104	0.036	0.098	0.405**	0.109	0.065	0.100
	1 per day	0.013	0.118	0.129	0.101	0.068	0.097	0.358**	0.109	0.230*	0.103
Total expenditure on nutrition		−0.044**	0.003	−0.027**	0.002	−0.015**	0.001	−0.028**	0.002	−0.011**	0.001
Use of time	5 min more per day (ref)	0.000	x	0.000	x	0.000	x	0.000	x	0.000	x
	15 min more per day	−0.164	0.115	0.081	0.103	0.065	0.094	0.126	0.106	0.038	0.101
	30 min more per day	−0.306*	0.118	−0.113	0.102	−0.041	0.095	−0.076	0.108	0.002	0.100
	60 min more per day	−0.474**	0.133	−0.286**	0.101	−0.212*	0.098	−0.217	0.113	−0.041	0.106
Expected outcomes	Longer life expectancy and weight loss of up to 0 kg after 4 months (ref)	0.000	x	0.000	x	0.000	x	0.000	x	0.000	x
	Longer life expectancy and weight loss of up to 2 kg after 4 months	0.444**	0.130	0.341**	0.108	0.471**	0.109	0.253*	0.122	0.418**	0.114
	Longer life expectancy and weight loss of up to 4 kg after 4 months	0.456**	0.123	0.256*	0.108	0.653**	0.104	0.416**	0.112	0.735**	0.106
	Longer life expectancy and weight loss of up to 6 kg after 4 months	0.564**	0.130	0.428**	0.111	0.888**	0.122	0.663**	0.128	0.927**	0.114
SD											
Constant (opt-out)		2.943**	0.196			2.375**	0.154	2.693**	0.185	2.381**	0.145
Meals provided	Personalized dinner	0.000	x	0.000	x	0.000	x	0.000	x		
	Personalized lunch and dinner	−0.098	0.279	0.370*	0.188	0.130	0.226	0.475*	0.228		
	Personalized breakfast and dinner	0.650**	0.225	0.967**	0.164	0.622**	0.164	−0.679**	0.188		
	Personalized breakfast, lunch, and dinner	−0.088	0.202	−0.066	0.138	0.113	0.222	0.564**	0.202		
Number of dietician appointments	0 per month (ref)	0.000	x	0.000	x	0.000	x	0.000	x	0.000	x
	1 per month	1.412**	0.197	1.355**	0.162	0.923**	0.151	0.838**	0.173	0.686**	0.175
	2 per month	−0.009	0.264	−0.307	0.216	0.330	0.170	−0.139	0.205	−0.105	0.257
	3 per month	0.434	0.364	−0.250	0.242	0.429	0.222	0.857**	0.184	−0.512*	0.215
Number of behavioral reminders	0 per week (ref)			0.000	x			0.000	x		
	1 per week			0.871**	0.168			0.729**	0.184		
	3 per week			−0.196	0.318			−0.043	0.196		
	1 per day			−0.187	0.275			0.137	0.232		
Total expenditure on nutrition		0.037**	0.003	0.031**	0.002	0.019**	0.001	0.028**	0.002	−0.009**	0.001
Use of time	5 min more per day (ref)	0.000	x					0.000	x	0.000	x
	15 min more per day	−0.128	0.184					−0.006	0.169	−0.027	0.180
	30 min more per day	−0.105	0.300					0.494*	0.217	0.013	0.251
	60 min more per day	0.862**	0.213					0.639**	0.229	0.585**	0.216
Expected outcomes	Longer life expectancy and weight loss of up to 0 kg after 4 months (ref)	0.000	x			0.000	x	0.000	x	0.000	x
	Longer life expectancy and weight loss of up to 2 kg after 4 months	0.618**	0.220			−0.106	0.440	−0.582**	0.148	−0.355	0.231
	Longer life expectancy and weight loss of up to 4 kg after 4 months	−0.358	0.290			−0.239	0.228	0.119	0.182	−0.052	0.232
	Longer life expectancy and weight loss of up to 6 kg after 4 months	0.300	0.303			0.894**	0.153	0.559*	0.237	−0.202	0.515

* Significant at P < 0.05. ** Significant at P < 0.01.

expenditure on nutrition) showed here statistically significant estimates in similar direction in all countries as well. The opt-out indicated that people preferred one of the 'personalized meal' options over their current eating pattern. Moreover, the attribute 'expected outcomes' showed that people preferred kilograms of weight loss over no weight loss. Preference heterogeneity was found in all countries in the cost attribute and the number of dietician appointments.

The relative importance of the attributes for 'PN advice' is shown in Fig. 3. Relative to other attributes, the total expenditure on nutrition was the most important attribute, followed by the expected outcomes. In the Netherlands, the US, Spain, and Poland, the type of PN advice was the least important attribute, while in the UK this was the number of behavioral reminders. Fig. 4 shows the relative importance of the attributes for 'personalized meals'. Relative to other attributes, the total expenditure on nutrition was also found here to be the most important attribute in all countries. This was followed by the expected outcomes, except for the Netherlands, where relative to other attributes, the number of dietician appointments was the second most important attribute. The number of behavioral reminders was the least important relative to other attributes in the Netherlands and the US. 'Meals provided' was the least important in the UK and 'Use of time' in Spain and Poland.

The percentage of people that always chose their current eating style (i.e., opt-out) instead of 'PN advice' was 13.3 % in the Netherlands, 9.7 % in UK, 9.7 % in US, 6.0 % in Spain, and 11.0 % in Poland. On the other hand, the percentage of people that always chose 'PN advice' and always preferred 'PN advice' with the lowest cost level (i.e., dominant decision-making on cost) was 0.8 % in the Netherlands, 1.0 % in UK, 0.6 % in US, 2.6 % in Spain, and 1.0 % in Poland. For 'personalized meals' these percentages were quite comparable. The percentage of people that always chose their current eating style was 9.2 % in the Netherlands, 8.2 % in UK, 7.2 % in US, 4.8 % in Spain, and 7.2 % in Poland. Moreover, the percentage of people that always chose for 'personalized meals' with the lowest cost level, was 1.9 % in the Netherlands, 1.0 % in UK, 1.4 % in US, 2.2 % in Spain, and 1.6 % in Poland. Details on these results can be found in Appendix D.

3.3. Willingness to pay

Final WTP estimates are shown in Table 5. For the 'PN advice' intervention, the WTP increases as the expected weight loss resulting from 'PN advice' also increases. Overall, highest WTP estimates were found for six kilograms of weight loss. Respondents from Poland were willing to spend an extra 16.63 euros per week during the intervention period (four months) for an anticipated weight loss of six kilograms after those four months compared to zero kilograms. The uncertainty around this estimate (Interquartile range (IQR)) is worth mentioning. More specifically, the highest WTP within the IQR that people want to spend extra per week for PN advice is 37.39 euros. Respondents in the UK seemed to be willing to pay least for 'PN advice', which was 1.82 euros per week for two kilograms of anticipated weight loss after four months. Moreover, the general population with a current expenditure on nutrition that was labeled as 'high', were willing to pay more for 'PN advice' than respondents who had an expenditure on nutrition labeled as 'low'. However, opposite results were found for two kilograms of weight loss and six kilograms of weight loss in the US. It is however worth mentioning, that there was also uncertainty found around these WTP estimates. More details about the WTP divided by total expenditure can be found in Appendix E.

For the 'personalized meals' intervention, the WTP increases as well if the expected weight loss resulting from 'personalized meals' is increasing. The general population were willing to pay most for 'personalized meals' in Poland, where they would be willing to pay an extra 25.78 euros per week during the intervention period for six kilograms of anticipated weight loss after four months compared to zero kilograms. Additionally, higher WTP estimates were found for 'personalized meals' when respondents' current expenditure on nutrition was labeled as 'high', compared to when respondents' current expenditure on nutrition was labeled as 'low'. The smallest difference was found in the UK for four kilograms of weight loss, where the WTP was 0.93 euros higher in the 'high' labeled group compared to the 'low' labeled group. The largest difference was found in Poland for six kilograms of weight loss, where the WTP was 7.50 euros higher in the 'high' labeled group compared to the 'low' labeled group.

3.4. Potential participation rate

The results in Table 6 show that the least preferred PN advice also had the lowest predicted participation rate, ranging from 19 % in the Netherlands to 34 % in Spain. This least preferred PN advice was constructed by finding the attribute levels that were most often least preferred in the different countries. The participation rate for two PREVENTOMICS interventions related to the PN advice were approximately the same, since only one attribute level differed (i.e., type of personalized nutrition advice). These participation rates ranged from 29 % in the Netherlands to 49 % in Spain, with slightly higher uptake for PN advice on recipes instead of products. The most preferred PN advice was associated with an estimated potential participation ranging from 70 % in the UK and US to 81 % in Spain.

The predicted uptake for the 'personalized meals' intervention is shown in Table 7. This intervention is somehow comparable with the PREVENTOMICS intervention that studied personalized meals, and therefore the predicted uptake for this scenario was calculated. The 'real' costs of this intervention are uncertain but could be estimated to be

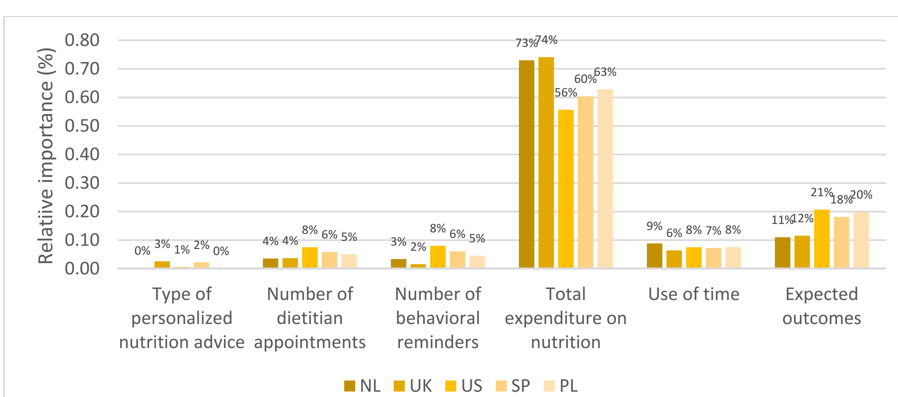

Fig 3. Relative importance (in %) of attributes in 'PN advice' based on the panel MIXL, stratified by country. *Note: NL, Netherlands; UK, United Kingdom; US, United States; SP, Spain; PL, Poland.*

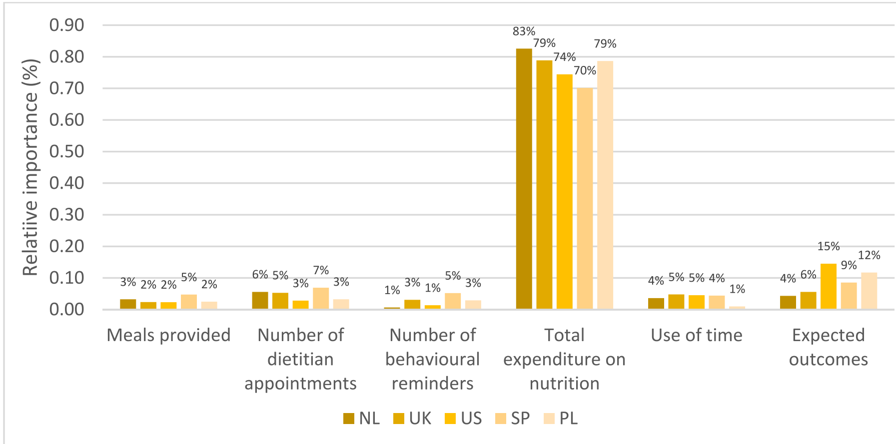

Fig 4. Relative importance (in %) of attributes in 'Personalized meals' based on the panel MIXL, stratified by country. *Note: NL, Netherlands; UK, United Kingdom; US, United States; SP, Spain; PL, Poland.*

Table 5
Willingness to pay (WTP) for losing weight, stratified by country.[a]

'PN advice'	The Netherlands			UK			US			Spain			Poland		
	Median	*IQR (25)*	*IQR (75)*	*Median*	*IQR (25)*	*IQR (75)*	*Median*	*IQR (25)*	*IQR (75)*	*Median*	*IQR (25)*	*IQR (75)*	*Median*	*IQR (25)*	*IQR (75)*
2 kg loss	5.97	3.89	12.05	1.82	1.20	5.51	4.89	−3.12	14.32	8.26	3.91	20.38	10.19	6.26	21.20
4 kg loss	9.06	6.79	18.15	6.73	4.65	20.73	11.61	2.88	28.74	12.60	7.38	28.26	16.96	11.73	31.57
6 kg loss	9.21	3.89	8.27	9.20	−0.54	24.84	14.61	−6.33	42.12	16.43	3.02	38.89	16.63	10.00	37.39
'Personalized meals'	The Netherlands			UK			US			Spain			Poland		
	Median	*IQR (25)*	*IQR (75)*	*Median*	*IQR (25)*	*IQR (75)*	*Median*	*IQR (25)*	*IQR (75)*	*Median*	*IQR (25)*	*IQR (75)*	*Median*	*IQR (25)*	*IQR (75)*
2 kg loss	6.45	1.49	14.63	8.24	4.90	24.66	12.47	7.74	32.91	7.15	−2.74	23.39	11.38	7.99	23.31
4 kg loss	7.03	4.09	16.16	6.18	3.67	18.49	16.28	10.30	46.41	13.12	7.33	31.88	20.44	14.33	42.54
6 kg loss	8.61	5.61	18.48	10.34	6.15	30.96	20.95	−2.35	59.45	18.41	6.67	48.65	25.78	18.33	53.19

Note: [a] Medians, including the IQR were reported, since parameters were not normally distributed. The WTP, compared with the reference level of 0 kg, is given in Euros. IQR, interquartile range; kg, kilograms; PN, personalized nutrition; UK, United Kingdom; US, United States.

Table 6
Expected participation rates (predicted uptake) for different PN intervention scenarios, based on the attribute estimates of the MIXL model for 'PN advice'.

	Predicted uptake mean (%)					Explanation
	The Netherlands	The UK	The US	Spain	Poland	
Least preferred	19 %	29 %	32 %	34 %	25 %	PN with advice on products, 3 dietician sessions per month, 0 reminders per week, highest cost level, 60 min of extra time and 0 kg of weight loss.
PN advice on recipes: PREVENTOMICS intervention~	29 %	37 %	41 %	49 %	39 %	PN with advice on recipes, 1 dietician session per month, 1 reminder per week, level 3 on costs, 60 min of extra time and 2 kg of weight loss.
PN advice on products: PREVENTOMICS intervention[+]	29 %	35 %	41 %	48 %	37 %	Same as PREVENTOMICS intervention with advice on recipes, but then with advice on specific food products.
Preferred intervention	73 %	70 %	70 %	81 %	75 %	PN with advice on recipes, 1 dietician session per month, 1 reminder per day, level 1 on costs (0 euros), 5 min of extra time and 6 kg of weight loss.

Note: ~PREVENTOMICS intervention carried out in Poland and the UK. [+]PREVENTOMICS intervention carried out in Spain. PN, personalized nutrition; UK, United Kingdom; US, United States.

either the third level of the cost attribute (163 euros) or the fourth level (244 euros), which is why we showed the uptake of both scenarios. For a cost level of 163 euros, this participation rate ranged from 31 % in the Netherlands and Poland to 48 % in Spain. This was slightly lower for a cost level of 244 euros. The least preferred intervention, constructed in the same way as described by 'PN advice', resulted in an uptake ranging from 18 % in the Netherlands to 34 % in Spain. Moreover, the uptake for the most preferred intervention ranged from 73 % in the UK to 87 % in Spain.

3.5. Attribute level estimates differences and scale parameter

MNL models of all five countries were used to perform the Swait and Louviere test. Based on the results of the chi-square tests, we can reject the hypothesis of equal attribute level estimates ($p < 0.05$). In other words, despite correcting for possible scale differences, the differences in attribute level estimates between the Netherlands and the UK, US, Spain, or Poland were statistically significant. Thus, the differences that we found in the datasets are because of significant differences in preferences (and likely also scale differences) in the countries.

Table 7
Expected participation rates (predicted uptake) for different PN intervention scenarios, based on the attribute estimates of the MIXL model for 'Personalized meals'.

	Predicted uptake mean (%)					Explanation
	The Netherlands	The UK	The US	Spain	Poland	
Least preferred	18 %	27 %	30 %	34 %	21 %	Personalized meals with all 3 meals delivered, 1 dietician session per month, 1 reminder per week, highest cost level, 60 min extra time and 0 kg of weight loss.
Personalized meals with a cost level of 163 euros: PREVENTOMICS intervention~	31 %	38 %	42 %	48 %	32 %	Personalized meals with lunch and dinner delivered, 0 dietician sessions per month, 1 reminder per week, level 3 on costs, 5 min extra time and 2 kg of weight loss.
Personalized meals with a cost level of 244 euros: PREVENTOMICS intervention~	26 %	33 %	36 %	41 %	25 %	Same as PREVENTOMICS intervention with a cost level of 163 euros, but then with a cost level of 244 euros.
Preferred intervention	76 %	73 %	78 %	87 %	80 %	Personalized meals with lunch and dinner delivered, 1 dietician session per month, 3 reminders per week, level 1 on costs (0 euros), 15 min extra time and 6 kg of weight loss.

Note: ~PREVENTOMICS intervention carried out in Denmark. Kg, kilograms; PN, personalized nutrition; UK, United Kingdom; US, United States.

4. Discussion

This study aimed to gain insight into the preferences for PN interventions as well as to show the WTP for PN interventions and to calculate the participation rates for hypothetical PN interventions in the general population in Europe and US. People's preferences for specific interventions are important for informing PN development, implementation, and reimbursement decisions. From the results, we can conclude that for the two PN interventions that were studied (i.e., PN advice and personalized meals), a low 'total expenditure on nutrition' was the most crucial factor for respondents in all countries when deciding to choose a PN intervention. This was expected, as PN interventions are generally not reimbursed in these European countries and the US (Briggs Early & Stanley, 2018; Brinkmann-Sass et al., 2020; MedTech Europe, 2021; Poley, 2015). Moreover, we found that respondents are willing to use PN interventions; the predicted uptake for the most preferred 'PN advice' intervention and for the most preferred 'personalized meals' intervention was different across countries (all uptake higher than 70 %) and was highest in Spain, with an uptake of 81 % and 87 % respectively. The least preferred intervention also showed different uptake across countries (e.g., 34 % in Spain for 'personalized meals' compared to 18 % in the Netherlands). This indicates that in some countries such as Spain, the a priori uptake is already higher compared to, for example, the Netherlands. The interest in PN interventions might be higher in countries such as Spain. Notably, adjusting the levels of the interventions resulted in an increased participation rate in the Netherlands (i.e., 76 % for 'personalized meals'), aligning it more closely with the participation rate in the US (i.e., 78 %). This suggests that the participation rate in the Netherlands might be more influenced by the specific content of the intervention than in other countries.

The WTP for the interventions varied per country, per intervention and per change in anticipated kilograms of weight loss. Overall, the highest WTP for both 'PN advice' and 'personalized meals' during the intervention period was found for six kilograms of anticipated weight loss after four months. For example, the highest WTP that people want to spend during the intervention period for 'personalized meals' was an extra 25.78 euros per week for six kilograms of anticipated weight loss after four months, compared to zero kilograms.

To our knowledge, this is the first study that investigated people's preferences for two specific types of high level PN interventions in Europe and US. However, preference research has been conducted on nutrition interventions (personalized or not) with slightly other focusses or methods than used in this study. The relatively high WTP reported for six kilograms of weight loss is in line with previous research on patient preferences for diabetes management (Bøgelund et al., 2011; Veldwijk et al., 2013). Moreover, the sensitivity of the respondents to an increase in costs and the limited value that respondents attach to behavior change is also in line with previous research by Ryan et al., 2015 who investigated the preferences of the general population in the UK for lifestyle interventions.

A study by Pérez-Troncoso et al., 2021 also showed that respondents were willing to pay for PN interventions. They used latent class logit models to reveal four classes of respondents and showed one class with respondents that would be likely to pay for a high level of PN service. In the other classes people were less or not at all inclined to pay for PN interventions. Similar to our study, these results showed that there is a market for PN, but that there is heterogeneity in the preferences of people regarding PN and their WTP. Both 'total expenditure' and 'expected outcomes' were set at random in most countries with the panel MIXL models in our study, indicating heterogeneity in the value attached to these attributes and thereby also in the WTP for PN to lose weight. This argument is strengthened by the result that respondents with a higher current expenditure on nutrition are generally willing to pay more compared to people with a lower current expenditure.

Future research should explore the heterogeneity found in this study and to investigate what groups are most willing to pay for and to use PN interventions (e.g., latent class modelling) (Livingstone et al., 2020; Ryan et al., 2015). Earlier research showed for example that a group of people who had a high prevalence of NCDs were more interested in a high level of PN and were willing to pay more (Pérez-Troncoso et al., 2021). Moreover, it could be expected that respondents with a higher income, and thus more ability to pay, are more willing to pay for PN interventions (Ali & Ali, 2020). It would also be interesting to investigate, for example, how goals (both health related or non-health related) of individuals influence preferences for PN interventions, since a study by Benning et al., 2020 showed that this could play an important role in individuals' health related decisions. Additionally, people's eating context could have a potential role on people's intention to use PN (Reinders et al., 2020). For example, eating outside the home could be seen as a potential barrier to keep using PN interventions, and it would therefore be interesting to see if and how this explains heterogeneity in preferences of people regarding PN interventions. Lastly, by declaring heterogeneity in DCEs, it would be interesting to pay attention to the social and mental support of people, since this might influence their preferences (Rutten-Van Mölken et al., 2020).

Comparisons of the relative importance of the different attributes showed the importance of the cost components for the general population, whereas all other attributes were less important. The participation rates that we calculated for two scenarios for 'personalized meals' of the PREVENTOMICS intervention, in which we only varied the cost level, showed the sensitivity to costs as well. These rates showed that when costs were increased to the next cost level, participation rates decreased by 5–7 % across countries. This indicates that respondents were quite sensitive to an increase in costs. These results complement earlier studies (Ryan et al., 2015; van Gils et al., 2011; Veldwijk et al., 2013;

Wanders et al., 2014) and suggest that developers of PN interventions should focus on PN interventions with low costs, try to obtain public subsidies for some or all of the costs, or use financial incentives to increase the uptake of PN interventions that lead to greater weight loss, and thereby prevent diet-related diseases and increase life expectancy. Public subsidies of some of the costs would decrease the amount that individuals need to pay out-of-pocket to participate in a PN intervention. Payers might be interested in partly subsidizing (i.e., co-financing) PN interventions for specific subpopulations. Future research could study which subpopulations should receive financial subsidies (e.g., people with diabetes and a low income).

Another possible way to increase uptake of PN interventions is by using financial incentives. A study by Molema et al., 2019 showed that a preferred type of incentive is to reward participants after completing a lifestyle program with a cash reward of 100 euros, if the participant attended at least 75 % of the scheduled meetings. Something comparable could be done by PN interventions to increase uptake. Another way to increase uptake and thereby increase (and maintain) weight loss is a 'commitment lottery' where winners are drawn from all participants but can only claim their prize (100 euros) if they also attained their goals (Swaluw and Der, 2018). Since these lotteries are known to be effective in increasing physical activity for up to 52 weeks (Swaluw and Der, 2018), this commitment lottery could increase the uptake of PN interventions and thereby increase their effectiveness.

4.1. Strengths and limitations

This study has several strengths. First, we followed good research practices, where we used qualitative methods, such as focus groups for attribute and level development and think-aloud sessions for testing the questionnaire (Bridges et al., 2011; Soekhai et al., 2019). The DCEs validated the results of the focus groups and those from other studies, where the price was also found to be very important, providing face/theoretical validity of our study outcomes. Second, the inclusion of five different countries in this DCE, comprising European countries from the northern, eastern, southern, and western Europe and the US, with data of at least 500 respondents per country, gives a good overview of the preferences in different countries and might be a starting point to investigate preferences in more countries.

This study also has some limitations. First, due to practical reasons, focus groups and think aloud sessions were only done in the Netherlands. However, since no large differences in preference structures between countries were found, it can be concluded that this had no impact on the validity of the outcomes of our DCEs. Second, we used online panels to recruit the respondents for our study. In this way, only respondents with access to the internet were recruited, which might potentially lead to selection bias. However, earlier research has shown that there is no indication that online surveys yield inferior results compared with paper-based surveys (Determann et al., 2017).

Third, we did not randomize the order in which our two DCEs were shown to the respondents; 'PN advice' was always shown first. Additionally, before the choice tasks of 'personalized meals' were shown to the respondent, we asked respondents for their ability to get by in terms of money. This could have changed the way respondents thought about their WTP for a PN intervention. However, we expected that people's WTP for 'personalized meals' was higher than for 'PN advice' and our results confirm this. Moreover, as expected, respondents with a higher current expenditure on nutrition had a higher WTP compared to people with a lower expenditure, indicating theoretical validity and reliability of our results.

Fourth, we found some differences between our quantitative study results (i.e., the DCE) and the qualitative study (i.e., focus groups). In our quantitative study, respondents attached much more value to costs than other attributes, whereas respondents in our qualitative study stated that other attributes were important as well. This might indicate that respondents in our qualitative part gave socially desirable answers. Moreover, research has shown that framing (i.e., how information is presented) of different attributes can influence the WTP (Howard & Salkeld, 2009). 'Total expenditure on nutrition' was in our WTP calculation defined as the proxy for costs, which included two components of expenditure per week. Framing these costs in costs per week instead of per day/month/year, might have influenced the WTP outcomes. Future research should test this hypothesis.

Lastly, an important shortcoming of DCEs in general is that it is rarely possible to include all possible attributes and levels, meaning that results are contingent upon having selected only the most important attributes of choice. Previous studies have however shown that well designed DCE studies predict up to 91 % of individual choices in real life (de Bekker-Grob et al., 2020).

5. Conclusion

The general population seems to be willing to pay for PN interventions to lose weight and thereby to prevent NCDs. However, their WTP might not cover the actual costs for PN, which raises questions about who would pay for PN interventions that are worth implementing. To increase uptake for PN interventions, this study suggests several options: (partly) subsidizing costs, financial incentives and commitment lotteries. Moreover, it is important for developers of PN interventions to keep the costs as low as possible since people are most sensitive to the costs; whether this is because of the WTP or the ability to pay can be debated. More research is needed to explain the heterogeneity in preferences within the countries (e.g., latent class modelling), since our models showed preference heterogeneity between, but also within, the different countries, and this might result in specific recommendations for specific groups within countries.

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Ethical statements

Ethical approval for the involvement of human subjects in this study was granted by the internal ethical review board of the Erasmus School of Health Policy & Management, Reference number IRB 20-15 Galekop, 05/29/2020. Participants gave informed consent via three different statements: *1): I have been sufficiently informed about the study by means of the information sheet above. I have read the information sheet and have been given the opportunity to ask questions (via email). These questions have been answered sufficiently. 2): I am taking part in this study voluntarily. I am not under any explicit or implicit pressure to take part in this study. It is clear to me that I can pull out of the study at any time, without stating reasons. 3): I hereby consent to having the data collected during the study processed in the manner stated in the enclosed information sheet. This consent therefore also applies to processing data regarding my health.* An affirmative reply was required on the three statements to enter the questionnaire. They were able to withdraw from the questionnaire at any time without giving a reason. The study was explained to consumers in the online questionnaire. They were informed that they would participate in the questionnaire using their personal computer, that all data will be de-identified and only reported in the aggregate. All participants acknowledged an informed consent statement in order to participate in the study. They were financially compensated for their participation by the data company.

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

The authors do not have permission to share data.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodqual.2023.105075.

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