Proceedings of the Nutrition Society (2015), **74**, 171–176 doi:10.1017/S0029665114001529
 First published online 24 October 2014

The Nutrition Society Irish Section Meeting was held at the University of Ulster, Coleraine on 18–20 June 2014

Conference on 'Changing dietary behaviour: physiology through to practice' Symposium 4: Changing diet and behaviour – putting theory into practice

Promoting healthy dietary behaviour through personalised nutrition: technology push or technology pull?

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The notion of educating the public through generic healthy eating messages has pervaded dietary health promotion efforts over the years and continues to do so through various media, despite little evidence for any enduring impact upon eating behaviour. There is growing evidence, however, that tailored interventions such as those that could be delivered online can be effective in bringing about healthy dietary behaviour change. The present paper brings together evidence from qualitative and quantitative studies that have considered the public perspective of genomics, nutrigenomics and personalised nutrition, including those conducted as part of the EU-funded Food4Me project. Such studies have consistently indicated that although the public hold positive views about nutrigenomics and personalised nutrition, they have reservations about the service providers' ability to ensure the secure handling of health data. Technological innovation has driven the concept of personalised nutrition forward and now a further technological leap is required to ensure the privacy of online service delivery systems and to protect data gathered in the process of designing personalised nutrition therapies.

Personalised nutrition: Nutrigenomics: Benefit: Risk: Information technology: Food4Me

What is personalised nutrition?

Internet and mobile phone technology has become integral to our daily activities and health and eating behaviour is no exception with recent technical advances having fuelled a drive towards direct-to-consumer (D-T-C) personalised nutrition. Personalised nutrition is an innovative concept that seeks to identify individual nutritional needs based on health status, genotype[(1)] and/or phenotype[(2)] and then to provide healthy eating advice that is tailored to suit the individual (Food4me.org). Meanwhile, there is a growing body of evidence for the effectiveness of tailored feedback in bringing about healthy behaviour change[(3–6)]. Surveys of D-T-C services have suggested that they are effective in producing healthy behaviour change in approximately one-third of users[(7–10)]. Awareness of D-T-C genetic tests is increasing among consumers[(11)]. Those with a stake-hold in the delivery of personalised nutrition see immense potential to transform preventative and therapeutic nutrition and in doing so, to benefit public health and reduce health costs[(12)]. Personalised nutrition not only has potential for the tailoring of diet to individual health needs, but also to that of groups of people among the general public[(13)]. For personalised nutrition intervention to have any real and enduring impact upon public health,

Abbreviations: D-T-C, Direct-to-consumer.

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however, we need to understand and take into account the public vision for such services[14]. Early D-T-C personalised nutrition initiatives have, on the whole, not been commercially successful. Despite the recent rapid advance in interactive health technology[12] and the potential for societal benefit, there is a dearth of research in the area of personalised nutrition and nutrigenomics from the perspective of the general public[15,16]. Much of what research exists has focused on genetic testing albeit in various contexts, while fewer studies have considered personalised nutrition in particular.

What do the public think about nutrigenomics?

The future success of personalised nutrition in practice will depend upon the public being ready and able to take up aspects of the technology that are essential to service delivery. Personalised medicine and personalised nutrition share certain technologies. Genetic profiling is common to personalised medicine and nutrition and is likely to be important (along with phenotype, etc.) in informing personalised nutrition initiatives in the future. Understanding attitudes towards genetic testing, therefore, is relevant to understanding public response to nutrigenomics which represents the more 'medicalised' level of personalised nutrition provision.

Qualitative enquiry into societal views on genetic testing undertaken in the USA[17–23], Australia[24], Switzerland[25], the Netherlands[26] and the UK[27], has indicated that people are aware of the potential benefits and hold generally positive attitudes towards genetic testing. Potential drivers of the uptake of genetic testing include own health[17,18,24,28,29], the health of other family members and descendants[17–19,24], for research purposes[17,24,30] and curiosity[10,18,24,25,28,30,31]. All these studies, however, also catalogued concerns surrounding the enabling technology. Online privacy and the potential for information to be used by companies for commercial gain or to fall into the hands of insurers, employers or government agencies are among issues that have been consistently raised[17–27,32,33]. Aspects of the service delivery system itself may also need to be personalised. Whereas some studies of factors determining uptake of genetic testing[23,34], have suggested that consumers liked the notion of autonomy and being in control[33], other works have implied that some consumers would prefer the input of a health professional[32,35,36]. In view of the differing perspectives, the mode of service delivery may need to be personalised.

Survey studies conducted in the USA[8,37–47], Canada[48], Russia[49,50], Finland[51,52], Sweden[53], the Netherlands[54], Australia[55], Canada[56] and the UK[57] have indicated largely positive attitudes towards genetic testing. The public also appear positive about donating genetic material to biobanks[19,58,59] and willing to supply genetic material for research purposes[60]. Reasons suggested by the public for taking up genetic testing not only include improving one's own health[61–64], but also of other family members and descendants[62–66] . Unsurprisingly, therefore, those with a family history of inherited conditions have been found to have more favourable attitudes towards genetic testing[21,55,67] and may be willing to pay more[56]. A sizeable proportion would avail of genetic testing for no reason other than curiosity[42,49,50,61,62,68]. Others, on the other hand, may not want to know test results unless treatment was available[53,54].

Despite generally positive attitudes towards genetic testing, and in keeping with existing qualitative studies into genetic testing (see previous paragraph), quantitative research, mainly surveys conducted over the last couple of decades conducted in the USA[8,37,68–71], Canada[48,56], Australia[72], Europe[73], the UK[59], Finland[74,75] and the Netherlands[76] also indicate considerable concern among the public about internet privacy, data security, data use and data destiny[41,43,44,51–56]. Previous surveys into public attitudes towards genomics[52,53,55,67], however, have failed to recruit samples that have been representative of the general population, making it difficult to draw firm conclusions as to the response of various societal groups to this emerging technology. Attitudes to genetic testing, however, appear to vary by gender, age and educational level. Males[8,52,57,63] and older individuals[11,37,52,57] appear most favourable towards the notion of genetic testing. Analyses of the impact of education level upon attitudes towards genetic testing have produced mixed results[11,21,40,46,77–79]. Those educated to a higher educational level[21,78] and those in minority ethnic groups[43,44] appear particularly concerned over data protection, use and destiny.

What does the public think about personalised nutrition?

Whereas personalised medicine relates genotypic information to propensity for disease, personalised nutrition relates genotypic information to optimal diet and health[80]. Personalised nutrition also differs from nutrigenomics in taking a broader view of health and dietary health promotion and considering not only genotype, but also phenotype and lifestyle. This could render personalised nutrition less ethically sensitive and more amenable to public health promotion. However, consumer response to nutrigenomics and personalised nutrition remains an under researched area. Only a handful of qualitative (Morin[81]) and survey[82,83] studies have considered the public perspective of nutrigenomics, all of which have indicated that between one-third and a one-half of those surveyed would be willing to avail such services and to follow a tailored diet. Having a health problem was also associated with being positive about receiving genetic-profiling information for the purpose of personalising their diet[82,83]. Research conducted in the Netherlands has indicated that consumers may be more amenable towards web-based personalised nutrition if they were in control of the use of the results[84]. In keeping with this notion, other studies have implied that doubts about data security, data use and destiny would deter use of such services[82,83].

https://doi.org/10.1017/S0029665114001529 Published online by Cambridge University Press

The Food4Me project

The EU-funded Food4Me project appears to be the first of its kind to have adopted a mixed, qualitative and quantitative, survey design to gain an understanding of what would determine or deter uptake and compliance with personalised nutrition among the European general public and to establish the best way to deliver such services.

Focus group discussions were held in each of eight European countries (Spain, the UK, Ireland, the Netherlands, Poland, Portugal, Greece and Germany) during early 2012. Discussion was prompted using scenarios that depicted personalised nutrition at three successive levels of 'medicalisation' for which lifestyle, phenotypic and genetic information was collected (Food4me.org). The concept of personalised nutrition was viewed positively with potential to enhance health. Discourses arising in all eight countries framed personalised nutrition in terms of perceived benefit and risk[85]. The sort of benefit expected from personalised nutrition were health related and similar to those which have been previously reported[61–64] and included those related to health and fitness such as losing weight, building muscle, preventing and treating disease. D-T-C personalised nutrition services were likened to 'the food equivalent of a personal trainer'. Themes otherwise centred on the online delivery technology. The convenience of accessing dietary health services in the comfort of one's own home directly and not having to involve the general practitioner were also considered advantageous. The potential for anonymity afforded by such a system could serve to spare embarrassment and enable greater honesty in reporting dietary health behaviour.

Perceived risks were unrelated to personalised nutrition *per se* but rather to aspects of the delivery system itself such as those incurred by unwittingly visiting spurious websites or as a consequence of a lack of online security. Although in favour of personalised nutrition, the European public were unanimous across eight countries in expressing negative views on the ability of web-based enabling technology to ensure privacy and overcome issues surrounding data protection, usage and data destiny[85]. As has been found in previous qualitative studies of genetic testing[17–27,32,33] and nutrigenomics[82], issues surrounding data mishandling arose with concerns expressed about where information could end up. Possibilities discussed included the potential for commercial exploitation, for example, the selling of data to advertisers or spammers, as well as the more sinister possibility of surveillance purposes by insurers, employers and government agencies.

The next stage in the research process was to determine the distribution and generalisability of these ideas quantitatively. The prior qualitative research findings were used to inform the selection of items and validated scales and for inclusion in the Food4Me survey. The resultant questionnaire was translated and back-translated into the native languages of each of the nine EU countries (Germany, Greece, Ireland, Poland, Portugal, Spain, the Netherlands, the UK and Norway) involved in the study. Members of the European public (*n* 9381) were quota sampled to be nationally representative for each country, on sex, age and education level and then surveyed online during February and March 2013. Similar to the previous surveys of public opinion of genetic testing[41,43,44,51–56], the Food4Me survey found that perceived benefit was associated with intention to take up personalised nutrition. Statistical modelling suggested that the benefit attributed to personalised nutrition contributed to more favourable attitude towards and intention to adopt personalised nutrition[86]. Perceived benefit was also associated with less perceived risk. Perceived risk was unrelated to intention to take up personalised nutrition. A possible explanation for this finding, and one suggested by the prior qualitative research, is that risk was not actually related to the concept of personalised nutrition but to the online delivery technology.

The Food4Me results, therefore, agree with those of previous studies that have investigated attitudes to genetic testing in suggesting that the public are acutely aware of the threat for data mishandling and misuse. Together, the qualitative and survey results suggest that to encourage uptake of personalised nutrition and enable people to achieve healthy dietary change, we must emphasise benefits while making the delivery system secure. Participants taking part in the initial qualitative studies were able to make suggestions as to how to minimise the damage should a privacy or data-handling mishap occur, for example, storing demographic, lifestyle and biological data separately. Nevertheless, the issue of how to ensure online privacy and protect and control data usage and destiny remains.

What does the future hold for personalised nutrition?

Previous research findings provide some clues as to why despite evidence that tailored interventions are effective in bringing about healthy behaviour change, early attempts to deliver personalised nutrition services on a commercial scale have failed. Expectancy value theories allow us to consider the implications of these findings for behaviour change. Protection motivation theory[87–89] holds that the likelihood of a behaviour occurring, for example, taking up personalised nutrition, will depend upon the perceived size, severity and likelihood of any associated risk and perceived ability to reduce the risk. This implies a need for further consumer research to establish the perceived size, severity and likelihood of risk associated with online D-T-C personalised nutrition as well as perceived ability to reduce the risk and interaction with perceived benefit.

The overarching message from the research into the public response to genetic testing, nutrigenomics and personalised nutrition is that for D-T-C personalised nutrition to be taken up on a societal scale, people will need assurances that all online interactions would be private and that the provider will have ability to effectively handle and protect information collected in the endeavour to design personalised diets. In the wake of accidents

https://doi.org/10.1017/S0029665114001529 Published online by Cambridge University Press

resulting in public data falling into the 'wrong' hands and recent revelations about how data generated through social media and other personal internet activities is used for marketing purposes and commercial gain, perceived weaknesses inherent in such technology are likely to limit the future development, consumer uptake and growth of such services.

Potential consumers, although positive about the concept of personalised nutrition, are telling us that in order for them to take up such services the information collected will require regulation[90]. Control of the handling and use of health-related data will only be effective if the technology is in place to enable compliance with regulation[91]. Interdisciplinary research and innovation is needed urgently to render the delivery of health systems such as personalised nutrition secure and enable this potentially important public health innovation. Delivering personalised nutrition to the public will require working closely with information technologists in getting the delivery system perfected. Technological innovation has driven the concept of D-T-C health systems. The future of personalised nutrition would also appear to lie in the hands of information technologists. Meanwhile, promotion of personalised nutrition to the general public would do well to emphasise the (personal) benefits of personalised nutrition.

Acknowledgements

The authors would like to take this opportunity to acknowledge the work of the focus group moderators, observers and transcribers for their input into the qualitative study as well as GfK who undertook sampling and data collection.

Financial Support

The Food4Me project received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 265494.

Conflict of Interest

None.

Authorship

B. S.-K. drafted the manuscript and A. R. collected and reviewed the literature. All authors contributed to the design of the Food4Me studies and data collection. L. F. led the work.

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https://doi.org/10.1017/S0029665114001529 Published online by Cambridge University Press