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Review Article

Is Too Much Sugar Bitter? The Impacts of Sugars on Health

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Abstract

This paper reviews the associations of sugars consumption with non-communicable diseases. Evidence from meta-analyses, systematic reviews and cohort studies have demonstrated associations between sugars intake and dental caries, weight gain, type 2 diabetes and cardiovascular diseases. Children consuming increased amounts of Sugar Sweetened Beverages (SSBs) are 1.5 times more likely to be overweight. In adults, higher consumption of SSBs is associated with a 26% higher risk of developing type 2 diabetes. Adults with an increased intake of sugars (17%-21% of calories from added sugars) compared to those with lower intakes (8% of calories) had a 38% increased risk of CVD mortality. This association remained significant after adjusting for other CVD risk factors. Additionally, those consuming sugars higher that the recommended level of 10% of total energy are more likely to develop dental caries. Reduction in sugars consumption requires a myriad of interventions to reduce supply and demand at the national and global levels along the sugar supply chain. This needs to be supplemented with public health policies which reduce the availability of sugars in early years' settings, schools and workplaces and promoting positive behaviour change.

Keywords: CVD; Diabetes; Dental Caries; Obesity; Sugar (s)

Introduction

The Nepalese saying 'Too much sugar is bitter' may hold some truth. John Yudkin's 1970's research linked sugars to the development of dental caries, diabetes, obesity and heart disease. The debate about the impact of sugars on health began with Yudkin's seminal text (1972) [1], which was largely dismissed. The British Sugar Bureau and the World Sugar Research Organization called it science fiction. Forty years on, robust evidence has emerged from systematic reviews and meta-analyses establishing the association between sugars and chronic diseases. The WHO in 2012 commissioned two reviews on which it based its current guidelines on sugars intake. One review examined the effects of sugars on dental caries and the second on obesity. Sugar consumption increases the risk of dental caries, one of the most prevalent chronic diseases globally affecting 80% of the world population [2]. Excessive sugars consumption leads to added calories, which leads to weight gain, thereby increasing the risk of type 2 diabetes and heart disease.

The burden of Non-Communicable Diseases (NCDs) has increased in the past 20 years, they are now the leading causes of death. NCDs were responsible for 38 million (68%) of the world's 56 million deaths in 2012 [3]. Over the past 50 years, the consumption of sugars has increased worldwide. Association between sugars and NCDs including dental caries, obesity, diabetes and cardiovascular disease has led to a public health crisis. Therefore, the aim of this paper is to review the associations between sugars and NCDs based mainly on systematic reviews and meta-analyses.

Definition of Sugars

The definition of sugars has been inconsistent. To establish a plausible association between a risk factor (sugars) and any given outcome, it is important to rigorously define the risk factor. A standardised definition of sugars has now been developed defining free sugars as [4]:

- Monosaccharides (such as glucose, fructose)
- Disaccharides (such as sucrose or table sugar) that are added to food and drinks by the manufacturer, cook or consumer
- Sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates.

Global Sugars Consumption

The pattern of how we consume sugars has changed from adding table sugar to our food to manufacturers incorporating sugars into processed foods along the food supply chain. Sugars are now ubiquitous, 'hidden' in food including in baby food and drinks. This means that we may be unwittingly consuming food and drinks high in sugars. This is reflected in population data and in national diet and national surveys. Globally, sugars consumption has been gradually increasing from 154 million metric tons in 2009/2010 to 173 million metric tons in 2015/2016 [5]. For example, globally the highest consumers of sugars are adults in Chile consuming 143 g of added sugars (35 teaspoons) per day. In Europe, the total sugar intake varies from 75.8g day for adults in Spain, 93.4g in the UK, rising to 138.9g in the Netherlands. Children are generally consuming more sugars than adults in Europe. Sugars intake in the UK among children is 8% higher than that of an adult, and 22% and 30% in the Netherlands and Belgium, respectively [6]. In England, 30% of energy intake in children aged 11-18 years is derived from sugars in soft drinks and fruit juices [7].

Sugars and Obesity

Globally, the prevalence of obesity is increasing among adults and children. Examining the trends across OECD countries, 18% of the adult population is classified as obese, but there are large variations in prevalence (Figure 1). For example, in the US and Mexico 1 in 3 adults are obese, compared with 1 in 20 adults in Norway [8].

Similarly, the prevalence of childhood obesity varies across OECD countries, where 31% of children in the US aged 15 years are classified as overweight or obese compared with 9.5% in Denmark [8]. In Europe, there has been a surge in obesity. In 2008, 1 in 4 children aged 6-9 years were overweight or obese in EU and by 2010 this increased to 1 in 3 children [9]. Recent estimates show that around 2.8 million deaths per year in the EU result from causes associated with overweight and obesity. Additionally, 7% of national health budgets across the EU are spent on diseases linked to obesity each year. There are obvious and persistent inequalities in the prevalence of obesity and poor dietary behaviours, with those from lower socio-economic status to be more likely affected [10].

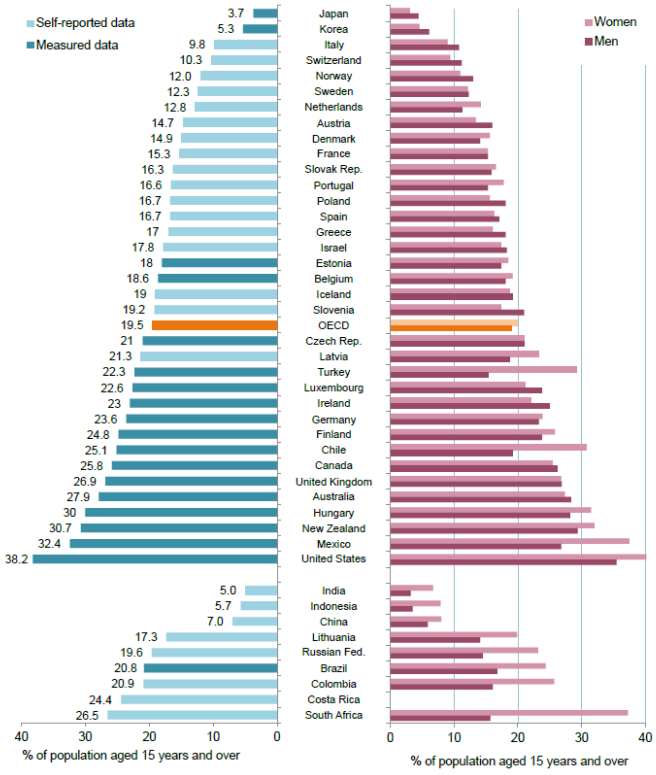

Figure 1: Prevalence of adult obesity in OECD countries in 2015.

The WHO commissioned a systematic review of cohort studies and randomized controlled trials examining the association between sugars and body weight separately in children and adults using consistent and agreed definitions of free sugars. Analysis of trial data in adults demonstrated an increase in sugars consumption resulted in 0.75kg of weight gain ($p<0.001$) in adults, at follow-up [11]. Furthermore, reductions in sugars consumption resulted in significantly reduced weight (-0.8kg, 95%CI -1.21 to -0.39). Findings from cohort studies showed similar trends, with 11 studies showing positive associations between sugars intake and anthropometric measures. In children the associations between sugars intake and weight gain were less consistent. From the 5 trials aimed at reducing sugars intake in children found no association between sugars consumption and BMI. The reasons for these

ambiguous results in children are due to poor adherence with diet advice and the trials were longer in duration than those for adults. This meta-analysis was rigorous in using the GRADE system for assessing the strength of the evidence and the quality of the data and the inclusion of randomised controlled trials and cohort studies.

However, the most consistent evidence has stemmed from associations between consumption of sugar sweetened beverages (SSBs) and weight gain. Meta-analysis of 5 cohort studies, showed that children with high intakes of SSBs were 1.55 (95% CI: 1.32, 1.82) more likely to be overweight or obese when compared to children with a lower intake [11]. There have been several systematic reviews and meta-analyses assessing associations between SSBs and adiposity. A review in 2013, included 32 studies (cohort and RCTs), 20 in children and 12 in adults. In cohort studies in children, an increase of one daily serving of SSBs was associated with a 0.06 (95% CI: 0.02, 0.10) unit increase in BMI over one year [12]. RCTs in children showed reductions in BMI when SSBs were reduced and studies in adults showed increases in body weight when SSBs were added.

Consumption of SSBs is common during adolescence and is regarded as a contributor to the epidemic of obesity because of its high sugar content, low satiety, high glycaemic load, and incomplete compensation for total energy [13]. SSBs may encourage increased energy intake leading to excessive weight gain, since sugar is less satiating when provided in liquid when compared with the solid form [13]. Therefore, energy from liquids may not be fully compensated for; making it easier to over-consume food and drinks.

The totality of the evidence from experimental and observational studies demonstrate the sugars intake contributes to an increase in energy intake, thereby disrupting energy balance and leading to an increased risk of weight gain. However, gaps in our knowledge still exist on the exact physiological mechanisms and the interaction with the environment, which results in weight gain [14].

Sugars and Type 2 Diabetes

The number of people with type 2 diabetes has quadrupled since 1980 [15]. Globally, the number of adults with diabetes increased from 108 million in 1980 to 422 million in 2014. This means that 1 in 11 adults have type 2 diabetes and this is projected to increase in the future (Figure 2).

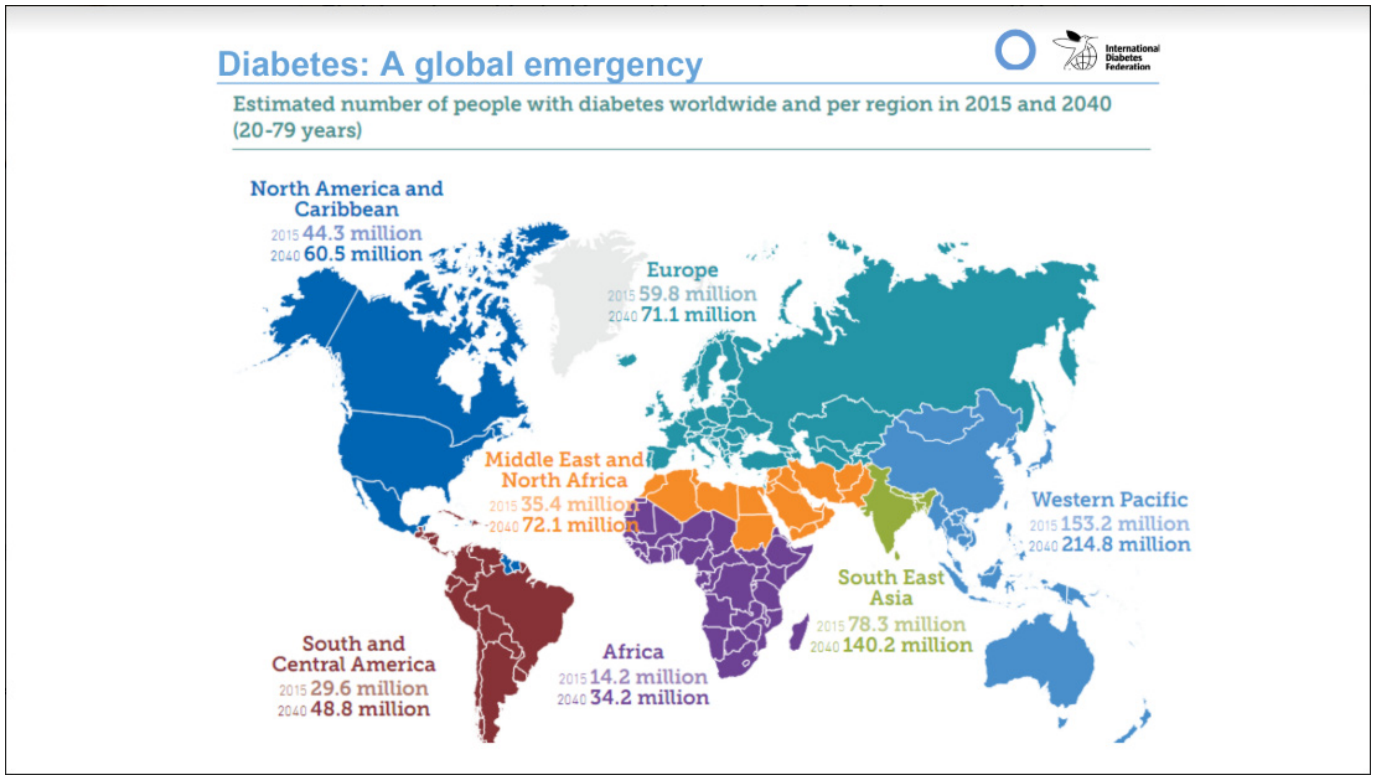

Figure 2: The number of people with diabetes worldwide in 2015 and projections for 2040 (Source: International Diabetes Federation).

SSBs provide the most consistent and significant dietary factor associated with type 2 diabetes rates in large epidemiological studies. A meta-analysis of studies included 8 studies and 310, 819 participants, showed those who consume 1 or 2 servings of SSBs per day have a 26% increased risk of type 2 diabetes [16]. A further meta-analysis in 2014, which included 6 prospective studies including 280,000 individuals confirmed the associations between SSBs intake and a 20% risk of type 2 diabetes (RR: 1.20/330 ml per day (95 % CI 1.12, 1.29, P< 0.001). This study also confirmed a dose-response and type 2 diabetes risk [17].

The link between SSBs intake and diabetes is both direct and indirect [18]. Direct effect is that SSBs are associated with an increased incidence of type 2 diabetes. Indirect effects include SSB consumption can lead to weight gain, which is one of the main risk factors for type 2 diabetes [18].

Sugars and Cardiovascular Diseases

Globally, cardiovascular diseases are the top cause of mortality, resulting in 17.7 million deaths per year, affecting mainly low and middle income countries [4]. Risk factors include high blood pressure, obesity, smoking, excessive alcohol consumption, diabetes and sedentary lifestyles.

The association between sugars intake and CVD is derived mainly from cohort studies as availability of long term trial data is limited. A prospective cohort study assessed the association between added sugar intake and cardiovascular diseases mortality among US adults by examining data from National Health and Nutrition Examination Survey (NHANES, 1988-1994, 1999-2004, and 2005-2010) involving 31,147 participants. Compared with those who consumed 8.0% of calories from added sugar, individuals who consumed approximately 17% to 21% of calories from added sugar had a 38% higher risk of CVD mortality. This association remained significant after adjusting for the CVD risk factors, such as blood pressure and total serum cholesterol and total calories [19]. Furthermore, frequent intake of SSBs (≥7 servings/week) increased the risk of cardiovascular mortality.

The American Heart Association has recently developed a scientific statement on the risk of added sugars in the diet and the risk of cardiovascular diseases in children [20]. The investigators found a significant association between consumption of fructose and hypertension, which was independent of obesity among children [21]. Similarly, a study of adolescents demonstrated an association between SSB intake and raised blood pressure, after adjusting for obesity [22]. The hypothesised mechanisms demonstrate that an increase in sugars intake leads to a significant increase in energy intake, which can result in increased risks of obesity, type 2 diabetes and CVD. This was confirmed by the SACN report, which included a meta-analysis, showing an increase or a decrease in intake of sugars resulted in a corresponding increase or decrease in energy intake [18].

Sugars and Dental Caries

A systematic review commissioned by the WHO exploring the effect of sugars on dental caries identified 55 studies [23]. A large effect size was detected in relation to the effect of sugars consumption on dental caries (standardised mean difference for DMFT 0.82, 95% CI: 0.67, 0.97). Consistency in the evidence, which was of moderate quality showed an association between sugars consumption and the development of dental caries; a higher rate of caries was found in those consuming sugars higher than 10% of energy when compared with less than 10% of energy, for both primary and permanent dentitions.

Discussion

The increasing burden of chronic diseases is largely determined by socio-environmental factors, these factors in turn influence health behaviours. Our lifestyle patterns have drastically changed in the past twenty years, shaped by longer working hours, less physical activity and the abundant availability of fast food. This obesogenic environment has affected overall food consumption patterns with evidence of increased risks in NCDs [24]. What is alarming is the consumption of hidden sugars in baby food and drinks that encourage a sweet palate from a very young age. The consumption of sugars globally is above the WHO's recommended level of 10% of total energy intake [4]. The WHO recommendation of reducing free sugars to 5% of total energy intake is challenging. The guideline and two thresholds of sugars intake (5% and 10%) is based on evidence from the effects of sugars on dental caries and weight gain.

There are challenges in studying sugar as the single cause of chronic diseases. Trials aimed at reducing sugars intake may result in changes in other aspects of the diet, and thereby making it difficult to establish a dose response curve. There is a gap in our knowledge in establishing thresholds for adverse effects on Type 2 diabetes and cardiovascular diseases. Currently, we have limited understanding of metabolic mechanisms. Furthermore, there are limitations in study design and dietary measurements and the bias associated with self-reported data. There are limited studies examining the associations between sugars intake, diabetes and cardiovascular outcomes. A further complication is that the majority of trials are of shorter duration and compliance with dietary interventions can be challenging, especially in children. Additional research should incorporate well designed trials of adequate duration with rigorous use of theoretical behaviour change models.

Despite these challenges, it is clear that NCDs including cardiovascular diseases and diabetes are leading causes of morbidity and mortality worldwide. The prevalence of obesity is increasing among adults and children with its associated healthcare and wider economic costs. Children are increasingly consuming more sugars, less likely to undertake physical activity and more

likely to be exposed to energy dense food and drinks, especially SSBs [7].

What strategies could be effective in halting the rise in NCDs and reducing health inequalities? The WHO Global Action Plan to reduce the prevalence of NCDs comprises a range of public health actions. These include early intervention and creating healthy public policies that tackle the underlying social determinants, but also interventions that empower individuals and communities [25]. A multi-sectoral approach involving different governmental sectors (business, agriculture, trade, education, health etc.) is required. Public health policy is imperative in intervening at the root of the sugar supply chain, by influencing legislative and fiscal measures to reduce the demand and supply of sugars including marketing of unhealthy foods. However, this complex network is influenced by profits and trade agreements nationally and globally. The 'big 10 food brands' including Associated British Foods (ABF), Coca-Cola, Danone, General Mills, Kellogg, Mars, Mondelez International, Nestlé, PepsiCo, and Unilever have a turnover of over $1.1bn per day [26]. A global solution would be to eliminate sugar subsidies with support from the World Trade Organization. Using legislative and fiscal measures, the food industry should be actively involved in food reformulation and substitution, which could further reduce the amount of sugars in food and drinks. There is a slow, but welcome shift towards this goal with companies reducing portion size or quantity of sugars in chocolates and drinks.

Researchers and public health experts need to ensure their work is not influenced or funded inappropriately by the sugar industry, as this creates an obvious conflict of interest. Historically, the food industry has funded research across the globe and findings from research may be influenced by commercial incentives rather than by scientific evidence [27].

The taxation of sugars is implemented in a number of countries including the latest Mexico. It introduced a tax on SSBs in 2014, which has led to a 12% reduction in sales, and this has had the largest impact on those from lower socio-economic groups [28]. It is too early to show whether this will have resulted in reducing the prevalence of NCDs. Fiscal policy alone may be insufficient and therefore a continuum of interventions (up-, mid- and low-stream) is required. Empowering communities and individuals in positive behaviour change should provide individuals with supportive environments in healthy early year's settings, schools and the workplace.

The education sector including universities and colleges can play a vital role in ensuring the future workforce deliver consistent health messages to individuals and communities. This does not have to solely focus on health professionals, but also those in social care and education. Training of under- and post-graduate health professionals needs to incorporate health inequalities and health professionals should be mobilised to be advocates of health [29]. Additionally, health professionals could opportunistically deliver brief interventions in clinical practice and be involved in community engagement, both of which are in their infancy.

Changing public policy can only be achieved with political prowess and mobilising public opinion on the impact of sugars on health with bold and evidence-based actions. This would not only halt the rising burden of NCDs, but build a healthy environment for current and future generations.

Disclosure Statement:

There is no conflict of interest.

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