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Sugars and health: a review of current evidence and future policy

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Abstract

The automation of the process of extracting sugars in the 1900's reduced cost and increased availability of sugars leading to a dramatic rise in consumption which reached a peak in the 1970's. There are different definitions for sugars not naturally available in foods and free sugars is the term used by WHO. The epidemiological evidence of the associations between sugars and obesity and type 2 Diabetes Mellitus (DM) is fairly strong and consistent, particularly for sugar sweetened drinks (SSB) in adults. The Department of Health in the UK and many other countries have recently updated their recommendations for free sugars as a result of this scientific evidence. In the UK the recommended amount of free sugars is currently 5% of energy (reduced from 10%) which is difficult to meet and very different from current British dietary patterns. Reducing intakes of free sugars is a challenge and will necessitate a range of different actions and policies. Public Health England has put forward 8 suggestions but the four most likely to improve dietary behaviour based on available evidence are social marketing, reduction of marketing of high sugar foods and drinks to children, reformulation and reductions in portion size and a sugar excise tax. Any action taken needs to be evaluated to check inequalities are not widened. The new childhood obesity strategy has incorporated some but not all of these strategies and may not go far enough. It is likely that government policies alone will not be sufficient and a change in the food culture is necessary to see real progress.

History of Sugar

In the UK, sugar cane was imported from around 1300 and sugar beet in the 1700s but it was the automation of the process of extracting sugars in the 1900s that brought about huge change. Development into a modern and efficient sector led to sugar becoming cheap and plentiful from that time[(1)] and sugar consumption grew exponentially. Based on sales data, at its peak approximately 50kg of sugar was purchased per year per person in the 1970's[(2)]. This equates to 130g every day or 500kcal per day although consumption has reduced over the past few years and continues to decline[(2)]. Many countries have high intakes of sugars with the US topping the league table according to 2015 data from Euromonitor[(3)]. There are many sources of sugars including fruits and milk. However this review focuses on free sugars which include sugars added to foods and drinks as well as sugars in fruit juice. Non-milk extrinsic sugars (NMES) are often used as an estimate of free sugars and also exclude milk and fruit sugars and include fruit juice but have a slightly different definition as they do not include dried or pureed fruits[(4)]. The term added sugars is also used which refers to sugars added to foods but does not include pure fruit juice. Total intakes of NMES are 12% of total energy in adults, 15% of total energy in children and 16% of total energy in adolescents[(5)]. In adults this equates to about 60g per day on average based on 2000kcal energy intake.

The interest in sugars consumption is due to its potential impact on health. According to the World Health Organization (WHO), over the last 100 years mortality from communicable diseases has decreased and the proportion of people dying from non-communicable diseases (NCDs) has increased due to improved sanitation, vaccinations and antibiotics[(6)]. Life style factors such as smoking, a lack of physical activity, high alcohol intake and poor diet now play a major role in increasing early death and disability and WHO has set clear guidelines for countries to follow to reduce the prevalence of NCD's[(7)]. Although it is possible (albeit hard) to stop smoking and give up alcohol it is not possible with diet, arguably making it the most challenging lifestyle factor to improve. The two most common causes of death in the UK are cardiovascular disease and cancers with approximately a third of all deaths due to CVD in the UK[(8)] and there are a number of markers of higher risk for CVD including type 2 diabetes mellitus (type 2 DM) and its precursors (high blood sugars and low insulin sensitivity), obesity and blood pressure. This review focuses on the links between sugars and the risk of cardiovascular disease (and its markers), recommendations across the world, the main sources of sugars and how we can reduce consumption in the UK.

Scientific evidence

There is a large body of epidemiological evidence on diet and health of varying quality making it important to focus on high quality studies and reviews. The best quality scientific study is considered to be a randomised controlled trial with systematic reviews of RCTs considered to be the best quality scientific evidence to use to inform policy. However, this is rarely available and therefore lower quality evidence that is prone to bias is relied upon. The best observational study is a longitudinal cohort where data is collected on the exposure before the health outcome. Cross sectional studies where information on the exposure and outcome is collected at the same time are considered to be a weak study design[9].

Unfortunately there are no systematic reviews of free sugars intake and CVD. There is one longitudinal study using data from a subgroup of the large American survey NHANES. This study reported that risk of CVD increased with increasing added sugars intake[10] and the risk was significant at levels of added sugar intake above 15% of total energy. There were very few participants with added sugars intake of less than 5% of total energy. Due to the lack of systematic reviews on risk of CVD it is necessary to look at systematic reviews of added sugars intake and markers of CVD such as body fatness. A review of randomised controlled trials assessing differences in body fatness between diets high and low in added sugars found that diets high in sugars increased body fatness although few of the trials included were more than 8 weeks in duration[11]. The difference in levels of added sugars varied between studies but the pooled estimate indicated that the difference in body fatness was 0.75kg (95%CI 0.30 to 1.19kg)[11]. The mechanism for this increase in weight gain is most likely due to increased energy intake with a diet higher in free sugars. In the Carbohydrates and Cardio-metabolic Health report by the Scientific Advisory Committee on Nutrition (SACN) a review of similar trials and energy intake reported that energy intake was 1275KJ higher (95% CI 889 to 1660KJ) on the diet higher in free sugars[4]. A review of trials that replaced free sugars with other types of carbohydrate and therefore did not change the energy content of the diet reported no differences in body weight between the groups[11]. More research is needed to determine the mechanisms and how the metabolic impacts of specific sugars increase risk of obesity and type 2 DM[12].

One of the largest sources of free sugars is sugar sweetened beverages (SSB). SSBs are the largest contributor of free sugars in children and adolescents in the UK and the second largest contributor in adults ranging from a contribution of 25% of NMES in adults to 40% in

adolescents[5]. Mean intakes of NMES from SSBs are therefore around 20g per person per day which does not include sugars from fruit juices. Intakes are larger in the US[13] and higher in lower income families[14]. There are health concerns that high intakes of sugars from SSB increase risk of weight gain and type 2 DM.

A number of systematic reviews of the effect of SSBs on weight and BMI have been published[15; 16; 17; 18; 19]. The most recent of these is the review by Malik which included 10 trials (the strongest study design to determine causality) published up to 2013[15]. For adults they included 6 results from 5 trials measuring the effect on weight of adding SSB to the diet. Although the trials varied in length and intakes of SSB, all the trials reported higher weight with higher intakes of SSB. The pooled estimate indicated that weight was increased by 0.85kg (95% CI 0.5-1.2Kg) with higher SSB consumption. The results for children were not as clear cut. Although all the 5 trials indicated that a lower SSB intake reduced weight the pooled estimate was not statistically significant for children. The differences in findings could be due to the differences in the trial methods used for children. All 5 trials in children measured the effect on weight of reducing SSB in the diet unlike the trials in adults which measured the effect on weight of adding SSB to the diet. This is an important difference which may be due to ethical constraints in studies involving children and young people. Many of the other systematic reviews that have been published also report that high intakes of SSB increase weight but they had mixed results as to whether these increases were statistically significant or not. They all included a large number of cohorts and cross-sectional studies and very few trials and are therefore more prone to bias[16; 18; 19].

Evidence on risk of type 2 DM with higher intakes of sweetened drinks from trials is scarce and therefore the evidence provided here is based on longitudinal cohorts. A systematic review of cohorts (of at least 3 years in duration) that was included in the DoH review of carbohydrates and cardio-metabolic health reported a 20% increase in risk of type 2 DM with each portion (330mls) of sweetened drink[20]. Imamura and colleagues reported similar results of an 18% increase in risk with one portion of sweetened drink and took this a step further and reported the population attributable fraction for type 2 DM from SSB[21]. The population attributable fraction was higher in the US but in the UK they estimated that 79,000 new cases of type 2 diabetes in the UK over the next 10 years will be attributable to SSB consumption equivalent to a population attributable fraction of 4% (95%CI 2 to 6%)[21].

Nutrition policy and recommendations for sugars consumption

Implementation of nutrition policies to improve dietary quality and health are well established in the UK. For example, in the late 19th Century a large proportion of army recruits during the Boer war were found to be under-nourished resulting in action from the British government to reduce stunting and under-weight in young men[22]. An important tool for currently providing advice on a healthy diet is the Eatwell Guide which has recently been updated[23]. The description of the Guide is as follows; "The Eatwell Guide is a policy tool used to define government recommendations on eating healthily and achieving a balanced diet." A healthy diet is high in plant foods such as fruits and vegetables and wholegrain foods with moderate amounts of protein and dairy foods and a small amount of foods and drinks high in fats and sugars. One of the surprising features of this updated guide is that water has made an appearance but sugar sweetened drinks (one of the main contributors to free sugars intake) is absent from the picture.

The growing body of scientific evidence that high sugars consumption increases risk of weight gain and type 2 DM has led to many countries updating their recommendations. In the UK the Scientific Advisory Committee on Nutrition (SACN) made new recommendations on the amounts of free sugars reducing it from 10% of total energy to 5% (based on an average population level)[4]. There is no specific recommendation for sugar sweetened drinks but the aim is to reduce as much as possible. This was based on large systematic reviews of carbohydrate and cardio-metabolic health and dental caries commissioned by the Department of Health. Public Health England (PHE) has responded with recommendations to reduce free sugars in the British population[24].

WHO conducted a review of the evidence and published recommendations on free sugars consumption in 2015 [25]. They strongly recommended that free sugars should not provide more than 10% of energy in a healthy diet and make a conditional recommendation that free sugars should be reduced further to not more than 5% of energy based on low quality evidence on dental caries. In Germany, the German Nutrition Society (DGE) concluded that there was sufficient evidence to recommend that sugar sweetened drinks should be drunk 'rarely' although in their 10 dietary guidelines they do not define 'rarely'[26]. Dietary guidelines for European countries are provided by the European Food Safety Authority (EFSA) who updated their dietary guidelines in 2010. However they did not provide recommended upper limits for sugars[27] despite acknowledging that high intakes were detrimental for dental caries, particularly in children. In 2015 the US the Department of Health and Human Services updated dietary guidelines for Americans for 2015 to 2020. The

recommendations for added sugar remained the same as in previous editions at 10% of added sugars as a percent of total energy[28]. Australia and New Zealand communicate food based dietary guidelines to the public and recommend that discretionary foods high in saturated fats and added sugars are eaten occasionally (defined as once per day)[29]. A recent report was published on sugar sweetened beverages and was a call to action to reduce consumption although the authors stopped short of making recommendations on intake of SSB[30].

Intakes of sugars in the UK

Actual dietary consumption is difficult to assess due to widespread under-reporting of diet but the national diet and nutrition survey 4 year rolling programme (NDNS 4 yr RP) estimates that non-milk extrinsic sugars (NMES) is around 12-16% of total energy, at the lower end for adults and at the upper end for adolescents and children. In adults, the main sources are confectionery (27%), sweetened drinks (25%) and cakes and biscuits (20%) based on the NDNS 4 year data[31].

The new recommendation of 5% of total energy is the equivalent of 25g or 100kcal per day in a 2000kcal/day diet. It is useful to know what a diet looks like that meets the recommendations for sugars and fibre. The British Nutrition Foundation have published menus with ideas for meals and snacks that meet these recommendations[32] and most would agree that the suggested meals and snacks are very different from the typical diet eaten in the UK, although perhaps more similar to the intake of someone on a weight reducing diet.

Reducing consumption of free sugars

Changing dietary behaviour is extremely difficult. In the UK, most people know what to eat for a healthy diet such as more fruit and vegetables[33] but diet quality is poor[5]. Education is usually not enough on its own which is why Public Health England has suggested a range of strategies. In RCTs evaluating behaviour change education leaflets are commonly the 'usual care' used in the control group such as in a trial to improve the quality of children's packed lunches[34]. In this trial, there were small (although statistically significant) improvements in some foods and nutrients including savoury snacks (decrease), dairy foods (increase), fruit (increase) and vegetables/salad (increase) but no change in sweetened drinks or confectionery[34]. A systematic review and meta-analysis of programmes aiming to reduce the consumption of SSBs or increase water consumption is currently in progress[35].

Public Health England have published a report titled Sugar Reduction: the evidence for action[24]. They identified 8 priority areas for action as follows:

1. Reduce price promotions (supermarkets)
2. Reduce marketing (food industry)*
3. Clarity with nutrient profiling (PH Nutritionists)
4. Reformulation and reduced portion sizes (food industry, restaurants/cafes)*
5. Sugar tax (government)*
6. Improved buying standards (government)
7. Accredited training (various)
8. Raise awareness of health issues and provide practical steps to help reduce sugar (nutritionists, media)*

These areas for action together with related up to date scientific evidence were communicated to all MPs in June 2016 in a research briefing on Sugar and Health Policy[36] written by the Parliamentary Office of Science and Technology (POST). These briefings are produced in consultation with academics and other experts researching and working in the area of interest. Earlier in the same year a POSTnote on Barriers to Healthy Food was published[37] which highlighted the inequalities in diet and possible solutions. Suggestions included improving school meals, regulating advertising, reformulating food and reducing portion sizes of energy dense foods. It is clear that over the last decade actions to reduce childhood obesity have only been effective in children living in wealthier households while obesity rates for children in deprived areas continue to increase[38]. It is agreed that a range of strategies are needed as there is no one single solution.

The four policy areas where there is existing evidence that action will result in behaviour change include the following; social marketing and information provision, marketing of foods, reformulation and portion size, and a sugar tax. These are discussed in more detail.

Social marketing and information provision

Providing effective communication materials is not as easy as it sounds and is unlikely to bring about behaviour change in isolation although it is often a pre-requisite to more intensive interventions. The Nuffield Council on Bioethics published an intervention ladder where providing information is at the bottom of the ladder and a complete ban is at the top[39]. They believe that there needs to be ethical justification as you move up the ladder to implement more stringent measures. Social marketing aims to provide information in different formats to

raise awareness and change attitudes and has been shown to be effective in improving a range of public health behaviours[40]. In the UK the Change 4 Life programme engages the public to encourage them to look at their diet and levels of physical activity and make changes to improve their health[41]. Although evaluation of Change4Life specifically has been patchy and evaluation on impact is mixed[42; 43], it is clear that it has had a wide reach. Other interventions involve providing information in a simple format such as providing nutrient information on food labels or in leaflets on how to reduce sugars consumption. Poor quality, complicated or inconsistent information has the potential to do more harm than good. For example, on the nutrition label of some sweetened drinks the sugar content per 100ml and per 250ml portion is provided while the bottle is actually 440mls making it very difficult to calculate exactly how much sugar is in the whole bottle. It is important that people are consulted on what information they would like to be provided and not to make assumptions. Public engagement is key in this area. Of course it will not be easy as different groups of the population will vary in what they find acceptable or useful which is why information needs to be tailored to different social groups. Evaluations should be carried out to ensure that inequalities are not widening as a result of information provided[44]. One review of the impact of different policy types on obesity risk concluded that implementing a range of policies is the best method to reduce the likelihood of widening inequalities[45].

These suggestions of public engagement and evaluation do not just refer to information provided by public health nutritionists and food labels provided by the food industry. They also include information provided by the media. This is particularly difficult as the media is interested in new news and public health nutritionists are interested in a consistent, uncontroversial (and usually old) message, a problem discussed at length by Dr Ben Goldacre[46]. In a review of nutrition related articles in popular newspapers most articles were found to be of poor quality[47]. Although most nutrition scientists (or any scientist for that matter) would agree that dissemination of findings is important, achieving this without confusing or ‘switching off’ the public is extremely difficult. These issues were discussed recently by Professor Lawrence Krauss, a physicist interviewed on Radio 4s Life Scientific on 31st May 2016. Professor Krauss agreed that dissemination of scientific research was extremely important but the problem was that by its nature most of scientific research is speculative and therefore most of scientific research is wrong. In his view, being wrong is part of being a good scientist; that is, being bold and pushing forward the frontiers which is how it should be if you are working at the forefront of your career. He stressed that being

wrong is not the same as making a mistake and that he is wrong and confused most of the time! This makes it difficult for university press officers, scientists and the media to avoid the public becoming overwhelmed with information and conflicting messages but nevertheless it needs to be tackled.

Marketing to children and young people

Marketing of energy dense foods such as sweetened drinks and fast foods to children and adolescents is big business and many times higher in terms of spending than the marketing of fruits and vegetables[48]. WHO has recommended that governments curb marketing of foods high in fats, sugars and salt to children[49]. The evidence for the short term impact of advertising on dietary behaviour is convincing with a systematic review of trials concluding that higher intakes of energy dense foods are consumed after watching adverts for foods high in fats, sugars and salt[50]. However, quantifying the impact of marketing on children over the long term is more problematic in terms of study design and data collection. Nevertheless there is enough evidence to reduce marketing of these foods to children and to have a 9pm watershed on television. Children are exposed to marketing in many different formats, not just on television. Controls on other platforms such as online advertising is proving to be even more difficult although curbing marketing in cinemas could be more straightforward. There is understandable resistance to further restrictions from the food industry[51].

Reformulation and portion sizes

Reformulation has successfully improved dietary quality in the UK. Salt has been reduced in a wide range of foods which has led to population reductions in sodium and a moderate but clinically important reduction in blood pressure[52]. Trans-fats have also been reduced in many foods making it likely that a higher proportion of adults are meeting the recommendations for trans-fats in the UK. In order to reduce the free sugars content of a portion of a particular type of food, there are two options; either the sugars are replaced with another ingredient or the portion size is reduced. For sweetened drinks, it is possible to replace the sugars with artificial sugars without substantially altering the texture of the product. There are now a wide range of drinks on the market that contain a mixture of artificial and caloric sugars, reducing the overall energy content of drinks. However, replacing sugars in foods is more complicated. As sugars are less energy-dense than fats and similar in energy density to other carbohydrates, the sugars cannot be replaced by anything without increasing the energy content or altering the texture of the food. Therefore for sweet

foods such as cakes and biscuits the best solution is to reduce the portion size. A report by the British heart Foundation in 2013 concluded that portions of meals and snacks had generally increased over the last 20 years[53]. A recent Cochrane review, the highest quality systematic review available, concluded that increases in portion size of food and drinks increased energy intake by 12-16% and this was statistically significant using meta-analysis[54; 55]. Higher energy intakes potentially lead to higher weight and BMI. We reported higher BMI in adolescents with larger portions of cakes and biscuits using NDNS data[56]. A number of recommendations are put forward to reduce portion sizes such as reducing the default size, reducing the size of plates and glasses, adding new smaller sizes and removing larger ones, restricting non-absolute pricing, restricting price promotions on larger portions and demarcating single portions in packaging[55]. Some food companies are taking steps to reduce portion sizes of their products and we hope this will encourage others to follow suit.

Taxing sugary foods and drinks

There is also evidence that taxing sugar has an impact on sugar consumption. A systematic review of taxes and subsidies on different food types concluded that taxes on sugar sweetened beverages did reduce sales and consumption[57]. A 10% tax on SSBs reduced consumption by approximately 10% on average and a 20% tax on SSB reduced consumption by approximately 15% based on different types of data such as modelled data and sales data[57]. Since this review was published in 2014, results from the SSB excise tax in Mexico have been published which indicate that sales of SSB reduced by 6% in response to a one peso per litre (approximately 10% excise tax) introduced in January 2014[58]. The authors also reported that the reduction in taxed drinks was larger in families of low socio-economic status. A tax on sugary drinks in the UK was announced in 2016 and is to be implemented in 2018[59]. Although the response to this tax is mixed and the exact impact is difficult to predict, it is likely to have a positive effect on consumption and health based on experiences in other countries.

Food culture

There are many areas where policies can be introduced to reduce the sugar consumption in the UK but in order for these policies to be welcomed and accepted it is ultimately necessary to change the food culture. The Stanford Encyclopaedia of philosophy provides discussion of the definition of culture which is complex[60]. The definition of culture remains controversial despite extensive research but broadly includes “knowledge, belief, art, law, morals, custom,

and any other capabilities and habits acquired by man as a member of society"[60]. Successful behaviour change requires us to change the man-made part of the environment where we happily police ourselves and do not rely on laws governing mandatory behaviour. There are many important aspects of food culture and four of these are explored further here.

Firstly is the desire to have a constant availability of food. Food (and most often unhealthy food) is available almost everywhere in the UK including on a train, in a sports centre and in shops that used to sell just clothes. Existing research estimates that the average person is bombarded with visual food cues about 200 times per day[61] leading to significant amounts of mindless eating. There are many countries in the world where there is no food on trains or in sports centres but this will not change unless people ask for it. Economic factors are often stated as a reason for selling energy dense food, such as in cinemas. Economic factors can be overruled if sufficient numbers believe in a different system. Unfortunately this is often not the case. The standards for school food which banned vending machines in schools do not have to be followed by Academies and this has resulted in the reintroduction of vending machines into some schools as a way of providing additional income.

The second area is the acceptability of the constant consumption of food. Although in many countries it would not be acceptable to eat on the street, at the bus stop, on the bus or at your desk it is acceptable in Britain. Snacking is big business and we are some of the biggest snackers in the world with two thirds of children eating crisps in their packed lunch every day[62] and widespread consumption of crisps, cakes and biscuits reported in the national survey[5]. This results in a poor quality diet, particularly for young people[63], compared with many other western countries.

Thirdly, unhealthy fast food is more focused on foods high in trans-fats and salt than foods of low energy density containing vegetables and a higher water content. Globally, a wide range of fast foods (food that can be ordered and cooked in a few minutes) is available and there are good examples across the world such as sushi and vegetable noodle soups that are healthier than many of the offerings on the average British high street. Interventions that help garner public support for healthier takeaway options and provision of support for fast food chefs to provide healthier meals and snacks are badly needed. This may be more successful than interventions to reduce fast food and snacking consumption

Lastly, portion sizes on offer are often inappropriate for the majority of the population. Portion sizes have increased and the comprehensive Cochrane review looking at the impact

of portions including packaging and plate size that concluded that increases in portion size increased energy intake by 12-16% has already been discussed[54; 55]. In order for the range of offered portions to reduce in size the smallest portion on offer needs to be more popular. At the moment the most popular size is probably medium. Although the food industry is strongly encouraged to reduce the energy content of snacks such as cakes and biscuits the portion size and nutritional quality of foods from food outlets appears to be lagging behind those sold in supermarkets[64]. Restricting choice of portions available is likely to be unpopular meaning important work needs to be done to change attitudes to encourage consumers and customers to ask for smaller portions which in turn will be provided. It is also important to consumers that the absolute cost of a smaller portion is not more expensive. Offering smaller cakes and biscuits at a proportionally lower price is likely to result in a smaller portion size consumed although of course it is possible to buy 2. The scale of resistance to this approach should not be overestimated. In New York the mayor attempted to pass a law to ban soda cups of more than 32oz but lawyers got involved and claimed it was reducing choice and against human rights – and they won. It is clear that change in all of these four areas needs to be gradual in order to improve acceptability.

Conclusions

In summary, high intakes of free sugars, particularly in drinks, are bad for health but new more stringent recommendations for free sugar intakes are tough to meet. In order to reduce the consumption of free sugars, action is needed from everyone - the food industry, supermarkets, restaurants, public health nutritionists, government and the media. Success will require a range of new policies to be implemented as well as a change in the food culture. We will know when we are truly successful when the inequalities in health such as the inequality in childhood obesity across the social spectrum has reduced. The Childhood Obesity Strategy released in 2016[65] has taken some steps to achieving this but did not mention many of the suggestions provided by PHE such as marketing to children, price promotions or restricting non-absolute pricing. We wait to see if this is enough action to truly say we have succeeded in our aims.

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