22 Dietary sugars and NCDs

Burden, epidemiology, and priority interventions

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Definition of sugar[1]

Sugar is the generic name for sweet-tasting water-soluble carbohydrates. Sugars (or saccharides) can appear in the form of single carbohydrate building block units (i.e. monosaccharide, such as glucose $C_6H_{12}O_6$) or molecules made of two units (i.e. disaccharide such as sucrose). Glucose (its D-isomer being also called dextrose), fructose (fruit sugar), and galactose (dairy sugar) are main monosaccharides (simple sugars), while common disaccharides include sucrose ('table sugar', glucose + fructose), lactose (glucose + galactose), and maltose (glucose + glucose). Sugars have different sweetness. Compared to sucrose (reference = 1), the sweetness of lactose is ~0.16, maltose ~0.4, galactose ~0.65, glucose ~0.8 and fructose ~1.5. In comparison, non-saccharide substances can be much sweeter: aspartame (dipeptide methyl esther) 180–250, stevia (a naturally occurring vegetal glycoside) 40–300, or sodium saccharin (sulfonyl) 300–700.

Several groups of foods contain substantial concentrations of sugar:

- Intrinsic sugars incorporated within the structure of intact fruit and vegetables (mainly glucose, fructose).
- Milk (lactose and galactose).
- Free sugars (mainly glucose and fructose), defined by WHO[2] as 'added to foods and beverages and those naturally present in honey, syrups, fruit juices and fruit juice concentrates'.

The WHO Manual on Food Drink and Taxation to Promote Healthy Diet[3] defines sugary drinks as:

> all types of beverages containing free sugars and these include carbonated or non-carbonated soft drinks, fruit/vegetable juices and drinks, liquid and powder concentrates, flavoured water, energy and sports drinks, ready-to-drink tea, ready-to-drink coffee, and flavoured milk drinks. The term is sometimes used interchangeably with sugar-sweetened beverages (SSBs), which are defined identically.[4]

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Production and per capita consumption

Sugar is found in the tissue of most plants. Honey and fruit are abundant natural sources of monosaccharides (glucose and fructose). Sugar cane and sugar beet are the main sources of disaccharides from which the refined sugar sucrose is extracted industrially. The sugar extracted from corn (corn syrup) is glucose, and is often transformed industrially into fructose.

The average person currently consumes ~24 kg of sugar each year, ranging from <20 kg in Africa (albeit increasing) to >50 kg in North America.[5] A large proportion of sugar in the diet comes from sugary drinks and foods such as confectionery, desserts, cakes, jams, and breakfast cereals. Among adolescents in several European countries, sugar represents approximately a quarter of the total energy intake. Free sugars contribute 80% of this total sugar intake, with soft drinks and fruit juices contributing similar substantial proportions of the total sugar intake.[6]

Physiology of sugar[1]

Disaccharides, similarly to other edible carbohydrates (i.e. polysaccharides found in starches), are hydrolyzed into monosaccharides by the intestine (glucose, fructose or galactose) to: 1) provide energy through cellular aerobic respiration and concomitant production of ATP used by the cells for energy; 2) be converted into glycogen in the liver and skeletal muscle as short-term energy stores; 3) be converted into structural polysaccharides (e.g. pectin for cell walls) or; 4) be transformed in body fat by *de novo* lipogenesis as long-term energy stores.

However, sugar has distinctive characteristics compared to starches when it comes to digestion.

- First, digestion is more rapid for sugars than starch and sugar intake rapidly increases blood glucose levels, which stimulates insulin production by the pancreas to facilitate glucose storage as glycogen and its conversion into body fat.
- Second, the rapid absorption of sugars by the intestine partially bypasses the endocrine regulatory loops (e.g. ghrelin) for appetite and satiety, thus delaying the sensation of having eaten enough, especially when consumed in liquid form, possibly leading to calorie overconsumption.
- Third, sugars trigger neurophysiological dopamine-related 'reward' mechanisms, which further stimulate energy intake.[7]
- Fourth, the quicker increase and fall of insulin, after eating sugar vs starches, leads to reactive low glucose levels, thus driving appetite.
- For example, drinking 500 ml of soft drink/fruit juice and eating 100 g of bread (2 large slices) each provide around 250 calories. Yet, satiety will be much lower following a sugary drink as it is absorbed nearly instantly. Bread (or indeed fruit) will in comparison be absorbed considerably more

slowly. The result is that there is a much greater desire for further food and drink following a sugary drink compared with an intake of a less refined food.

Health effects of high sugar intake and related NCD burden

High sugar intake, including soft drinks and fruit juices, is a significant driver of obesity, diabetes, cardiovascular disease, and tooth decay in children and adu lts.[8,9,10] High intakes of glucose and fructose are also common causes of hypertriglyceridemia and non-alcoholic fatty liver disease.

Disease burden

Table 22.1 (data from IHME) shows that the proportions of all deaths attributable to a diet high in SSBs increased from low levels in 1990 to higher levels in 2019 in low- and middle-income countries with inverse trends in HICs. This partly reflects the relatively low but rapidly increasing consumption of SSBs in low- and middle-income countries driven by the large and increasing supply of cheap sugar in the world market.[11] The age-standardized mortality rates attributable to a diet high in SSBs decreased in all regions, partly reflecting improving prevention and control of the health consequences of SSBs. Around three-quarters of the SSB-related deaths were attributable to cardiovascular disease (CVD) and one-quarter to diabetes. Of note, estimates in Table 22.1 do not include sugar sources other than SSBs, such as beverages with naturally occurring sugar (e.g. fruit juices) and the many foods that include added sugars.

Recommended dietary intake of sugar

WHO recommends that adults and children reduce their intake of free sugars to <10% of their total energy intake throughout the life-course and ideally to <5%. Public health interventions should therefore aim at limiting dietary intake of free sugars, particularly sugary drinks that have little nutritional value beyond energy supply. For example, a 3 dl glass/bottle of a sugary drink can typically contain as much as ~30–40 g of sugar (i.e. ~120–160 calories), and regular consumption of sugary drinks can contribute up to 20–30% of the total daily calorie intake, particularly among children. Sugar concentration is even

Table 22.1 Mortality attributable to high dietary intake of sugar-sweetened beverages (IHME)

	Global		*HICs*		*Upper MICs*		*Lower MICs*		*LICs*	
	1990	*2019*	*1990*	*2019*	*1990*	*2019*	*1990*	*2019*	*1990*	*2019*
Proportion of all deaths (%)	0.32	0.43	0.60	0.50	0.38	0.51	0.20	0.37	0.12	0.19
Age-standardized rates (per 100,000)	4.3	3.1	4.1	2.2	4.7	3.3	4.7	3.9	4.7	3.7

larger in fruit juices (natural or reconstituted), e.g. around 9–25 g/100 ml vs soft drinks (9–12 g/100 ml), which implies that consumption of fruit juices (but not that of fresh fruits) should also be limited.

Non-calorie sweeteners, also called non-sugar sweeteners

The food industry is increasingly replacing part or all sugar in sweetened drinks with natural non- or low-calorie sweeteners (e.g. stevia, which provides a very low-calorie intake) and/or artificial sweeteners (e.g. aspartame, which provides virtually no calories), particularly in countries that impose a tax on sugary drinks. Consumption of beverages including non-caloric sweeteners may be associated with a lesser weight gain than ordinary sugar beverages and with no current evidence of adverse health effects,[12,13] but further trials are needed to better assess this question. However, it seems that regular consumption of beverages with a sweet taste (including those with non-caloric sweeteners) can sustain a continued appetence for sugary foods (biscuits, etc.) which can contribute to excess calorie intake and overweight.[14]

Public health interventions to reduce the consumption of sugar

Policies and interventions to promote a healthy diet to reduce NCDs are discussed in Chapter 19. The following measures are specifically aimed at reducing dietary consumption of sugar and, particularly, added sugars. An asterisk appears for interventions recommended by WHO (Appendix 3 of the WHO Global NCD Action Plan).

*Promote a healthy diet low in sugar**

- Health education programmes,* including social marketing*, and dietary guidelines, at the national and subnational levels (including workplaces, schools and public places) should promote a healthy diet, including one that is low in sugar, and advocate for drinking water instead of sugary drinks. Making water fountains broadly available in public places and institutions is a useful practical companion intervention.
- Public procurement policies, for example setting nutrition standards for foods and beverages allowed to be provided or sold in and around schools.
- Nutritional labelling*, including sugar content, enables consumers to better select the products they buy.[15] Front-of-pack labels (FOPL) should be government-endorsed and enable consumers to correctly, quickly and easily identify products that contain excessive amounts of critical nutrients, preferably through mandatory front-of-package interpretative warning labels (e.g. as requested by law in Chile and being implemented in an increasing number of countries), since they have been proven to effectively reduce population's calorie intake and critical nutrients purchase.[16] Other common FOPL systems include traffic light systems or NutriScore.[17,18] Using a smartphone to scan a food's barcode (when barcodes provide such information)

is a user-friendly way for determining detailed food and beverage nutritional value (as well as environmental carbon impact for some of these barcode systems).

Reduce the marketing of sugary drinks and foods*

- This includes a ban or restriction on advertising/marketing of unhealthy foods and beverages, including sugary drinks, particularly when targeting children. This can be done through legislation banning advertisements for unhealthy foods and beverages on the internet, social media, television (e.g. during viewing hours by youth), banning the sale of sugary drinks in selected settings (e.g. schools) and restricting the placement of selected unhealthy products in supermarkets.

Reformulation of sugar products toward lower sugar intake*

- Reducing the production and consumption of ultra-processed foods and reformulating the food content of common sugar-rich foods and beverages are cornerstone strategies to reduce sugar intake at the population level. This may imply setting sugar content targets for selected foods and working with industry to achieve these through voluntary means[19] or, preferably, through regulation (e.g. Sugar Act in South Africa). Of note, several food manufacturers are decreasing the sugar level in selected ultraprocessed products sold in some countries, partly under the pressure of public health policy (e.g. sugar tax) and consumers' demand, with substantial differences in sugar content of the same foods across different countries.[20]

Excise tax on sugar-sweetened beverages*

WHO and other authoritative public health bodies recommend applying an excise tax on sugary beverages (also called SSBs, as mentioned above).[21,22] This measure was shown to be cost-effective for reducing the consumption of sugary drinks and the disease burden attributable to obesity, tooth decay and NCDs.[23,24]

- The tax should be sufficiently large to increase the cost of sugary drinks by ≥20% (and if possible, even more[25]) to effectively curb the sale of these drinks (price elasticity of -1: a 10% increase in price leads to a 10% decrease in consumption).[26] Almost 50 countries have implemented a tax on sugary drinks but only a few have implemented a tax that increased beverage costs by ≥20% or even ≥10%.
- A tax on sugary drinks sends a strong message to the population that regular consumption of sugary drinks should be avoided.
- A tax incentivizes the food industry to reduce the sugar content of their products.

- A few countries also impose a tax on fruit juices, given that sugar concentration is at least as high in fruit juices as in soft drinks. In addition, a tax on soft drinks alone may increase the sales of fruit juices. When implementing a tax on fruit juices, it is important to inform the public that it is healthier to consume fresh fruits (which also include fibre and other healthy nutrients) than fruit juices.
- Concerning tax structure, an excise tax per volume enables the price of inexpensive sugary beverages to increase by a large margin. Tax should be regularly adjusted to inflation and nominal economic growth to retain its impact. Tax may apply only to sugary drinks that exceed a certain sugar concentration, e.g. ≥5 g sugar/100 ml, as implemented in some countries.
- Galactose (for which concentration is ~4.5 g/100 ml in milk) is not associated with adverse health effects and unflavoured dairy products should be exempted from tax on sugary drinks.
- Food labelling on macronutrient content (including carbohydrates and free/added sugar) must be mandatory so that fiscal and customs authorities can tax sugary beverages accordingly (while additional interpretative labelling, e.g. a traffic light system, may be more useful to inform consumers, as mentioned above).
- Part of tax revenue may be earmarked to fund health-promoting activities, e.g. water fountains in schools or similar health initiatives. This also enhances tax acceptance by the public.
- It may be useful to promote other fiscal incentives aimed at reducing the price of commercially bottled water to facilitate a consumption shift away from sugary drinks.

Monitoring

Nutritional surveys in adults and children (e.g. STEPS, GSHS – Chapters 4 and 5 on surveillance) can inform on the consumption of sugary drinks and selected foods rich in free sugar. An accurate assessment of the intake of foods and macronutrients (including sugar) requires asking many questions to assess the volume and frequency of consumption of many foods (based on either food frequency questionnaires and/or dietary 24-hour recalls).

Marketing studies on the sales of foods and beverages rich in sugars as well as food composition surveys (based on labelling of commercial foods or through independent food content analysis) are useful to assess food sales and composition differences over time within the same country or between countries.

Notes

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