Making personalised nutrition the easy choice: creating policies to break down the barriers and reap the benefits

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Abstract

Personalised diets based on people's existing food choices, and/or phenotypic, and/or genetic information hold potential to improve public dietary-related health. The aim of this analysis, therefore, has been to examine the degree to which factors which determine uptake of personalised nutrition vary between EU countries to better target of policies to encourage uptake, and optimise the health benefits of personalised nutrition technology. A questionnaire developed from previous qualitative research was used to survey nationally representative samples from 9 EU countries (N=9381). Perceived barriers to the uptake of personalised nutrition comprised three factors (data protection; the eating context; and societal acceptance). Trust in sources of information comprised 4 factors (commerce and media; practitioners; government; family and friends). Benefits comprised a single factor. Analysis of Variance (ANOVA) was employed to compare differences in responses between the United Kingdom; Ireland; Portugal; Poland; Norway; the Netherlands; Germany; and Spain. The results indicated that those in Greece, Poland, Ireland, Portugal and Spain, rated the benefits of personalised nutrition highest, suggesting a particular readiness in these countries to adopt personalised nutrition interventions. Greek participants were more likely to perceive the social context of eating as a barrier to adoption of personalised nutrition, implying a need for support in negotiating social situations whilst on a prescribed diet. Those in Spain, Germany, Portugal and Poland scored highest on perceived barriers related to data protection. Government was more trusted than commerce to deliver and provide information on personalised nutrition overall. This was particularly the case in Ireland, Portugal and Greece, indicating an imperative to build trust, particularly in the ability of commercial service providers to deliver personalised dietary regimes effectively in these countries. These findings, obtained from a nationally representative sample of EU citizens imply that a

parallel, integrated, public-private delivery system would capture the needs of most potential consumers.

Key words: Survey; Personalised Nutrition; Nutrigenomics; Attitudes; Europe; Food4me

1. Introduction

1.1. Public health, inequalities and the need for personalised health promotion

Public health challenges currently facing Europe (EU) are well documented and include the need to reduce the occurrence of obesity, as well as the incidence of non-communicable dietary related diseases such as type-2 diabetes, cardiovascular disease and certain cancers (EC, 2014). Current policy emphasises prevention rather than treatment in addressing public health problems. Interventions to promote health and prevent non-communicable health conditions, however, have tended to focus almost exclusively on educational approaches and interventions based on communication, such as labelling, with only limited success (McGill et al., 2015). Individualised or personalised health promoting interventions, in contrast, have been shown to be successful in bringing about healthy behaviour change in as many as one third of users (de Bourdeaudhuij & Brug, 2000; Egglestone et al., 2013; Elder et al., 2009; Webb et al., 2010).

Public health promotion efforts are complicated by unequal distribution of health conditions across societal groups and European countries (Divajeva1 et al., 2014). In recent years, the gap in health outcomes has widened between the highest and the lowest social strata within the EU (UCL Institute of Health Equity, 2013) and such inequalities are likely to increase further as the economic crisis continues (Stuckler et al., 2010). This indicates that there is a need to widen access to supporting health services promoting prevention (Wilson and Langford, 2014; EC, 2014). Digital technological advances are expected to revolutionise preventative public health care (EC, 2014) by enabling an individualised approach to health that would be cost effective and, if made available to all, could go some way toward addressing cross-national and socio-economic inequalities in health (Wilson and Langford, 2014; EC, 2014).

1.1.1. The future potential for personalised nutrition

Individualised dietary health interventions such as personalised nutrition, which are directed toward reversing current trends in the occurrence of non-communicable diseases, should go some way toward reducing health inequalities in health associated with dietary choices. Personalised nutrition, defined as the delivery of personalised diets based on information related to people's existing diets and lifestyle and/or phenotypic information (e.g. nutrient profile; blood cholesterol; Body Mass Index; blood pressure etc) and/or genetic data (Celis-Morales et al, 2015; Ferguson et al, 2014). There is evidence to suggest that an ICT-based approach to personalised nutritional intervention would be cost effective and sustainable in the long term (WHO., 2009). Personalised interventions, particularly those which are web-based, have been shown to be more effective than standard public health directed advice in inducing compliance with healthy eating recommendations (Food4me White Paper, 2015; Hageman et al., 2014). If rolled out to the general population, therefore, personalised nutrition could offer an effective means through which to address challenges and inequalities related to the prevention and management of obesity and non-communicable disease (Brug, et al., 1999). In effect, personalised nutrition has the potential to meet at least six out of the ten public health policy objectives outlined by the European Commission: prevention of disease; encouragement of healthier lifestyles; enhancement of well-being; improved access to health care; promotion of health information; and support of dynamic health systems and new technologies (EC., 2014). Previous research has suggested that these are also the types of benefits perceived to be important among the general public (Morin, 2009; Poínhos et al., 2014; Stewart-Knox et al., 2013; Su and Lu, 2012) (table 1). Personalised nutrition, if adopted widely, holds potential to reduce health care costs by as much as 13% (Marsh and McLennan Co, 2014). Digital interventions are considered

relatively simple to adapt to cultural requirements (Scarinci et al., 2014; Thornton et al., 2014) and as such could be particularly useful at the European level. The European Commission (EC) aims to make personalised diets widely accessible by 2050 (EC., 2014; Bock et al., 2014).

Insert table 1 here

1.1.2. Personalised nutrition is based on more than just genetics

Whereas only a few studies have focused on attitudes towards personalised nutrition (table 2), a corpus of research has examined attitudes toward genetic testing in the context of personalised medicine (Gibney & Walsh, 2013). Genetic testing, however, would constitute only the most 'medicalised' aspect of personalised nutrition. Existing research into genetic testing, therefore, has only limited relevance to personalised nutrition which represents a more holistic concept, which may or may not involve genetic testing. Qualitative and survey studies undertaken within Europe and beyond have indicated positive attitudes towards genetic testing, however, suggest that this aspect of the technology is unlikely to act as a barrier to adoption of personalised nutrition services (for a review see Stewart-Knox et al., 2014).

Insert table 2 here

1.1.3. Personalised nutrition and behaviour change

The EU funded Food4me research project has been novel in taking a 'bottom-up' approach whereby results of qualitative enquiry and existing literature were used to inform the development of theory upon which the survey and intervention study protocols were designed. Food4me has also been unique in taking personalised nutrition as a holistic concept that encompasses an array of personal, lifestyle, dietary, phenotypic and genetic data into account and which may be fed back to the individual along with a personalised prescription for action regarding food choices (e.g. Food4me.org). The effectiveness of tailored interventions can be enhanced by the application of appropriate theory (WHO., 2009). Digital methods can incorporate behaviour change techniques such as those based on Social Cognitive Theory (SCT) (Bandura, 1989). Qualitative research conducted as part of the Food4me project (Rankin et al., 2016; Rankin, 2015) indicated that individuals' perceived the direct-to-consumer (D-T-C) approach to personalised dietary health promotion in a way that was consistent with SCT. Self-efficacy can be increased and behaviour change brought about through intervention that sets goals, enables self-monitoring and which provides of feedback and social support (Rankin et al., 2016; McGloin and Eslami, 2015; Prestwich et al., 2014; Lara et al., 2014). According to SCT (Bandura, 1989), self-efficacy, the belief in one's ability to execute behaviour, is an important driver of behaviour change and food self-efficacy is a construct which has been shown an important factor determining food choice (Davison et al., 2015). Self-efficacy, however, is less influential in determining behaviour where there is low perceived control (Bandura, 1989). Personalised nutrition, especially when made available D-T-C, puts control firmly in the hands of the individual (consumer/client/patient, etc.) rendering them active in goal setting, assimilating feedback and monitoring progress. Previous research has suggested that Europeans would welcome the degree of control over

their health that such an approach would afford (Ronteltap et al., 2009). This has been corroborated by survey research conducted as part of the Food4me project, which has indicated that high Internal Health Locus of Control (Internal HLoC) (i.e. where health is perceived to be under the control of the individual by that individual) and Nutrition Self-Efficacy (NSE) (i.e. one's beliefs in capabilities to perform a desired task) both constitute major drivers of intention to adopt personalised nutrition (Poínhos et al., 2014). Those who volunteered to take part in the Food4me proof of principle study tended to have higher levels of NSE and internal HLoC compared to the general population survey participants (Food4me., 2015). This congruence with theories of behaviours change should render personalised approaches to dietary health promotion particularly effective in bringing about compliance with prescribed diets, and in supporting the individual in their endeavours to manage their dietary-related health behaviours. For tailored health innovations to be effective and sustainable, however, policies will need to be put in place that treat people as partners in the design and delivery of support services and enable people to manage their own health (Wilson and Langford, 2014). The Food4me project in providing the European public with a voice in how personalised nutrition is developed and delivered to society represents a first step for such a partnership.

1.2. Public perspectives on personalised nutrition

The Food4me survey explored the views of the European public across nine countries (Spain, the UK, Ireland, the Netherlands, Poland, Portugal, Norway, Greece and Germany) to gain an understanding of what would constitute best practice for the effective delivery of personalised nutrition. Qualitative (Berezowska et al., 2014; Stewart-Knox et al., 2014; and, 2013) and survey (Poínhos et al., 2014) research conducted in Europe as part of the Food4me

project in these nine countries has suggested that the EU public hold, in general, positive attitudes toward personalised nutrition. These were reflected in the observation that approximately one third of those surveyed indicated that they were willing to pay as much as 50% more for personalised than non-personalised nutrition advice (Fischer et al., 2016). In other words, personalised nutrition is a product of high perceived value for which a proportion of society is prepared to pay a premium. These findings align with those of previous survey studies of public attitudes toward personalised nutrition (Roosen et al., 2008; Stewart-Knox et al., 2009; Su and Lu, 2012) which have indicated that between one third and a half of Europeans would be keen to take advantage of personalised nutrition.

1.2.1. Perceived benefits of and barriers toward personalised nutrition

Among the benefits of personalised nutrition anticipated by the Food4me study participants were increased fitness, time saving and convenience as well as benefits to other family members (Stewart-Knox et al., 2014; and, 2013) (table 1). The European public, however, also perceived risks to be inherent in the on-line delivery systems that would provide personalised nutrition services, such as data mishandling and commercial exploitation of data (Poínhos et al., 2014; Stewart-Knox et al., 2014; and, 2013) (table 1). Similarly, previous qualitative (Morin, 2000) and survey (Roosen et al., 2008) research has highlighted concerns around data security. Primary analysis of the Food4me survey results, however, has suggested that the latter is not likely to prove a barrier to adoption of personalised nutrition. The extent to which an individual perceived the benefits associated with the intention to adopt personalised nutrition directly predicted intention to adopt it. Given that the prior qualitative studies (Stewart-Knox et al., 2013) suggested the perceived risks were not associated with personalised nutrition as such, but rather with the digital

interface used to deliver it, it was not surprising that the survey (Poínhos et al., 2014) found that perceived risk was only indirectly associated with attitudes and intention to take up such services. Further analysis of the Food4me survey results (Berezowska et al., 2015) has suggested that perceived risk associated with data security was associated with the degree of control the provider was perceived to have over information. This suggests that service providers need to emphasise the benefits of personalised nutrition whilst taking measures to instil confidence in the ability of the provider's ability to handle personal information securely.

Another barrier highlighted by the Food4me study was the difficulty perceived by study participants in adhering to a personalised dietary plan in social situations (Stewart-Knox, 2013) (table 1). This was not surprising given that food choices are socially embedded (Robinson et al., 2013). Other qualitative investigations into factors determining healthy eating have also implied that a major perceived barrier to healthy eating is the competing requirements of other family members (Baruth et al., 2014; Cason-Wilkerson et al., 2015; McGuffin et al., 2015). Personalised nutrition interventions, therefore, may have to take into account the preferences of not only the individual, but also of other household members. Eating outside the home was also deemed a potential problem in adhering to health eating plans. This result aligns with the results of the EU-funded HECTOR project (2011) which indicated that foods eaten outside the home tended to be less healthy than those consumed within the home. Broader policies, therefore, may be required to encourage catering outlets, including those based within workplaces, to provide healthy fast food options and to cater for personalised diets.

1.2.2. Trust in potential providers of personalised nutrition

Contrasting views on whether public or private institutions would be most trusted to deliver on personalised nutrition were identified in the Food4me qualitative study. Some preferred personalised nutrition to be delivered as part of existing health services, while others favoured the anonymity and convenience afforded by commercial offerings (Berezowska et al., 2014; Fallaize et al., 2015; Stewart-Knox et al., 2014; 2013). This finding was novel given that previous studies have unanimously implied that the public would prefer services to be delivered through existing health provision (Pavlidis et al., 2012; Su and Lu, 2012; Wendel et al., 2013). The Food4me survey confirmed that a large proportion of Europeans preferred health service provision, but also identified a second potential market comprised of those who preferred the anonymity and degree of control that D-T-C personalised nutrition would afford (Food4me White Paper, 2015). This could imply a dual market for personalised nutrition as well as a need to tailor the delivery support system to differing needs. It is conceivable that in some cases D-T-C services could provide added value, for example, by delivering meals directly to the individual's home.

1.2.3. The European policy context and personalised nutrition

Existing research, including that which has been conducted as part of the Food4me study, has established that Europeans hold positive views on personalised nutrition and are open to the concept of D-T-C personalised nutrition services (table 2). That the European public appear amenable to personalised nutritional health technologies bodes well for positive public health impacts, provided that policies are put in place to render such a system available, effective and sustainable. For policy to be effective in addressing a problem, however, it has to be defined locally (Goldstein, 2009). Having established the factors determining and deterring the uptake of personalised nutrition, this analysis explores the

distribution of these factors across the different EU countries, using data from the Food4me survey sample.

Financial deficits varied considerably between EU countries during 2015 (EC Europa, 2016). Of the EU countries surveyed, public debt (% GDP) was higher in Greece (176.6) Portugal (130.2) and Ireland (107.5) moderate in Spain (99.3), the UK (88.2) and Germany (74.9) and lower in the Netherlands (68.2) and Poland (50.4). Norway, which is one of the wealthiest countries in the world, increased government spending during 2015 (Trading Economics, 2016) and showed the lowest public debt at 30% of GDP (Country Economy, 2016). According to the health economics perspective, prices symbolise the value (costs versus benefit) of a good or service (such as personalised nutrition) (Mazzocchi et al., 2009). Alongside is the notion that the wider economic environment influences individual decisions. Given differences in the economic circumstances between EU countries, therefore, the value attributed to personalised nitration and associated decisions could be expected to differ between European countries.

The perceived benefits of personalised nutrition, perceived barriers to the uptake of personalised nutrition, trust in the various agencies to provide personalised information and preferences for the provision of such services, therefore, have been compared cross-nationally on the assumption that owing to differing economic circumstances and food related cultures (Grunert et al., 2012), there will be cross national differences which may need to be addressed through both national and EU policy.

2. Methods

2.1. Sampling and Procedure

Ethical approval was granted by each of the lead academic organisations. Volunteers aged 18+ years were recruited from a market research agency panel (GfK-NOP) in 9 European countries (Germany, Greece, Ireland, Poland, Portugal, Spain, the Netherlands, the UK, and Norway). These countries were considered broadly representative of Northern, Southern, Eastern and Western European locations. Although the countries are diverse in food culture, they are all regulated centrally. Recruits were quota sampled to be nationally representative (n>1000) for each country in terms of sex, age and level of education (see Poínhos et al., 2014 for a full account) Having obtained informed consent, the survey was administered on-line (N=9381) during February and March 2013. The operational definition of personalised nutrition was: "healthy eating advice that is tailored to suit an individual based on their own personal health status, diet, physical activity and/or genetics." The response rate was 31.9 %.

2.2. The Questionnaire

Prior qualitative research findings (Stewart-Knox et al., 2013) conducted in the same nine countries as the Food4me survey, informed the selection of items for inclusion in the questionnaire. The resultant questionnaire was translated and back-translated into the native languages of each of the nine EU countries. The tool was then pre-piloted off-line and piloted on-line in the UK and Portugal (see Poínhos et al., 2014 for a full account).

Perceived barriers to the uptake of personalised nutrition were assessed using 18 items for which responses were measured on a 5-point Likert scale ranging from 1 = 'Completely disagree' to 5 = 'Completely agree' and which showed high reliability (α= 0.905). Trust in agencies to provide personalised dietary information was assessed using 14 items for which

responses were measured on a 5-point Likert scale ranging from 1 = 'Trust extremely' to 5 = 'Distrust extremely' and which showed high reliability (α = 0.877). Perceived benefits of personalised nutrition were assessed using 9 items for which responses were on a 5-point Likert scale ranging from 1 = 'Not increase it at all' to 5 = 'Increase it extremely' and which showed high reliability (α= 0.938). Preferences for providers of personalised nutrition were assessed using the question: "Please indicate the extent to which you would prefer the following people or organisations to provide a personalised nutrition service - your family doctor/GP; private health care providers; dieticians/nutritionists; or, supermarkets". Responses were measured on a 5-point Likert scale ranging from 1 = 'Not at All' to 5 = 'Extremely'.

2.3. Data Analysis

Cronbach's Alpha was applied to the sets of items (benefits; barriers; trust in agencies), each scored on Likert-Scales, indicated that the mean values had sufficient reliability to meet the assumption that the percentage of variance estimated was because they are measuring the same underlying concept and unlikely to be random. The unweighted mean value of these sets of items, therefore, has been taken as a quasi-interval scale for the analysed constructs. That there are multiple items, meaningful concepts and high Cronbach Alpha coefficients showing internal consistency in a large sample, implied these data were adequate for Factor Analysis.

Three separate exploratory factor analyses were conducted using Bartlett's method were used to test the adequacy of the procedure and to check the factor structure of: (1) perceived benefits of personalised nutrition; (2) barriers to the uptake of personalised

nutrition (on-line interface; eating context); and, (3) trust in agencies to convey information on personalised nutrition (commerce/media; professionals; government; friends/family). The extraction method was principal component analysis. The barriers and trust factors then underwent Varimax rotation with Kaiser normalisation. Items with a loading magnitude greater than 0.50, and factors with an eigenvalue greater than 1, were included. Three factors together explained 69% of the variance in barriers. Data protection explained 32%, eating context 23% and societal acceptance 13% of the variance in barriers (table 3). All 18 items were accounted for in the analysis and there was no cross loading. Four factors together explained 67% of the variance of trust in agencies to provide information on personalised nutrition: commerce/media (39%); professionals (13%); government (8%); and, friends/family (7%) (table 4). One factor explained 67% of the variance and was described as perceived benefit (table 5). Of the 10 items, 9 loaded heavily onto this factor. When summated, data from Likert scales are considered as interval and can be analysed using parametric methods (Boone & Boone, 2012). Based on the rotated factor solution, therefore, the latent constructs identified were calculated by averaging the items assigned to each factor.

One-way, between-groups ANOVA were conducted to compare between-country differences in the 3 factors representing responses to items on perceived barriers (table 3), the 4 factors representing trust in service agencies (table 4), the single factor related to benefits of personalised nutrition (table 5) and the mean (SD) of the 4 items assessing preferences for who should deliver personalised nutrition. Statistical analysis was conducted using SPSS (Version 21.0; SPSS UK Ltd; Chersey, UK), and MPlus (Version 7.2). P values < 0.05 were considered significant.

Insert tables 3-5 here

3. Results

3.1. Sample Description

The chi-square goodness-of-fit test showed that the countries were similar in gender composition (χ 2= 4.51, df=8, ns) with males accounting for 51% of the sample. The modal age-group, both for the total sample as well as within country was 40-54 years (35%). Modal education level for the whole sample was "middle" (39%). This was similar across the countries apart from the UK where the modal education level was "low" (49%) and the Netherlands where there was an equal number in the "middle" (36%) and "high" (36%) education levels.

3.2. Perceived Barriers to the Uptake of Personalised Nutrition

One-way ANOVA indicated significant differences between countries on all three factors: F1 – data protection ($F=28.27$; $df=8$; $p<0.05$); F2 – the eating context ($F=38.52$; $df=8$; $p<0.05$); and, F3 – societal acceptance ($F=17.15$; $df=8$; $p<0.05$). Those in Spain rated barriers related to data protection significantly higher than other countries (table 6). A homogenous sub-set comprised of Norway, Ireland, Netherlands and UK gave significantly lower ratings compared to other countries on barriers related to data protection. Those in Poland rated barriers related to the eating context (social) significantly higher, while the Netherlands rated them lower, than any other country. The other countries formed a homogenous sub-set on the eating context variable.

Insert table 6 here

3.3. Trust in Agencies to Provide Information on Personalised Nutrition

There were significant differences between factors across countries in terms of trust in agencies to provide information on personalised nutrition: F1 - commerce/media ($F=25.59$; $df=8$; $p<0.05$); F2 - professionals ($F=7.64$; $df=8$; $p<0.05$); F3 - government ($F=28.25$; $df=8$; $p<0.05$); F4 - friends/family ($F=30.90$; $df=8$; $p<0.05$). Greek participants rated trust in commerce and the media to provide information on personalised nutrition significantly lower than any other country (table 6). Participants in Spain, the Netherlands and Portugal formed a homogenous subset with a significantly higher trust in commerce and the media than other countries. The UK participants rated trust in professionals to provide information on personalised nutrition significantly lower than any other country. Greek and Irish participants formed a homogenous subset that indicated significantly higher trust in professionals than other countries. Participants in the Netherlands, Greece and Poland comprised a homogenous subset that indicated significantly lower trust in government to provide information on personalised nutrition. Spanish participants indicated significantly higher trust in government agencies than any other country. Norwegian participants indicated significantly lower trust in friends and family to provide information on personalised nutrition compared to all other countries. There was a homogenous subset comprised of participants from the UK, Ireland, Germany and Poland, which indicated significantly higher trust in friends and family than other countries.

3.4. Perceived Benefits of Personalised Nutrition

Significant differences were observed between countries in terms of perceived benefits ($F=138.75$; $df=8$; $p<0.05$). Those in Greece rated the benefits of personalised nutrition significantly higher than any other country (table 6). There was a homogenous subset comprised of Polish, Irish, Portuguese and Spanish participants which rated the benefits of personalised nutrition higher. Another homogenous subset comprised participants in the Netherlands, UK, Norway and Germany, which rated the benefits of personalised nutrition significantly lower than participants in other countries.

3.5. Preferences for Providers of Personalised Nutrition

There were between - country differences in preferences for family doctors/GP ($F=34.79$; $df=8$; $p<0.05$), private health care providers ($F=58.51$; $df=8$; $p<0.05$), dieticians/nutritionists ($F=82.65$; $df=8$; $p<0.05$) and supermarkets ($F=32.767$; $df=8$; $p<0.05$) to provide personalised nutrition. Participants in Ireland, Portugal and Greece formed a homogenous group of countries significantly more likely to advocate that personalised nutrition be delivered through the family doctors/GP (table 6). Those in Ireland, Portugal, Greece and Poland formed a homogenous group that were significantly less likely than other countries to advocate that personalised nutrition be delivered by private health organisations. Those in the Netherlands were significantly less likely than any other country to select the family Doctor/GP or private health providers. Those in Germany were less likely than other countries to advocate that personalised nutrition be delivered by a dietician/nutritionist. Participants in Ireland, Portugal, Greece and Poland were more likely than other countries to indicate that they preferred personalised nutrition to be delivered by a dietician/nutritionist. Compared to other countries surveyed, participants in Norway were less likely, while those in

Portugal were more likely, to want supermarkets involved in the delivery of personalised nutrition.

4. Discussion

This study has been novel in having explored the distribution of perceived benefits, barriers and trust in the various agencies to provide information on personalised nutrition between different EU countries with a view to determining how such issues could be addressed via policy. Previous research has suggested that greater perceived benefit is crucial to the acceptance of personalised nutrition (Morin, 2009; Poínhos et al., 2014; Stewart-Knox et al., 2013; Su and Lu, 2012). In this regard, EU citizens in Greece, Poland, Ireland, Portugal and Spain, where the benefits of personalised nutrition were rated higher than other countries, could imply enhanced potential for the impact of personalised nutrition in these countries.

Health economists assume that relative prices have meaning and can predict consumption (Mazzocchi et al., 2009). Willingness to pay (mean % reference) for personalised nutrition, therefore, can be assumed to reflect the value attributed to it and the likelihood of adopting it. Previous analysis of the Food4me survey has indicated that willingness to pay varies by EU country such that those in Greece were willing to pay most, irrespective of whether nutritional advice was based on diet, diet plus phenotypic or diet plus phenotypic plus genotypic information (Fischer et al., 2016). Given those in Greece rated the benefits of personalised nutrition relatively higher and were willing to pay a relatively higher price for services, they could be assumed to ascribe a relatively value to personalised nutrition and could be expected to be the most likely among the countries studied to take up personalised nutrition.

Between-country differences in perceived benefits of and willingness to pay for personalised dietary health promotion appear to reflect between-country differences in the health lifestyle profile of volunteers screened for the Food4me Proof of Principle study and who had opted to take up personalised nutrition (Livingstone et al., 2015). Those screened for the Food4me Proof of Principle study in Greece, for example, also had a significantly greater mean BMI (26.7), higher incidence of sedentariness (50.2%) and were significantly more likely to report being on a therapeutic diet (9.6%) than any of the other countries (Livingstone et al., 2015).

That Greece, along with Portugal, Ireland and Spain were experiencing the greatest public debt in at the time of the survey (EC Europa, 2016), however, begs the question of what an effective policy to promote personalised nutrition would look like. Perhaps economic subsidies could be considered in these more financially challenged countries? Participants in countries with the least public debt (the Netherlands, UK, Norway and Germany) (EC Europa, 2016; Country Economy, 2016) in contrast rated the benefits of personalised nutrition to be significantly lower than other countries. This accords with the previous finding that those in the Netherlands were willing to pay least for personalised nutrition irrespective of level of medicalization (Fischer et al., 2016). This might imply some scepticism as to what personalised nutrition can deliver, and which may need to be addressed through a common policy for citizens to take up personalised nutrition in the more economically stable countries such as the Netherlands. It is also possible that people in these countries may assume that the economic resources are available with which to treat illnesses. In the meantime, policies could embed personalised nutrition within existing health promotion activities. Policies based on economic principles would seek to create incentives (benefit) for people to make nutritional decisions that have potential to benefit both the individual (by improving health)

and wider society (such as decreasing health care costs) (Mazzocchi et al., 2009). Accordingly, qualitative enquiry (Berezowska et al., 2014) has implied that the perceived value of personalised nutrition would be enhanced by employing nutrition professionals to communicate personalised plans, provide advice and support. Policies should seek to add perceived value to personalised nutrition interventions through the publication of guidelines that recommend that health professionals such as registered dieticians devise, prescribe and communicate personalised nutritional plans. Meanwhile, registered dieticians may require further training and incentives to encourage them into the field (Abrahams et al., accepted with revision).

Participants in Spain rated the barriers associated with personalised nutrition, particularly those linked to data protection, higher than in any other country, suggesting that uptake of personalised nutrition in Spain may depend upon implementation of effective policies to protect data. Consistent with the results from the Lipgene survey (Stewart-Knox et al., 2009), which suggested that concerns about personal information being used by insurers, employers and other authorities were foremost for citizens in Germany, Portugal and Poland, high levels of concern with data protection were observed in these same countries in the current analysis. A previous survey conducted in Germany (Roosen et al., 2008) also indicated that perceived lack of data security could be a barrier to uptake of personalised nutrition. Together these findings suggest that for personalised nutrition to be taken up in Spain, Germany, Portugal and Poland, data protection policies need to be implemented, along with stringent regulations to protect personal data from being "sold on" or misused. The results of qualitative research in the Food4me studies offered suggestions for regulatory policy, including the prominent display of website logos, staff credentials and contact details (Fallaize et al., 2015; Stewart-Knox et al., 2013). There was also the suggestion that a

guarantee of data protection be provided (Stewart-Knox et al., 2013). Of note, participants in Norway, Ireland, Netherlands and UK provided significantly lower ratings than other countries for perceived barriers to adoption of personalised nutrition associated with data protection. This might indicate that such issues would be less likely to deter uptake of personalised nutrition in these regions, or perhaps that greater adoption of internet based health services has increased people's' willingness to provide personal data in relation to novel health- related applications. Previous analysis of the Food4me survey responses has suggested that perceived risk associated with data security may be greater where genetic data are included (in addition to lifestyle and phenotypic data) when personalising nutrition advice (Berezowska et al., 2015). This implies that particular care needs to be taken when handling genetic data. One suggestion that arose from the prior food4me qualitative studies was that personal and biomedical data be stored separately. This implies a requirement for policies to ensure that personal and biological data are stored separately.

It was previously reported that people anticipated problems in adhering to a prescribed diet in social situations (Stewart-Knox et al., 2013). The current analysis showed that barriers related to the social eating context were rated most highly by participants in Poland, suggesting that, in order to be able to comply with tailored diets, those in this region may require particular support in complying with a personalised eating plan in social situations, especially when eating outside the home. Technological advances such as those which enable personalised nutrition to be delivered (e.g. ICT services, information and communications technology) also hold the potential to revolutionise how and where health is promoted (Wilson and Langford, 2014). Difficulties encountered in adhering to a personalised diet when outside of the home could be addressed by integrating the dietary health technology into society. Schools and workplaces are among just some of the

institutions that could provide effective vehicles through which to deliver personalised eating plans and provide support. Food retailers and other commercial environments could also cater to needs associated with personalised diets. Policies and incentives therefore will be needed to encourage public bodies and businesses to facilitate personalised eating plans in the workplace and in the wider community where people go to eat.

Consistent with the preliminary qualitative studies (Fallaize et al., 2015), which indicated that larger, more 'well known' private healthcare providers (such as BUPA) were more trusted than smaller, less well-known web providers, the results have suggested that participants in the UK have a relatively high degree of trust in government agencies to provide information on personalised nutrition. This implies an imperative to involve the NHS when introducing personalised nutrition to the UK. Common European wide policy, meanwhile, should assist health professionals in obtaining training and provide support in the delivery of personalised nutrition services. There does, however, appear to be some hope for the future uptake of commercially delivered direct to consumer (D-T-C) services. Of the one third who responded to the Food4me survey and indicated they were willing to pay a premium for personalised over non-personalised nutrition advice (Fischer et al., 2016) most tended to be male and on higher incomes suggesting a potentially lucrative niche market for commercial personalised nutrition service provision. That those participants in Spain, the Netherlands and Portugal indicated greater trust in commerce and the media to deliver personalised nutrition messages, suggests that commercial D-T-C ventures may be better received in these countries. Participants in the Netherlands, Greece and Poland reported relatively lower trust in government to provide information about personalised nutrition, which may imply a need for independent organisations with a commercial interest in delivering personalised nutrition D-T-C to be involved in the delivery of personalised

nutrition within these countries. Discussants who took part in the prior qualitative studies (Fallaize et al., 2015; Stewart-Knox et al., 2013) suggested that government backing would serve to engender trust in commercial personalised nutrition schemes. This suggests a need for policies to be developed which could encourage public and private organisations to work in partnership, so that access to personalised nutrition can be as wide as possible. This also suggests that there is a need to explore further how the food industry (food producers; processors; retailers) could be encouraged to participate with government organisations through public/private partnerships in the delivery of personalised nutrition. Congruent with the notion of parallel or joint health service/commercially delivered services, the Food4me survey indicated a strong preference for health service professionals to provide personal nutrition. A substantial proportion also endorsed private health care providers and supermarkets (figure 1). This corroborates the notion that there are two markets for personalised nutrition, one favouring public and the other private delivery. This may also imply that to be effective, services should involve existing health care provision even where commercial companies are involved. That those in the less economically stable EU countries (Ireland, Portugal and Greece) were most likely to advocate that personalised nutrition be delivered through the family doctors/GP or a dietician/nutritionist implies a need for specific policies that encourage companies to collaborate with health systems in the delivery of personalised nutrition in these countries.

Insert figure 1 here

These data were derived from what appears to be the largest and widest scoping survey of attitudes to personalised dietary health intervention conducted to date. It was appropriate to conduct this survey on-line given that most available personalised nutrition services are delivered, at least in part, by means of internet technology (Ronteltap et al., 2012). The response rate for this study, although similar to that found by other online surveys (e.g. see Fan and Yan, 2010), could be considered low (32%). That the sample was quota sampled to be nationally representative, should have compensated for any bias inherent in the low response rate, as well as the high total number of responses. Questions and items can be assumed to have validity in having been derived from prior qualitative research conducted in all of the countries surveyed. Furthermore, the validity of the results is supported by the good internal consistency of the scales, despite these not having been subjected to previous psychometric testing. Another potential limitation associated with the survey is that because the notion of personalised nutrition is novel, the quality of response may have been affected by a lack of direct experience with the technology. Those who had volunteered to take part in the Food4Me proof of principle study appeared to be motivated differently to those the general population survey. Further enquiry of those who have experience of personalised nutrition, therefore, is needed.

5. Conclusion

The Food4me project has sought to provide the European public with a voice in the development of policies directed toward the effective application of personalised nutrition, and to consider mechanisms through which to enhance the benefits and break down perceived barriers likely to be encountered in implementing personalised nutrition. The ultimate outcome will be to widen access to personalised nutrition, enhance public health and well-

being, reduce health inequalities and reduce healthcare costs. Europeans possess shared health values and as such should be able to achieve common health-related objectives (EC, 2014). These findings in a nationally representative sample of EU citizens imply that a parallel, integrated, public-private delivery system would capture the needs of most potential consumers (Figure 2). The public would appear to be amenable to the concept of personalised nutrition and be aware of the potential benefits. These data, however, also provide evidence that different approaches may need to be taken in achieving objectives related to personalised nutrition in different EU countries.

Insert figure 2 here

There is a requirement not only to personalise diets, but also to personalise the approach to the delivery of the intervention, taking into account cross-national differences in perceived benefits, barriers and preference for the delivery of personalised nutrition. Policies are required to reassure the public that personal data are protected. Agencies involved in the delivery of personalised nutrition need to be regulated so that they can be trusted to provide personal dietary information. Policies will be required to encourage societal institutions, both public and private, to facilitate people in reaping the benefits of prescribed diets outside the home environment and, in doing so, encourage acceptance of this novel health promoting technology.

More general measures will need to be put in place to raise awareness and encourage eventual uptake of personalised nutrition, and in keeping with current policies (EC., 2014; Wilson and Langford, 2014), not only among the 'worried wealthy' but most especially

among the more ‘hard to reach’ societal groups. The implications are that policies directed toward the removal of barriers promotion of the benefits of personalised nutrition would encourage uptake of such services. Personalised nutrition speaks to both health and innovation policy and as such will need careful regulation, monitoring and coordination. This analysis, meanwhile, provides a basis upon which to place policies directed toward enabling initial attempts to roll out personalised nutrition to the general public, both as part of existing health provision and as a commercial enterprise.

7. References

Abrahams, M., Frewer, L., Stewart-Knox, B.J., revised and re-submitted. Factors determining the integration of nutritional genomics into clinical practice by registered dietitians.Trends in Food Science and Technology.

Bandura, A., 1989. Human agency in Social Cognitive Theory. American Psychologist 44, 1175-1184.

Baruth, M., Sharpe, P.A., Parra-Medina, D., Wilcox S., 2014. Perceived barriers to exercise and healthy eating among women from disadvantaged neighbourhoods: results from a focus groups assessment. Women and Health 54, 336-353.

Berezowska, A., Fischer, A.R.H., Ronteltap, A., van der Lans, I., van Trijp, H.C.M., 2015. Consumer adoption of personalised nutrition services from the perspective of a risk-benefit trade-off. Genes and Nutrition 10, 42.

Berezowska, A., Fischer, ARH., Ronteltap, A., Kuznesof, S., Macready, A., Fallaize, R., van Trijp HCM., 2014. 2014. Understanding consumer evaluations of personalised nutrition

services in terms of the privacy calculus: a qualitative study. Public Health Genomics 17, 127-140.

Boone, H.N., Boone, D.A. 2012. Analyzing Likert data. Journal of Extension 50, Article 2TOT2.

Bock, A.K., Maragkoudakis, P., Wollgast, J., Caldeira, S., Czimbalmos, A., Rzychon, M., Atzel, B., Ulberth, F., 2014. Tomorrow's healthy society - research priorities for foods and diets (Final Report). Joint Research Centre - Foresight and Behavioural Insights Unit: Luxembourg. ISBN: 9978-92-79-40070-4.

Brug, J., Campbell, M., van Assema, P., 1999. The application and impact of computer-generated personalized nutrition education: a review of the literature. Patient Education and Counselling 36, 145-156.

de Bourdeaudhuij, I., Brug, J., 2000. Tailoring dietary feedback to reduce fat intake: an intervention at the family level. Health Education Research 15, 449-462.

Cason-Wilkerson, R., Goldberg, S., Albright, K., Allison, M., Haemer, M., 2015. Factors influencing healthy lifestyle changes: a qualitative look at low-income families engaged in treatment for overweight children. Childhood Obesity 11, 170-176.

Celis-Morales, C., Livingstone, K.M., Marsaux, C.F., Forster, H., O'Donovan, C.B., Woolhead, C., Macready, A.L., Fallaize, R., Navas-Carretero, S., San-Cristobal, R., Kolossa, S., Hartwig, K., Tsirigoti, L., Lambrinou, C.P., Moschonis, G., Godlewska, M., Surwiłło, A., Grimaldi, K., Bouwman, J., Daly, E.J., Akujobi, V., O'Riordan, R., Hoonhout, J., Claassen, A., Hoeller, U., Gundersen, TE., Kaland, S.E., Matthews, J.N., Manios, Y., Traczyk, I., Drevon, C.A., Gibney, E.R., Brennan, L., Walsh, M.C., Lovegrove, J.A., Martinez, A.J.,

Saris, W.H., Daniel, H., Gibney, M., Mathers, J.C., 2015. Design and baseline characteristics of the Food4me study: a web-based randomised controlled trial of personalised nutrition in seven European countries. Genes and Nutrition 10, 450.

Country Economics., 2016. Norway National Debt. CountryEconomy.com http://countryeconomy.com/national-debt/norway

Davison, J., Share, M., Hennessy, M., Markovina, J., Bunting, B., **Stewart-Knox, B.,** 2015. Correlates of food choice in unemployed young people: the role of demographic factors, self-efficacy, food involvement, food poverty, dieting and physical activity. Food Quality and Preference 46, 40-47.

Divajeva1, D., Marsh, T., Logstrup, S., Kestens, M., Vemer, P., Kriaucioniene, V., Peresson, S., O'Kelly, S., Rito, A., Webber, L., 2014. Economics of chronic diseases protocol: cost-effectiveness modelling and the future burden of non-communicable disease in Europe. BMC Public Health 14, 456.

European Commission (EC)., 2014. Improving health for all European citizens. The European Union explained. Luxembourg. ISBN: 978-92-79-35689.

European Commission (EC) Europa., 2016. Economies of the Member States. Economic and Financial Affairs. http://ec.europa.eu/economy_finance/eu/countries/index_en.htm

Egglestone, C., Morris, A., O'Brien, A., 2013. Effect of direct-to-consumer genetic tests on health behaviour and anxiety: a survey of consumers and potential consumers. Journal of Genetic Counselling 22, 565-575.

Elder, J.P., Ayala, G.X., Slymen, D.J. Arredondo, E.M., Nadia R. Campbell, N.R., 2009. Evaluating psychosocial and behavioral mechanisms of change in a tailored communication intervention. Health Education Behavior 36, 366-380.

Fallaize, R., Macready, A.L., Butler, L.T., Ellis, J.A., Berezowska, A., Fischer, A.R.H., Walsh, M., Gallagher, C., Stewart-Knox, B.J., Kuznesof, S., Frewer, L., Gibney, M., Lovegrove, J.A., 2015. The perceived impact of the NHS on personalised nutrition delivery in the UK. British Journal of Nutrition 8, 1271-79.

Fan, W., Yan, Z., 2010. Factors affecting response rates of the web survey: A systematic review. Computers in Human Behavior 26, 132–139.

Ferguson, L., Bishop, K., Karunsinghe, N., 2014. Impact of personalized nutrition on public health. Clinical Aspects of Functional Foods and Nutraceuticals 371.

Fischer, A.R.H., Berezowska, A., van der Lans, I.A., Ronteltap, A., Rankin, A., Frewer, L.J., Kuznesof, S., Poínhos, R., Stewart-Knox, B.J., 2016. Willingness to pay for personalized nutrition across Europe. The European Journal of Public Health. doi: 10.1093/eurpub/ckw045

Food4me., 2015. Personalised nutrition: paving a way to better population health. A White Paper from the Food4me Project. European Food Information Council (EUFIC) (eds): Belgium.

Gibney, M.J., Walsh, M.C., 2013. The future direction of personalised nutrition: my diet, my phenotype, my genes. Proceedings of the Nutrition Society 72, 219-225.

Goldstein, H., 2009. Translating research into public policy. Journal of Public Health Policy 30, S16-S20.

Grunert, K.G., Wills, J, Celemin, L.F., Lahteenmaki, L., Scholderer, J., Bonsmann, S.S.G., 2012. Socio-demographic and attitudinal determinents of of nutrition knowledge of food shoppers in six European countries. Food Quality and Preference 26, 166-177.

Hageman, P.A., Pullen, C.H., Hertzog, M., Boeckner, L.S., 2014. Effectiveness of tailored lifestyle interventions using web-based and print-mail for reducing blood pressure among rural women with prehypertension: main results of the Wellness for Women: DASHing towards Health clinical trial. International Journal of Behavioural Nutrition and Physical Activity 11, 148.

HECTOR., 2011. Final Report Summary - HECTOR (Eating Out: Habits, Determinants and Recommendations for Consumers and the European Catering Sector).

http://www.nut.uoa.gr/hector/PublicDocs/D2.5%20Report%20Dietary%20Pattern.pdf

Livingstone, K.M., Celis-Morales, C., Navas-Carretero, S., San-Cristobal, R., O'Donovan, C.B., Forster, H., Woolhead, C., Marsaux, C.F.M., Macready, A., Fallaize, R., Kolossa, S., Tsrigoti, L., Lambrinou, C.P., Moschonis, G., Godlewska, M., Surwillo, A., Drevon, C.A., Manios, Y., Traczyk, I., Gibney, E.R., Brennan, L., Walsh, M.C., Lovegrove, J.A., Martinez, J.A., Saris, W.H., Daniel, H., Gibney, M., Mathers, J.C. 2015. Profile of European adults interested in internet-based personalised nutrition: the Food4me study. European Journal of Nutrition DOI: 1007/s00394-015-0897-y

Lara, J., Evans, E.H., O'Brien, N., Moynihan, P.J., Mayer, T.D., Adamson, A.J., Errington, L., Sniehotta, F.F., White, M., Mathers, J.C., 2014. Association of behaviour change techniques with effectiveness of dietary interventions among adults of retirement age: a systematic review and meta-analysis of randomised controlled trials. BMC Medicine 177.

Marsh and McLennan Co., 2014. How much could the world save through innovative healthcare delivery models? Oliver Wymann Health and Life Sciences. http://www.oliverwyman.com/content/dam/oliver-wyman/global/en/files/insights/health-life-sciences/2014/Jan/NYC-MKT08001-025%20global%20delivery%20models.pdf

Mazzochi, M., Traill, W.B., Shogren, J.F., 2009. Fat Economics. Nutrition, Health and Economic Policy. Oxford: Oxford University Press.

McGill, R., Anwar, E., Orton, L., Bromley, H., Lloyd-Williams, F., O'Flaherty, M., Taylor-Robinson, D., Guzman-Castillo, M., Gillespie, D., Moreira, P., Allen, K., Hyseni, L., Calder, N., Pettigrew, M., White, M., Whitehead, M., Capewell, S., 2015. Are interventions to promote healthy eating equally effective for all? Systematic review of socioeconomic inequalities in impact. BMC Public Health 15, 457.

McGloin, A.F., Eslami, S., 2015. Digital and social media opportunities for dietary behaviour change. Proceedings of the Nutrition Society 74, 139-148.

McGuffin, L.E., Price, R.K., McCaffrey, T.A., Hall, G., Lobo, A., Wallace, J.M.W, Livingstone, M.B.E., 2015. Parent and child perspectives on family out-of-home eating: a qualitative analysis. Public Health Nutrition 18, 100-111.

Morin, K., 2009. Knowledge and attitudes of Canadian consumers and health care professionals regarding nutritional genomics. OMICS A Journal of Integrative Biology 13, 37-41.

Pavlidis, C., Karamitri, A., Barakou, A., Cooper, D.N., Poulas, K., Topouzis, S., Patrinos, G.P., 2012. Ascertainment and critical assessment of the views of the general public and healthcare professional on nutrigenomics in Greece. Personalized Medicine 9, 201-210.

Poínhos, R., van der Lans, I.A., Rankin, A., Fischer, A.R.H., Bunting, B.P., Kuznesof, S., Stewart-Knox, B., Frewer, L., 2014. Psychological determinants of consumer acceptance of personalised nutrition in 9 European countries. PLoS One 9 c110614.

Prestwich, A., Sniehotta, F.F., Whittington, C., Dombrowski, S.U., Rogers, L., Michie, S., 2014. Does theory influence the effectiveness of health behavior interventions? Meta-analysis. Health Psychology 33, 465-474.

Rankin, A., Kuznesof, S., Frewer, L., Orr, K, Davison, J, de Almeida MDV., Stewart-Knox, B., 2016. Public perceptions of personalised nutrition through the lens of Social Cognitive Theory. Journal of Health Psychology 1-10 DOI 10.1177/1359105315624750

Rankin, A., 2015. Factors determining the uptake and effectiveness of personalised nutritional interventions. PhD thesis. Ulster University.

Robinson, E., Blissett, J., Higgs, S., 2013. Social influences on eating: implications for nutritional interventions. Nutrition Research Reviews 26, 166-176.

Ronteltap, A., van Trijp, H., Berezowska, A., Goossens, J., 2012. Nutrigenomics-based personalised nutritional advice: in search of a business model? Genes and Nutrition DOI 10.1007/s12263-012-0308-4.

Ronteltap, A., van Trijp, J.C.M., Renes, R.J., 2009. Consumer acceptance of nutrigenomics-based personalised nutrition. British Journal of Nutrition 101, 132-144.

Roosen, J., Bruhn, M., Mecking, R., Drescher, L.S., 2008. Consumer demand for personalized nutrition and functional food. International Journal of Vitamin and Nutrition Research 78, 269-274.

Scarinci, I.C., Moore, A., Wynn-Wallace, T., Cherrington, A., Fouad, M., Li, Y.F., 2014. A community-based, culturally relevant intervention to promote healthy eating and physical activity among middle-aged African American women in rural Alabama: Findings from a group randomised controlled trial. Preventive Medicine 69, 13-20.

Steptoe, A., Pollard, T.M., Wardle, J., 1995. Development of a measure of the motives underlying the selection of food: The Food Choice Questionnaire. Appetite 25, 267-284.

Stewart-Knox, B.J., Bunting, B.P., Gilpin, S., Parr, H., Pinhão, S., de Almeida, M.D.V., Gibney, M., 2009. Attitudes toward genetic testing and personalised nutrition in a representative sample of European consumers. British Journal of Nutrition 101, 982-989.

Stewart-Knox, B., Kuznesof, S., Robinson, J., Rankin, A., Orr, K., Duffy, M., Poínhos, R., de Almeida, M.D.V., Macready, A., Gallagher, C., Berezowska, A., Fischer, A.R.H., Navas-Carretero, S., Riemer, M., Traczyk, I., Gjelstad, I.M.F., Mavrogianni, C., Frewer, L.J., 2013. Factors influencing European consumer uptake of personalised nutrition. Results of a qualitative analysis. Appetite 66, 67-74.

Stewart-Knox, B.J., Rankin, A., Poínhos, R., Fischer, A.R.H., de Almeida, M.D.V., Kuznesof, S., Frewer, L.J., 2014. Promoting healthy dietary behaviour through personalised nutrition: a case of getting the technology right? Bulletin of the Nutrition Society doi: 10.1017/50029665114001529.

Stuckler, D., Basu, S., McKee, M., 2010. Budget crises, health, and social welfare programmes. BMJ 340, c3311.

Su, H-L., Lu, T-J., 2012. Exploring the consumer acceptance of and preferences in nutrigenomics-based personalized health management services. PICMET 12: Proceedings – Technology Management for Emerging Technologies 3050-58.

Trading Economics., 2016. Norway GDP Growth Rate 1978-2016. http://www.tradingeconomics.com/norway/gdp-growth

Thornton, L.E., Pearce, J.R., Ball, K., 2014. Sociodemographic factors associated with healthy eating and food security in socio-economically disadvantaged groups in the UK and Victoria, Australia. Public Health Nutrition 17, 20-30.

UCL Institute of Health Equity., 2013. Review of Social Determinants and the Health Divide in the WHO European Region: Final Report.

Webb, T.L., Joseph, J., Yardley, L., Michie, S., 2010. Using the internet to promote health behaviour change: a systematic review and meta-analysis of the impact of theoretical basis, use of behaviour change techniques and mode of delivery on efficacy. Journal of Medical Internet Research 12, e4.

Wendel, S., Dellaert, B.G.C., Ronteltap, A, van Trijp, H.C.M., 2013. Consumers intention to use health recommendation systems to receive personalised nutrition advice. BMC Health Services Research 13, 126.

Wilson, S., Langford, K., 2014. Ten ideas for 21st Century Healthcare. Innovation Unit.

World Health Organisation (WHO)., 2009. Interventions on diet and physical activity: what works: summary report. ISBN 978 92 4 159824.

Table 1: Perceived benefits and barriers to the uptake of personalised nutrition: results from the prior qualitative studies

Benefits	Barriers
Personal health:	Practical issues:
• Fitness;	• DIY testing;
• Weight loss.	• Unreliable postal service;
Health of family/future generations	• Trust in interpretation of results.
Convenient	Data protection:
Time-saving	• Spurious websites;
Anonymity:	• Lack of privacy;
• Not having to see GP;	• Misuse of data;
• Allows for honesty.	• Data mishandling;
Promotes self-efficacy/perceived control	• Commercial exploitation;
• Goal setting;	• Data destiny.
• Self-monitoring.	Social context.

Table(s)

Author / Year	Country	Sample size and characteristics	Study Design Methodology	Outcome measures	Key Findings and Policy Implications
Fischer *et al.*, 2016	Europe 9 countries	N=9381 Quota sampled Aged 18-65 yrs Mixed gender	On-line survey	Willingness to pay for PN	One third of sample willing to pay as much as 50% more for PN. Greece were willing to pay most and Netherlands willing to pay least, *Regulation to encourage and control commercial PN in Greece. *Provide incentive for those in Netherlands to take up PN.
Rankin et al., 2016	United Kingdom	N=32 Aged 18-65 Mixed gender	Focus groups	Theory to inform design of PN	Social Cognitive Theory (SCT) best fit model to describe the public perception of PN. Recommend PN services be designed using SCT
Berezowska *et al.* 2015	Europe 8 countries	N=9000+ Quota sampled Aged 18-65 yrs Mixed gender	On-line survey	Willingness to pay for PN	Perceived risk associated with data security higher if genetic data considered. *Regulate handling of genetic data.
Fallaize *et al.* 2015	United Kingdom and Ireland	N=73 Aged 18-65 and 30-65 yrs	Focus groups	Attitudes to PN* service delivery	Preference for services to be provided by government and delivered face to face. Payment was associated with increased commitment and motivation to comply with dietary recommendations. UK participants expected PN to be delivered free of charge on the NHS. *Provide publically funded PN in addition to commercial services
Poínhos *et al.* 2014	Europe 9 countries	N=9381 Quota sampled Aged 18-65 yrs Mixed gender	On-line survey	Intention to adopt PN	Benefit perception most important determinant of attitude towards adoption of PN. Nutrition self-efficacy a predictor of attitude and intention to take up PN. Perceived risk related to data security had a negative relationship with attitude and an inverse relationship with perceived benefit. *Promote benefits of PN. *Regulate data handling.
Berezowska *et al.* 2014	Europe 8 countries	N=124 Aged 18-65 yrs Mixed gender	Focus groups	Attitudes to PN services	Face to face interaction was deemed to reduce perceived risk and increase benefit. Qualified experts supported by scientific evidence increased value perception. *Recommend off-line communication with qualified health professionals.
Stewart-Knox *et al.* 2013	Europe 9 countries	N = 126 Aged 18-65 and 30-65 yrs Mixed gender	Focus groups	Attitudes to PN	Positive attitudes towards PN. Benefit: control; anonymity. Concerns over data protection, service provider. Barriers: social; motivational. *Promote benefits of PN. *Regulate data handling. *Policies to enable PN in society
Sanderson *et al.* 2013	USA (NY)	N=205 patients Aged 18+yrs Mixed gender	Structured interviews	Determinants of uptake of genomics to treat diet-related disease	Reasons for uptake: altruism; benefit to family members; personal health benefit; curiosity; and, understanding. Reasons for rejection: negative perception of research; not personally relevant; negative about procedures; practical barriers; and, fear of results. *Promote benefits of PN. *Regulate use of research. *Recommend qualified health professionals communicate results.

Wendel *et al*. 2013	Netherlands	N = 204 Mixed gender M age 38-3 yrs	Survey	Intention to receive/use PN	Usefulness of a system valued more and enjoyment valued less when a GP provided advice than if used out of their own curiosity. Trade-off between perceived risk and usefulness. *Recommend employment of qualified health professionals.
Pavlidis *et al*. 2012	Greece	N= 1504 51% female Aged <35 yrs	Survey	Views on nutrigenomics	Majority thought that nutrigenomics should only be offered through health professionals not directly online. Concern about results being interpreted incorrectly. *Recommend qualified health professionals communicate results.
Su & Lu, 2012	Taiwan	N = 258 63% Male	Online survey	Acceptance/ preferences for nutrigenomics	Perceived benefit contributed to acceptance of PN. Hospital service provider preferred over direct sale and DIY . *Promote benefits of PN. *Provide publically funded PN in addition to commercial services
Morin, 2009	Canada	N = 90 Mixed gender Age: n/a	Focus groups – discourse analysis	Knowledge Attitudes to PN	Early diagnosis could lead to better diet and disease prevention. Concern that validity of tests was not established. Potential breach of privacy of concern. *Fund and regulate use of research in PN. *Regulate data handling.
Ronteltap *et al*. 2009	Netherlands	N=438 Mixed gender Age 40-60 yrs	Evaluation of videos of PN scenarios	Perceptions and acceptance of PN	Public acceptance of PN is enhanced if perceived personal benefit, a supportive environment, and PN advice that can be easily incorporated into the daily routine. PN communication is preferred to be delivered by expert stakeholders. *Promote benefits of PN. *Recommend qualified health professionals communicate results.
Roosen *et al*. 2008	Germany	N=452 Mixed gender	Online survey	Attitudes to genetic profiling and PN	45% would agree to a genetic test to receive PN advice. *Fund research to encourage inclusion of nutrigenomic analysis in PN.
Brug *et al*, 1999	Various	N=8 (studies)	Literature review	Behaviour change theory (motivation, self-evaluation, agency)	Computer-tailored communications were more effective than non-tailored interventions particularly for reduction in dietary fat intake. Difficult to draw firm conclusions given the limited number of studies and reliance on self-report data. *Policies and research funding to enable digital solutions for PN.

*PN= Personalised Nutrition

Table 1: Review of results of previous investigations into the consumer view of personalised nutrition, results and *policy implications

Table(s)

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ITEM	FACTOR LOADING	FACTOR
I worry that a personalised diet plan is not effective	0.410	FACTOR 1 **DATA PROTECTION** **32% variance explained**
I worry about how my personal data might be used by authorities	0.881	
I worry that my personal data may not be treated confidentially	0.915	
I worry about how my personal data and test results might be stored	0.914	
I worry about how my personal data might be used by personalised nutrition providers	0.910	
I worry about how my personal data might be used by advertisers	0.888	
I worry about how my personal data might be used by insurance companies	0.874	
I worry that my personal data might be accessed by hackers	0.810	
Providing different foods for family members	0.598	FACTOR 2 **EATING CONTEXT** **23% variance explained**
Difficulties in maintaining healthy eating habits when eating out in restaurants	0.833	
Difficulties in maintaining healthy eating habits when eating at other people's houses	0.853	
Difficulties in maintaining diet when travelling	0.843	

Difficulties maintaining diet when at work	0.728	
Being told to eat foods you don't like	0.635	
Not being recommended to eat foods you like	0.636	
My family rejecting the adoption of personalised nutrition	0.786	FACTOR 3 **SOCIETAL 13% variance explained**
My friends rejecting the adoption of personalised nutrition	0.891	
Society rejecting the adoption of personalised nutrition	0.864	

Table 3: Perceived barriers to the uptake of personalised nutrition – factor structure, factor loadings and % variance explained

ITEM	FACTOR LOADING	FACTOR
Food retailers	0.803	FACTOR 1 **COMMERCE/MEDIA** **39% variance explained**
Food manufacturers	0.828	
Online personalised nutrition companies	0.723	
News media	0.734	
Social media	0.770	
Universities	0.725	FACTOR 2 **PROFESSIONALS** **13% variance explained**
Consumer organizations	0.724	
Dieticians/nutritionists	0.796	
Personal trainers	0.629	
Your family doctor	0.692	FACTOR 3 **GOVERNMENT** **8% variance explained**
Ministry or department of health	0.708	
The European Commission	0.556	
National Health provider	0.751	
Friends and family	0.817	FACTOR 4 **FRIENDS/FAMILY** **8% variance explained**

Table 4: Trust in agencies to provide information on personalised nutrition – factor structure, factor loadings and % variance explained

ITEM	FACTOR LOADING	FACTOR
Knowing what foods are best	0.835	FACTOR **PERSONALISED NUTRITION BENEFITS** **67% variance explained**
Losing weight	0.691	
Gaining weight	0.261	
Fitness	0.891	
Improving family's health	0.900	
Improving health	0.939	
Improving quality of life	0.930	
Improving sports performance	0.766	
Preventing a future illness	0.906	
Preventing expression of hereditary illness	0.855	

Table 5: Perceived benefits of the uptake of personalised nutrition – factor structure, factor loadings and % variance explained

Table(s)

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Factor	**Total** M (SD)	**Norway** M (SD)	**Germany** M (SD)	**Spain** M (SD)	**Greece** M (SD)	**Poland** M (SD)	**UK** M (SD)	**Ireland** M (SD)	**NL** M (SD)	**Portugal** M (SD)
Data Protection	**3.50 (0.84)**	3.30 (0.88) [1]	3.60 (0.88) [2]	3.70 (0.83) [3]	3.54 (0.78) [2]	3.60 (0.77) [2]	3.39 (0.88) [1]	3.37 (0.85) [1]	3.39 (0.85) [1]	3.61 (0.78) [2]
Eating Context	**3.63 (0.82)**	3.31 (0.93) [1]	3.80 (0.92) [4]	3.63 (0.72) [3]	3.81 (0.72) [4]	3.77 (0.78) [4]	3.59 (0.85) [3]	3.67 (0.73) [3]	3.51 (0.93) [2]	3.59 (0.68) [3]
Societal	**3.20 (1.09)**	3.12 (1.17) [2]	3.27 (1.20) [2]	3.21 (0.97) [2]	3.10 (1.08) [2]	3.45 (1.07) [3]	3.26 (1.10) [2]	3.28 (1.02) [2]	2.96 (1.21) [1]	3.11 (0.94) [2]
Trust in Commerce/Media	**2.54 (0.71)**	2.43 (0.71) [2]	2.53 (0.76) [2]	2.66 (0.73) [4]	2.33 (0.71) [1]	2.51 (0.71) [2]	2.54 (0.72) [2]	2.54 (0.68) [2]	2.63 (0.68) [4]	2.68 (0.64) [4]
Trust in Health Professionals	**3.34 (0.66)**	3.34 (0.67) [2]	3.27 (0.79) [2]	3.36 (0.67) [2]	3.39 (0.66) [3]	3.33 (0.69) [2]	3.23 (0.64) [1]	3.42 (0.60) [3]	3.35 (0.63) [2]	3.37 (0.58) [2]
Trust in Gov. Agencies	**3.28 (0.68)**	3.23 (0.62) [2]	3.38 (0.75) [3]	3.46 (0.66) [4]	3.16 (0.67) [1]	3.16 (0.68) [1]	3.33 (0.67) [3]	3.36 (0.68) [3]	3.14 (0.65) [1]	3.31 (0.69) [2]
Trust in Friends/Family	**3.32 (0.85)**	3.08 (0.79) [1]	3.47 (0.95) [3]	3.19 (0.87) [2]	3.25 (0.89) [2]	3.50 (0.80) [3]	3.40 (0.87) [3]	3.45 (0.83) [3]	3.28 (0.75) [2]	3.24 (0.76) [2]
Perceived Benefits	**3.08 (0.96)**	2.72 (1.04) [1]	2.94 (0.98) [2]	3.32 (0.81) [3]	3.55 (0.79) [4]	3.24 (0.86) [3]	2.71 (1.04) [1]	3.28 (0.87) [3]	2.61 (0.94) [1]	3.29 (0.83) [3]

PN = Personalised Nutrition. The UK = the United Kingdom. NL = the Netherlands. [1, 2, 3, 4]= Homogenous subsets (Results of ANOVA)

Table 6: Perceived benefit and barriers (data protection; family/social; trust in agencies) to the uptake of personalised nutrition - factor mean (M) and standard deviation (SD)

Figure(s)

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Figure 1: Preferences for the delivery of personalised nutrition

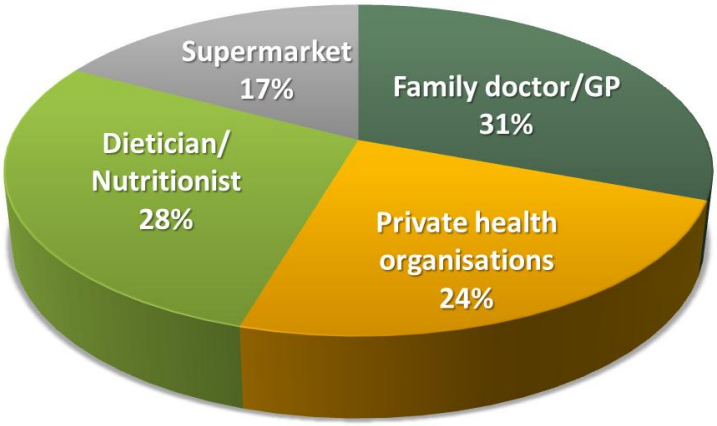

Figure 2: Policy map for the implementation of personalised nutrition in Europe