Proceedings of the Nutrition Society (2015), **74**, 215–220 doi:10.1017/S0029665114001645
 First published online 17 December 2014

The Nutrition Society Summer Meeting 2014 was held at the University of Glasgow on 14–17 July 2014

Conference on 'Carbohydrates in health: friends or foes' Symposium 2: New perspectives on carbohydrates and health

Carbohydrates and obesity: from evidence to policy in the UK

Susan A. Jebb

Nuffield Department of Primary Care Health Sciences, University of Oxford, Radcliffe Observatory Quarter, Woodstock Road, Oxford OX2 6GG, UK

Carbohydrates provide the major source of energy in the diet and hence the type and amount of carbohydrate consumed is an important consideration for weight control. Recent risk assessments have shown that there is no consistent association between the proportions of energy consumed as carbohydrate and body weight and reinforce the dominance of total energy intake as the primary determinant of body weight. However, they have highlighted evidence that different types of carbohydrate have specific effects on the risk of obesity. Short-term experimental studies suggest that some types of dietary fibre may be linked to increased satiation and cohort studies are supportive of an association between low intakes of fibre-rich, whole-grain foods and weight gain. But these observations are not supported by evidence of effects on body weight in randomised controlled trials, suggesting that high-fibre or whole-grain intake may simply be a marker of a broader dietary pattern. Recent attention has focused on the growing evidence of a positive association between the intake of free sugars and weight gain and particularly the risks linked to consumption of sugar-sweetened beverages (SSB). Given the high population-level intake of free sugars the challenge is to identify actions that will successfully reduce consumption to contribute to reductions in the prevalence of obesity. The present paper considers the range of policy options available, using the Nuffield ladder of intervention to provide a framework for risk management, with a focus on the consumption of SSB. Current policy interventions are largely based around consumer education and encouragement to industry to renovate products to reduce the sugar content of food and drinks and/or reduce portion size, but dietary change has been slow. Further measures, including the use of specific incentives/disincentives may be needed to change consumption patterns, some of which may infringe personal or commercial freedom. For these policies to be implemented will require sustained efforts to create a climate in which such interventions are acceptable or even welcomed by society as an appropriate protection against obesity and other diet-related ill-health.

Carbohydrates: Sugars: Obesity: Policy

Carbohydrates in the form of cereals, grains and sugar are quantitatively the most important source of dietary energy for most populations. In the UK, mean intakes of total carbohydrate represent 52 % dietary energy in children and 46 % in adults[1]. In recent decades, as the prevalence of obesity has increased, there has been growing interest in whether the source of energy in the diet constitutes a specific risk factor for obesity. There are potential differences in the risk of weight gain associated with the different subtypes of carbohydrate or specific carbohydrate-rich foods, either as a consequence of differences in the bioavailability on energy or the impact on post-meal appetite control.

Assessing the risk

Recent reviews conducted as part of the work of the WHO[2] and the Scientific Advisory Committee on Nutrition (SACN) have considered the relationship

Abbreviation: NMES, non-milk extrinsic sugars; SACN, Scientific Advisory Committee on Nutrition; SSB, sugar-sweetened beverages.

Corresponding author: Professor Susan A. Jebb, susan.jebb@phc.ox.ac.uk

between various sources of carbohydrates and energy intake, weight gain or the risk of obesity. The headline findings that are most relevant for considerations of dietary recommendations are summarised below.

Total carbohydrate

Assessing the relationship between total carbohydrate and body weight is complex because of the need to differentiate between the types of carbohydrate and account for substitution effects with other dietary constituents. Also, many studies that involve decreases in carbohydrate intake are just one part of broader weight loss interventions. Overall, a series of meta-analyses conducted for the SACN review found inconsistent evidence of the relationship between total carbohydrate and measures of weight status or obesity risk[3]. However, there is some limited evidence that a hypo-energetic diet with a higher proportion of carbohydrate and lower proportion of fat may be an effective intervention for weight loss in adults[3].

Dietary fibre

Mean intakes of dietary fibre in the UK, expressed as NSP are 14 g/d for adults, compared with a Dietary Reference Value of 18 g/d[1]. Intakes in children are also significantly lower than recommended. In an earlier WHO review on diet and the prevention of obesity in 2003, there was considered to be convincing evidence of an association between NSP and reduced risk[4]. This was based on mechanistic evidence of the links between dietary fibre, and increased satiety and satiation, observational data and short-term experimental studies[5]. However, more recent reviews for the draft SACN report on carbohydrates and health identified just five cohort studies in adults which met their stringent criteria and a meta-analysis found no consistent association with body weight change[3]. In six dietary intervention studies in adults, where changes in fibre intake were achieved through food and not supplements, there was no significant effect on energy intake[6–11]. There are no trials to examine the effects of increases in dietary fibre using food and not supplements on weight change or risk of obesity over periods of 1 year or more.

Wholegrain

Wholegrains have been recently defined by an international consortium as consisting of the intact ground, cracked or flaked kernel after the removal of inedible parts such as hull and husk, where the principal anatomical components (the starchy endosperm, germ and bran) are present in the same relative proportions as they exist in the intact kernel and allowing for very small losses during preparation[12]. There is no reference value for whole grain intake in the UK, although the mean intake of 14 g/d for adults is substantially below the US recommendation of 64 g/d, based on 3 × 16 g servings per d[13].

Cohort studies are broadly supportive of an association between higher whole grain intake and lower weight gain, although this is attenuated after adjustment for dietary fibre and other potential confounders[14,15]. However, there are only three trials that have examined the impact of substituting refined carbohydrate with wholegrain on energy intake[8,10,16] which collectively suggest a modest benefit. The largest of these studies, the Women's Health Initiative[16], was a complex multicomponent intervention. There was a small but significant increase of one-third of a serving of whole-grain per d, relative to the control group, from 1·1 to 1·4 servings, but the impact of the intervention on energy intake may reflect other components of the intervention, including decreases in dietary fat and increases in fruit and vegetable consumption. A 16-week highly controlled intervention which specifically substituted refined grain for whole grain products and did not include other dietary changes, found no difference in body weight between groups[17]. There are no trials over periods of more than 1 year reporting on weight change. Accordingly there is insufficient evidence to suggest a benefit of increases in whole grain foods to specifically control body weight, although they may contribute to broader improvements in diet quality.

Sugars

Sugars occur in the diet both as a natural component in foods such as fruit and dairy products, but are also added to a wide range of other foods and drinks. In the UK, the mean intake of total sugars for adults and children over 4 years is close to 100 g/d[1]. Over half of this is from non-milk extrinsic sugars (NMES). Consumption of NMES in different age groups ranges from a mean of 11·2 % in adults over 65 years and 11·9 % in children 1·5–4 years, to highs of 15·4 % in 11–18 years old[1], but all age groups exceed the recommended maximum of 10 % energy from NMES. Intake of NMES is numerically close to the proportion of 'free sugars', defined by WHO as sugars added to foods by the manufacturer, cook or consumer, plus sugars naturally present in honey, syrups, fruit juices and fruit concentrates.

Systematic reviews conducted for the SACN report on carbohydrates and health have shown that as the contribution of sugar in the diet increases, energy intake also increases[3]. The most robust data come from dietary intervention studies. A meta-analysis of seven trials in adults found that diets higher in sugars were associated with higher energy intakes (1274 (95 % CI 889, 1660) kJ/d; $P = <0{\cdot}001$; 304 (95 % CI 212, 397) kcal/d) over periods of 4 weeks to 6 months[3].

The review conducted for the draft WHO guideline report on sugars specifically considered the relationship between free sugars and the risk of obesity[2]. From a total of sixteen cohort studies identified among adults, eleven studies reported one or more positive associations between some measure of the intake of free sugars and the risk of obesity or increased adiposity. Only one study reported a significant negative association. Among children, twenty-three cohort studies were identified of which fourteen reported a positive association between increased consumption of sugar-sweetened beverages (SSB) and obesity and a further study showing a

https://doi.org/10.1017/S0029665114001645 Published online by Cambridge University Press

positive association with free sugars. Only four studies found a negative association[18].

However, more robust data come from dietary intervention studies in both adults and children. Ten studies in adults showed that increases in free sugars were associated with significantly higher weight than the control group (+0·75 (95 % CI 0·30, −1·19) kg; $P = 0·001$) with a clear association between the magnitude of the increase in sugars intake and weight increase[18]. Conversely, in five studies in adults that involved decreasing intake of free sugars, over periods ranging from 10 weeks to 8 months, there was a significantly lower weight reported at the end of the trial compared with the control arms (−0·80 (95 % CI −1·21, −0·39) kg; $P = 0·001$).

There have been numerous meta-analyses of both cohort studies and trials specifically reporting the effect of SSB on body weight. The most up-to-date analysis of cohorts, based on fifteen studies in children and seven in adults reported an increase of one serving per d of SSB was associated with a 0·06 (95 % CI 0·02, 0·10) unit increase in BMI in children and 0·22 (95 % CI 0·09, 0·34) kg weight gain in adults over 1 year[19]. In a meta-analysis of five intervention studies to reduce SSB in children, there was a −0·17 (95 % CI −0·39, 0·05) reduction in BMI gain[19]. The present trial data are supported by experimental evidence showing the poor satiating properties of energy consumed as liquid, relative to isoenergetic solid foods[20]. Collectively, the evidence makes a powerful case for specific recommendations to limit consumption of these beverages.

Accordingly, the balance of evidence supports the notion that the intake of free sugars, especially SSB, presents a risk for weight gain broadly in proportion to the magnitude of consumption. This, together with wider evidence pertaining to the risk of diabetes and oral health considerations, have led to draft guidance from WHO that proposes sugar intake be limited to a maximum of 10 % energy intake and that a reduction to <5 % dietary energy from sugar would have additional benefits[2]. Draft recommendations from the SACN suggest a population maximum intake for the UK of 10 %, with an average population recommendation of 5 % dietary energy from free sugar[3].

Managing the risk

Reviews of the evidence linking carbohydrates to health outcomes, together with surveillance data on intake, inform the strategy for risk management. Although intakes of fibre in the UK are lower than recommended, and increases in whole grain intake may be a useful strategy to increase fibre, the risk assessment does not warrant action on either of these components of the diet specifically to tackle obesity. However, the clear association between free sugars and increased energy intake or weight gain identifies a reduction in sugar intake as a key component of a wider strategy to reduce the prevalence of obesity. In the UK, among all age groups, beverages, including soft drinks, fruit juice and alcoholic drinks, typically provide about one-third of the free sugar in the diet with additional substantive contributions from cakes, biscuits, confectionery, preserves, breakfast cereals, yoghurts and other dairy-based desserts[1]. Although the individual contribution of each varies by age-group, these food groups account for about 80 % of the free sugars in the diet and form the principal targets for action.

Advice to reduce sugar intake to meet the present recommendation of no more than 10 % dietary energy has been a component of standard information to achieve a balanced diet for many years. Despite this, there has been little change in intake. For example, among adults (age 19–64 years) the proportion of dietary energy obtained from sugar has only decreased from 12·3 % in 2000–2001 to 11·5 % in the latest 2008–2012 survey[1]. Accordingly, if the draft recommendations from WHO and SACN are pursued, it will be necessary to consider a broader and potentially more innovative range of strategies to further restrict intake of sugars.

Traditional health promotion efforts have relied heavily on the provision of education and information. This focuses on the actions of individuals to alter their personal dietary choices. However, it is now increasingly recognised that the impact of individual-level behaviour change interventions is limited. Moreover, it risks exacerbating inequalities since the ability to enact the changes may require higher levels of executive functioning. So, while social marketing campaigns or advice from health professionals and other practitioners may be a useful component of risk management, especially for those who need additional support, action is also required to change elements in the wider environment which can encourage or enable individuals to modify their food intake, often without conscious decision-making[21]. This leads to a much wider range of policy options. However, some actions that have been proposed risk infringing the freedom of individuals to make unfettered choices, and in a democracy, must be accompanied by public acceptability for such interventions. This is likely to require stronger evidence that it will achieve the desired outcome.

To address these competing interests the Nuffield Council set out a framework in which to contemplate the range of options available for intervention[22]. It attempts to balance the magnitude of the risk against the potential for the infringement of personal autonomy.

Population-level options to reduce free sugars

The Nuffield ladder of interventions can be used to consider a range of options which might theoretically be deployed to reduce the intake of free sugars[21]. To achieve proportionality, the goal is to remain as close as possible to the lower rungs of the ladder while ensuring effective action. However, in practice, there is likely to be a portfolio of options deployed, to reach different subgroups of the population or in different settings.

Step 1. Do nothing or monitor the current situation. The UK is fortunate to have an extensive range of surveillance data on dietary intake and population health, particularly the National Diet and Nutrition Survey which provides detailed individual-level measures[1]. Over

https://doi.org/10.1017/S0029665114001645 Published online by Cambridge University Press

many years, this survey has documented the high level of consumption of NMES and it provides important information to inform the risk assessment. Related media coverage might make a contribution to public awareness that the intake of sugar exceeds recommendations.

Step 2. Provide information. Limiting the intake of sugar-rich foods has been a core component of healthy eating advice in the UK, as depicted in the EatWell plate (http://www.nhs.uk/Livewell/Goodfood/Documents/Eatwellplate.pdf).

More recently there has been a specific focus on the need to reduce the intake of SSB as evidence has emerged on the specific links to obesity. Social marketing campaigns such as Change4Life have specifically conveyed information on the sugar content of these drinks and advice to swap to low-sugar alternatives, such as water, non-nutritively sweetened beverages or low-fat milks. Observational data suggest a 8·6 % reduction in purchases of SSB in January 2014, coinciding with a peak of the Change4Life campaign messaging compared with the previous year and after adjusting for longer-term trends, which provides supporting evidence of a small positive impact of information provision[23].

Step 3. Enable choice. In recent decades, there has been a marked expansion in the dietary choices available to consumers with multiple variants of similar products designed to appeal to particular segments of the market. In the case of drinks, the growth of low- and no-sugar options has been remarkable and, according to the British Soft drinks Association, these products now account for 61 % of sales of soft drinks in the UK (British Soft Drinks Association, personal communication). However, beyond the drinks category, the availability of lower sugar variants has yet to reach the scale of lower salt options. The recent licensing of Stevia (a natural plant extract which provides intense sweetness) for use in Europe may herald new developments in a wider range of food and drink categories. However, the provision of greater choices for consumers must be accompanied by interventions to encourage and enable individuals to shift their consumption patterns to favour the lower sugar options. To date, the uptake of these alternative low/no-sugar products has been limited by a small but significant body of public anxiety about the safety of a number of non-nutritive sweeteners such as aspartame.

Step 4. Guide choices through changing the default policy. The middle of the Nuffield ladder emphasises the use of choice architecture (so called 'nudge') interventions. These actions involve changes in the microenvironment to cue behaviours associated with a healthier diet, typically with minimal conscious engagement[24].

The UK has had a concerted strategy since 2004 to reduce salt intakes through the reformulation of key food products[25]. In most cases, rather than offering a specific lower salt option, the composition of the core product has been changed over time towards healthier eating targets. Similar principles are now being applied to reduce sugar, effectively changing the default. This differs from simply increasing the choice available to consumers because it does not rely on an active decision by individuals to choose a different product. Instead the change is made at point of production, effectively ensuring the intervention reaches the whole population.

Step 5. Guide choices though incentives. As the market for no/low-sugar options increases, specific efforts may be required to incentivise change. Since many food and drink choices are automatic decisions, specific action is required to break the automatic selection process[21]. A clear example is the use of price discounts to encourage selection of the healthier choice; however, there is little information in the public domain on the magnitude of the price differential required to motivate change, nor on the economic sustainability of this approach. Other options that do not deploy fiscal incentives are beginning to emerge. For example, a recent announcement by drinks companies and cinema chains to alter drinks fountains to include a higher proportion of no/low-sugar options and to train staff to actively offer the lower sugar option as the default drink choice. Evidence of the effectiveness of this initiative is not yet available.

Step 6. Guide choices through disincentives. The possibility of introducing health-related taxes on food and drink to promote healthier choices has received considerable attention in recent years[26]. The possibility of a tax on SSB probably offers the most practical opportunity given the category can be easily defined and is a non-core, discretionary component of the diet. Unlike some other possible options, there is a clear alternative available to consumers in the form of no-sugar drinks and such a tax is unlikely to be regressive[27]. The debate centres on two elements: will a tax be effective and will a tax be publicly acceptable?[28]. The effectiveness of economic interventions to change behaviour relies heavily on modelling studies[29]. These analyses usually demonstrate a positive impact on consumption but with considerable uncertainty in the effect size which is heavily dependent on the assumptions of the model. Although small taxes have been deployed in some states in the USA and in some countries in Europe e.g. France and Hungary, the evaluation of the impact on consumption is patchy and weak. In an era of evidence-based policy making the status of the evidence has become a barrier to the implementation of this type of intervention. Moreover, public acceptability for any form of additional tax is limited. The UK government was forced to overturn an attempt to introduce a general sales tax on hot takeaway food and, even in the specific context of health-related taxation, studies have shown a clear public preference for initiatives based on education or choice architecture interventions, over taxation[30].

Step 7. Restrict choice. The higher steps on the Nuffield ladder reflect much more paternalistic interventions which overtly infringe personal autonomy. In the case of food, such interventions have to date, only been applied in very specific settings such as schools, where the duty of care is well established and accepted, especially for children.

The school food standards in England provide a striking example of the use of restrictions to shift consumption patterns[31]. In the case of sugar, the standards specifically prevent the sale in state-funded schools of

https://doi.org/10.1017/S0029665114001645 Published online by Cambridge University Press

most SSB, confectionery and chocolate. Similar standards exist for pre-school settings, but are not mandated. No such rigorous standards apply for other public institutions, even where the state is largely responsible for food provision, but represent a clear opportunity for intervention. Other restrictions on choice could include imposing bans on food and drink in specific places e.g. public transport. Such interventions would be critically dependent on public acceptability since they overtly infringe personal choice.

Step 8. Eliminate choice. The final step of the ladder would probably require a high standard of evidence showing causal links between a product and adverse outcomes and evidence of the likely effectiveness of the policy. However, even in the case of tobacco, where the health impact is much greater and far more wide-reaching and stringent policy measures are already in place, smoking bans involving the complete elimination of choice, are only deployed in very specific settings.

Summary

Policy makers are in the unenviable position of being criticised if they intervene without strong evidence of likely success, yet denigrated if they fail to take adequate steps to protect public health. Policy decisions must be based on evidence, but in the case of sugar, the evidence for effective interventions to reduce intake and decrease the prevalence of obesity is neither complete nor perfect. The art of policy-making, which commands public respect and drives sustainable change, lies in a proportionate response that strikes a balance between the strength of evidence available against the appropriate and acceptable degree of infringement of personal choice and/or commercial freedom. The rate of policy development with respect to controls on tobacco is symptomatic of the relatively slow pace of change in public opinion that may lag many years behind scientific evidence. Moreover, the causal linkage between sugar, or even SSB, and obesity is far weaker than the association between smoking and disease because of the inherent complexity of the diet and the multi-factorial nature of weight gain.

However, in the last few years there has been a considerable strengthening in the evidence that SSB represent a specific risk factor for obesity and, given other adverse health consequences, especially on oral health, there is a widespread scientific acceptance of the case for more stringent action than hitherto. There is a clear need to build public understanding of the risks of diets high in sugar and the options for intervention. The importance of information provision to raise awareness, inform consumers of the health risks of obesity and to advise on ways to reduce intake of sugar will continue to be an important component. In isolation, these may be of limited effectiveness in driving change but are important to influence public opinion in support of other policy interventions. Without public acceptance, new initiatives to encourage and enable lower sugar choices, particularly the switch to no/low-sugar beverages, will be ignored, given low priority or become difficult to enforce. In many countries, the introduction of seat-belt regulations or bans on smoking in public places have each been underpinned by sustained social marketing campaigns which have created the public climate in which political intervention is acceptable or even demanded.

The challenge for scientists is to move beyond classic risk assessment and to better define the effective policy options, particularly in the area of choice architecture interventions and harder policy options where evidence is currently scant. However, the slow pace of change to date suggests that there is also a need, through efforts to build public understanding and trust, to develop a social movement which tolerates or actively welcomes the introduction of stronger policy measures to improve diet which may need to curb the freedom of businesses to sell and individuals to purchase some of the products they currently consume.

Financial Support

Professor S. A. J. is supported by the National Institute for Health Research Collaboration for Leadership in Applied Health Research and Care (NIHR CLAHRC) Oxford at Oxford Health NHS Foundation Trust. The views expressed are those of the author and not necessarily those of the NHS, the NIHR or the Department of Health.

Conflicts of interest

S. A. J. is the independent Chair of the Public Health Responsibility Deal Food Network.

Authorship

References

1. Bates B, Lennox P, Prentice A *et al.* (2014) Public Health England. National Diet and Nutrition Survey: Results from Years 1–4 (combined) of the Rolling Programme (2008/2009–2011/12). Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/310997/NDNS_Y1_to_4_UK_report_Executive_summary.pdf
2. World Health Organisation (2014) Draft Guideline: Sugars intake for adults and children. Consultation date: 5–31 March 2014. Available at: http://www.who.int/nutrition/sugars_public_consultation/en/
3. Scientific Advisory Committee on Nutrition (2014) Draft Carbohydrates and Health report – Scientific consultation: 26 June to 1 September 2014. London: Public Health England.
4. World Health Organization (2003) Technical Report series. Diet, nutrition and the prevention of chronic diseases. Available at: http://whqlibdoc.who.int/trs/WHO_TRS_916.pdf?ua=1
5. Howarth NC, Saltzman E & Roberts SB (2001) Dietary fiber and weight regulation. *Nutr Rev* **59**, 129–139.

https://doi.org/10.1017/S0029665114001645 Published online by Cambridge University Press

6. Kesaniemi YA, Tarpila S & Miettinen TA (1990) Low vs high dietary fiber and serum, biliary, and fecal lipids in middle-aged men. *Am J Clin Nutr* **51**, 1007–1012.
7. Sciarrone SE, Strahan MT, Beilin LJ *et al.* (1993) Ambulatory blood pressure and heart rate responses to vegetarian meals. *J Hypertens* **11**, 277–285.
8. Turpeinen AM, Juntunen K, Mutanen M *et al.* (2000) Similar responses in hemostatic factors after consumption of wholemeal rye bread and low-fiber wheat bread. *Eur J Clin Nutr* **54**, 418–423.
9. Thompson WG, Rostad Holdman N, Janzow DJ *et al.* (2005) Effect of energy-reduced diets high in dairy products and fiber on weight loss in obese adults. *Obes Res* **13**, 1344–1353.
10. Andersson A, Tengblad S, Karlstrom B *et al.* (2007) Whole-grain foods do not affect insulin sensitivity or markers of lipid peroxidation and inflammation in healthy, moderately overweight subjects. *J Nutr* **137**, 1401–1407.
11. Olendzki BC, Ma Y, Schneider KL *et al.* (2009) A simple dietary message to improve dietary quality: results from a pilot investigation. *Nutrition* **25**, 736–744.
12. van der Kamp JW, Poutanen K, Seal CJ *et al.* (2014) The HEALTHGRAIN definition of 'whole grain'. *Food Nutr Res* **58**, 22100.
13. Thane CW, Jones AR, Stephen AM *et al.* (2007) Comparative whole-grain intake of British adults in 1986–7 and 2000–1. *Br J Nutr* **97**, 987–992.
14. Liu S, Willett WC, Manson JE *et al.* (2003) Relation between changes in intakes of dietary fiber and grain products and changes in weight and development of obesity among middle-aged women. *Am J Clin Nutr* **78**, 920–927.
15. Koh-Banerjee P, Franz M, Sampson L *et al.* (2004) Changes in whole-grain, bran, and cereal fiber consumption in relation to 8-y weight gain among men. *Am J Clin Nutr* **80**, 1237–1245.
16. Tinker LF, Bonds DE, Margolis KL *et al.* (2008) Low-fat dietary pattern and risk of treated diabetes mellitus in postmenopausal women: the Women's Health Initiative randomized controlled dietary modification trial. *Arch Intern Med* **168**, 1500–1511.
17. Brownlee IA, Kuznesof SA, Moore C *et al.* (2013) The impact of a 16-week dietary intervention with prescribed amounts of whole-grain foods on subsequent, elective whole grain consumption. *Br J Nutr* **110**, 943–948.
18. Te Morenga L, Mallard S & Mann J (2013) Dietary sugars and body weight: systematic review and meta-analyses of randomised controlled trials and cohort studies. *BMJ* **346**, e7492.
19. Malik VS, Pan A, Willett WC *et al.* (2013) Sugar-sweetened beverages and weight gain in children and adults: a systematic review and meta-analysis. *Am J Clin Nutr* **98**, 1084–1102.
20. Mattes RD (1996) Dietary compensation by humans for supplemental energy provided as ethanol or carbohydrate in fluids. *Physiol Behav* **59**, 179–187.
21. Marteau TM, Hollands GJ & Fletcher PC (2012) Changing human behavior to prevent disease: the importance of targeting automatic processes. *Science* **337**, 1492–1495.
22. Nuffield Council on Bioethics (2007) Public health: ethical issues. Available at: http://nuffieldbioethics.org/wp-content/uploads/2014/07/Public-health-ethical-issues.pdf
23. Public Health England (2014) Public Health England Marketing Strategy 2014–2017. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/326548/PHE_StrategyDoc_2014_10.pdf
24. Hollands GJ, Shemilt I, Marteau TM *et al.* (2013) Altering micro-environments to change population health behaviour: towards an evidence base for choice architecture interventions. *BMC Public Health* **13**, 1218.
25. He FJ, Brinsden HC & MacGregor GA (2014) Salt reduction in the United Kingdom: a successful experiment in public health. *J Hum Hypertens* **28**, 345–352.
26. Thow AM, Downs S & Jan S (2014) A systematic review of the effectiveness of food taxes and subsidies to improve diets: understanding the recent evidence. *Nutr Rev* **72**, 551–565.
27. Briggs AD, Mytton OT, Kehlbacher A *et al.* (2013) Overall and income specific effect on prevalence of overweight and obesity of 20% sugar sweetened drink tax in UK: econometric and comparative risk assessment modelling study. *BMJ* **347**, f6189.
28. Comans TA, Whitty JA, Hills AP *et al.* (2013) The cost-effectiveness and consumer acceptability of taxation strategies to reduce rates of overweight and obesity among children in Australia: study protocol. *BMC Public Health* **13**, 1182.
29. Shemilt I, Hollands GJ, Marteau TM *et al.* (2013) Economic instruments for population diet and physical activity behaviour change: a systematic scoping review. *PloS ONE* **8**, e75070.
30. Beeken RJ & Wardle J (2013) Public beliefs about the causes of obesity and attitudes towards policy initiatives in Great Britain. *Public Health Nutr* **16**, 2132–2137.
31. Spence S, Delve J, Stamp E *et al.* (2013) The impact of food and nutrient-based standards on primary school children's lunch and total dietary intake: a natural experimental evaluation of government policy in England. *PLoS ONE* **8**, e78298.

https://doi.org/10.1017/S0029665114001645 Published online by Cambridge University Press