

A Review of Excessive Sugar Metabolism on Oral and General Health

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Stomatologists and dental practitioners, as they are called in different parts of the world according to tradition and history, are basically physicians who specialise in the study and treatment of diseases of the mouth and surrounding structures. They have always been outstanding in advocating the reduction of sugar consumption, mainly due to its direct connection to the pathogenesis of dental caries. Increasingly, it has come to the attention of researchers, epidemiologists and many healthcare workers and professionals that excessive consumption of sugar is also closely tied to the increase in tandem of our current major health issues like obesity, diabetes, heart, liver and kidney disease, and a host of other associated ailments. This development of current health crises throughout the world wherever traditional diets are replaced with modern fast food diets, which are usually packed with hidden, added refined sugars, is extremely troubling. It becomes all the more urgent and incumbent upon clinicians and stomatologists throughout the world to redouble their efforts to reduce and even eliminate the excessive consumption of added or extrinsic or secondary or hidden sugars to food and drinks. It will not only be to reduce dental caries, but also to reduce the many systemic and organ diseases associated with added sugars and which also exacerbate many oral diseases. This review is to give a basic history of sugar, the current understanding of sugar metabolism and the developing literature and research on the impact of sugar consumption on oral and overall health, as the mouth cannot be divorced from the body and vice versa. The author hopes to kick-start more research into this area that will result in various positive developments in the food and drink industry and persuade stakeholders to comprehensively address this universal health crisis that is closely tied to excessive consumption of added sugar in all its forms.

Key words: health crisis, obesity, sugar

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Refined added sugar in the human diet was minimal for thousands of years. The scenario began to change when demand for sugar in Europe began to increase with the discovery of the Americas and the colonisation of distant places by the European powers. The growing industry was built mainly upon black slavery. Europeans sailed to West Africa kidnapping and buying slaves who were taken to many Caribbean islands, then

later to Brazil and central and North America, where many labour-intensive sugar plantations were established. The produce was then shipped back to a sugar-hungry Europe. Later, the industrial revolution enabled man to move away from muscle power to steam, oil and electric power, resulting in the cheap and plentiful mass production and supply of sugar. The habitual consumption of added sugar in food and drinks in human history is actually very recent, beginning only about 200 years ago and steadily increasing until today, where the industry annually produces up to 25 kg of refined sugar for every man, woman and child. This works out to 180 million tons of sugar annually, which is equivalent to 17 teaspoons of sugar per person per day in the world. Primarily it is worth US\$ 200 billion a year and by extension to the food industry up to US\$ 4 trillion a year. Such a huge consumption of a condiment that many doctors and nutritionists deem as physiologically unnecessary

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for human nutrition is disturbing, and there is evidence that it may be a major factor in the rise of many modern acute and chronic ailments.

Historically, dental caries increased in tandem with the increase of sugar consumption^{1,2,3}.

At the New Delhi FDI World Dental Congress in 2014, a policy statement entitled “Early Childhood Caries (ECC)” was being debated. As the debate progressed, this author was shocked to realise that we talked about everything except one of the major causes of ECC – the excessive consumption of sugar! After raising the issue, I was requested to draft a statement on the spot to be included. Thus at the FDI AWDC (World Dental Federation Annual World Dental Congress) 2014, the statement from Malaysia was adopted in the FDI Policy Statement “Perinatal and Infant Oral Health”: “There should be a concerted, integrated effort of parents, schools, health ministries and other stakeholders to decrease the intake of sugar in all its forms”⁴.

Following this effort, the FDI AWDC 2015 in Bangkok organised a World Oral Health Forum on “New World Health Organisation (WHO) Guidelines on Sugar Intake for Adults and Children”. The new guideline for sugar intake for adults and children is that the energy contribution of free sugar in all its forms should be reduced from the current 10% to 16%, to 5% or less. This practically translates into a simple rule of thumb meaning just five teaspoons of sugar per person per day. The problem that immediately arises is how to do it, because the whole world has been addicted to sugar for the past 100 years and is increasingly so, rapidly resulting in not only an increase in caries, but also obesity, diabetes and all the accompanying diseases that follow^{1,5,6}. This global health emergency must be tackled. But how do we tackle it?

Sugar metabolism

Regarding sugar metabolism, there is a consensus as to the following^{7,8}:

- Sugar is consumed basically as added sugar or non-added sugar. Added sugar, also called extrinsic or secondary sugar, is that which is added to food and drink. Non-added sugars, also called primary or intrinsic sugar, are sugars that already occur naturally in food such as fruits, vegetables and meats.
- Sugar consists of simple monosaccharides such as glucose, fructose, galactose and complex disaccharides called maltose, sucrose and lactose.
- “Sugar metabolism” is the process by which energy contained in foods is made available as fuel for the body. The body’s cells use glucose directly for energy.

Fatty acids can also be used for energy, but the process is indirect and takes a longer time.

- The body uses glucose directly while other sugars and carbohydrates are converted to glucose before the body can use them for energy after converting them to ATP (adenosine triphosphate).
- Glucose that is not immediately used is stored as glycogen in the muscles and fat in the liver and various other parts of the body. Fructose tends to convert rapidly to fat in the liver.
- Three main hormones control blood sugar concentration – glucagon, insulin and epinephrine. This is a very complex process that is still not well understood. Glucagon stimulates conversion of glycogen in muscles and liver to glucose. Insulin stimulates the transfer of glucose into cells. When insulin levels fall, glucagon and epinephrine (adrenaline) levels rise and more glucose is released from the liver. At the same time, growth hormone and cortisol levels rise, which cause body tissues (muscle and fat) to be less sensitive to insulin. As a result, more glucose is available in the bloodstream. Epinephrine (adrenaline) stimulates more glucose release from the liver, which in turn is affected by growth hormones and cortisol levels that cause muscle and fat to be less sensitive to insulin. This then can result in more glucose being retained in the blood and can deteriorate into type 2 diabetes.
- Non-added or intrinsic sugar occurs naturally in fruits, vegetables and meats and is consumed as part of the food, e.g. a whole fruit comes with all the accompanying fibre and other nutrients. Up to 30% of these sugars will not be absorbed, but will be metabolised by microbes in the gut.
- By contrast, added or extrinsic sugar consumed in a cold, fizzy soda drink sends a sugar rush straight into the blood, immediately challenging the body’s homeostatic mechanism to maintain blood sugar at a healthy level. Constant challenges can overwhelm the body’s homeostatic mechanism, resulting in high glucose levels, and over time this can push the body towards diabetes.
- There are also reports that indicate that sugar can suppress the satiety centre in the brain resulting in overeating because the subject is tricked into feeling hungry even though full.
- The WHO’s latest guideline on added sugar intake is that it should constitute 5% or less of a person’s daily calorific needs. Practically, this means a person should not consume more than five teaspoons or less added sugar a day. It is important to know that one can of soft drink contains 10 to 15 teaspoons of sugar.

Therefore, it is quite clear what has to be done to bring down the incidence of type II diabetes.

History of sugar

Sugar can be traced back several thousand years ago to the island of New Guinea where the natives found a very pleasurable taste from chewing on a grass we know today as sugar cane. It arrived on the Asian mainland in about 1000 BC. By AD 500, it was processed and consumed in India as a powder and used in small quantities as a medicine for headaches, tummy ache and impotence. The use of sugar then spread to Persia and to the Arabs and to the crusaders who came from Europe to battle over the holy lands. The Arabs brought it to a fine art by creating marzipan, a delectable mixture of almonds, sugar and egg. By AD 1500 onwards, demand grew in Europe and whole islands in the new world such as Barbados, Jamaica and many Caribbean islands were filled with sugar plantations. This largely resulted in the kidnap and slavery of millions of Africans over the years to be used in the labour-intensive plantations. As production increased, the price dropped so that by the 1900s, sugar had shifted from being a luxury item for the rich to a common staple of the people. In Europe, the consumption of sugar went from 2 kg a year in the 1700s to 50 kg in the 1900s. By 1900, high blood pressure affected 5% of people, while today high blood pressure affects 33% worldwide, while consumption of sugar has ballooned to up to 100 kg per year per person in many developed and developing nations. The rise in the consumption of sugar seems very much in tandem with the rise in obesity, which is closely followed by a rise in diabetes with all the concomitant diseases that accompany it.

The fateful decision

Following the end of World War II in 1945, the incidence of heart attacks gradually rose. American President Dwight Eisenhower suffered a heart attack in 1955 at the age of 55 and provided the impetus for an investigation by the health authorities as to the cause of heart disease. The well-known and respected physiologist and nutritionist Ancel Keys, who invented the K Rations for the US Army, came out with a study that fats and cholesterol were to blame for heart disease. The fateful decision that may have further tipped the blame for heart disease away from sugar was made in 1964. A group known as the Sugar Association approved project 226 to commission Harvard University for a paid article to address “negative attitudes towards sugar”. The Harvard article was published in 1967 and concluded that there

was no doubt that reducing cholesterol and saturated fat was needed to prevent heart disease, and downplayed the studies on sugar. This report was published in the *New England Journal of Medicine*. This article may have tipped opinions in general towards blaming fats and cholesterol rather than sugars as the major factor for the increase in heart disease until only recently, when fats and oils were declared generally innocent and that sugar is much more likely responsible. The effects of the article blindsided the dental industry so that focus from then on was on treatment and not prevention. Fluoridation of water, fluoride mouthwashes, toothpaste and gels, fissure sealants, better and better filling materials, etc were developed and marketed. The blame on fats and oils was further cemented when the Senate Committee, led by George McGovern, came out with the landmark paper “Dietary Goals for the United States” urging people to reduce the consumption of fat, red meat, eggs and dairy products. The growing obsession with low fats and cholesterol gave rise to a whole new food and drink industry with reduced fats and cholesterol, hence the ubiquitous presence of low fat and cholesterol free products today, not only in America but throughout the world.

The shocking revelation regarding the involvement of the sugar industry in misleading the public via the Harvard study was made by researcher Dr Cristin Kearns, of the University California San Francisco, in 2012 and was reported in all the major newspapers in the US, including the *New York Times*. The charge against fats and butter as the main cause of heart disease has since been debunked, culminating in a *Time Magazine* article absolving fats and butter^{2,9-14}.

The consequences upon oral health

How many millions of people have suffered as a result may be as bad, if not worse, than the scourge of tobacco. The epidemic of increasing incidence of obesity and diabetes worldwide with accompanying heart disease and other ailments over the past 30 years may be ostensibly traced to this fateful decision made by the food and drink industry. Robust evidence now shows links between excessive sugar consumption to obesity, heart disease, diabetes, and liver disease, in addition to tooth decay. Fluoridation of water is known to reduce the incidence of caries in teeth by up to 50%. However, the continued high consumption of sugar is the major cause of the other 50% of carious teeth. High sugar consumption also causes decay of less fluoridated teeth that might otherwise not decay. The impact of diabetes on oral health is well known. It exacerbates the severity of existing periodontal disease and speeds up the disease process

so that more teeth become mobile and are lost earlier, resulting in poorer nutrition and poorer health. Early loss of teeth affects a person psychologically due to poorer appearance and lowered confidence and, in turn, affects a person's mental health and productivity. These days most teeth are lost due to chronic periodontal disease, which is speeded up and exacerbated by diabetes which is linked to the excessive consumption of sugar^{5,15-18}.

The consequences upon general health

Oral health is closely tied to overall health, and vice versa. The latest WHO guidelines on added sugar consumption makes it quite clear that non-added sugar that is present intrinsically and naturally in foods is sufficient and adequate for good health. The message seems to be that added extrinsic sugar is unnecessary for nutrition and good health^{7,8,19}.

The sugar industry has a long history built largely in the past by slave labour and currently at the expense of huge areas of devastation to the rainforests of the Amazon and other parts of the world, all in order to add sugar to almost all our food and drinks. When you think about it sugar costs us billions of dollars in production and addition to our food and drinks, billions of dollars to treat the diseases as a result, all for a product that is unnecessary to our health and wellbeing. Even the excuse of making our food tastier holds little water. Studies have shown that sugar actually prevents us from enjoying all the different flavours and textures present in food. Also, the increasing use of added sugar was the result of a deliberate move by the sugar industry to put the blame on fats and oils 50 years ago, and which over the years has resulted in people all over the world cutting back on oils and fats until recently, when it was openly declared it was all a mistake and the risk label was then removed from natural oils and fats. But the damage had already been done; fats and oils gave taste to food and when they were reduced, guess what got added in to give food taste? Yes, more sugar and more salt was added, especially to manufactured and packaged food. This increasing addition of salt and sugar to food, especially fast food and packaged food, closely matches the rise in levels of obesity, diabetes, high blood pressure and other chronic diseases rife in modern life.

The various NCDs (non-communicable diseases) that are closely related to excessive sugar consumption are obesity, cardiovascular disease, gout, diabetes, peptic ulcers, hiatus hernia, gallstones, Crohn's disease/Irritable Bowel Syndrome, dental caries, dermatitis, joint disease, liver disease, cancer, negative effects on growth, maturation and longevity^{3,4,15,16,20,21}.

Worldwide, it is estimated that 180,000 deaths every year are attributed to the consumption of SSBs (sugar sweetened beverages), including 133,000 from diabetes, 44,000 from cardiovascular disease, and 6,000 from cancer^{21,22}.

The true cost of sugar to oral and general health

The true cost of sugar to the world can be examined via the cost to people, the planet and productivity. The cost to people is tied closely to the rise in obesity, which is closely tied to diabetes. In the past 35 years global diabetes has doubled from 4% to 8% of the population²³.

Professor Goodarz Danaei, co-lead author of the study and an assistant professor of global health at Harvard Chan School, said: "The most important risk factor for diabetes is obesity. Yet global obesity levels are soaring out of control."

In terms of the number of adults with diabetes in the world, this has increased from 108 million in 1980 to 422 million by 2014. East Asia and south Asia saw the largest rises of absolute numbers, and had the highest number of people with diabetes in 2014. In countries like Malaysia, the rate is rapid, from 12% in 2006 to 17% in 2017 and projected to hit 24% in 2020. Many developing and middle-income countries mirror this trend²⁴.

In 1990, 15% adults in the US were obese. By 2010, 25% were obese. Today, 40% of American citizens are obese. The US National Healthcare Expenditure is US\$ 3 trillion a year. 30% to 40% or about USD\$ 1 trillion is spent on healthcare expenses related to excessive sugar consumption.

In 2016, a report from the Harvard T H Chan School of Public Health claimed that the global cost of diabetes had hit US\$ 825 billion a year²⁵. The team also calculated the annual cost of diabetes – which included the cost of treating and managing the disease and its complications, such as limb amputations. This was calculated in International Dollars. The global cost was 825 billion dollars per year, with the largest cost to individual countries being in China (\$170 billion), the US (\$105 billion), and India (\$73 billion). The authors added that the calculation did not include work days lost due to diabetes, which would make the costs far greater if incorporated²⁵.

Dental diseases are a costly burden to health care services. The treatment of dental caries is expensive for governments in both developed and developing countries and costs between 5% and 10% of total health care expenditures in industrialised countries exceeding the cost of treating cardiovascular disease, cancer and

osteoporosis. In most developing, low-income countries, the prevalence rate of dental caries is high and more than 90% of caries is untreated.

The total cost of treating dental diseases globally in 2010 was estimated to be US\$ 450 billion. Today in 2017 this figure is closer to US\$ 500 billion. If half goes to treating dental caries and its sequelae, it means US\$ 250 billion. If half the caries is due to sugar consumption, then there is a potential global direct saving of US\$ 250 billion just by eliminating free extrinsic sugar from the human diet.

Obesity as a chronic metabolic disease

The solution may not be to eat less and exercise more; it may merely be just eliminating fully all added sugars! The obesity and caries epidemic is not the public's fault, but that of the deliberate, selfish, profit-oriented decision of greedy businessmen in charge of the sugar industry – and the world fell for it. In 2017, preventable deaths due to obesity have been found to exceed those due to smoking. In 1990, 15% adults in the US were obese. This percentage swelled to 25% in 2010 and currently stands at 40% for adults and 17% for children and teenagers. These figures are an indication for the rest of the world if we do nothing²².

Sugar raises insulin levels, which raise hunger levels and cause over-eating. Sugar also suppresses the satiety centre in the brain and causes more over-eating. A double whammy! Insulin levels of the population today have increased to three times the level they were in the 1980s. The industrial diet, also known as the modern processed food diet, is costing the world trillions of dollars.

The solution

Why are we suffering and spending so much money and allowing devastation to people, productivity and the environment due to the consumption of a commodity that may be unnecessary for human nutrition, unnecessary for health and, arguably, even for good, tasty food? Prevention is always better than cure. Treat the diseases caused by sugar consumption we must, yet we must begin and sustain a plan to reduce the consumption of added sugars in all their forms and eventually to do away with them altogether.

One teaspoon of sugar equals 4 g, 1 g sugar equals 4 calories, One teaspoon of sugar therefore equals 16 calories, and an adult requires 2500 calories of food a day, WHO recommended calories from added sugar to be 5%; 5% of 2500 calories equals 125 calories,

125 calories equals 30 g sugar, which equals eight teaspoons of sugar, meaning 5% is likely to be a concession. The unspoken recommendation appears to be that we need no added sugar – and that should be the target.

Should we now seriously consider a sustained campaign to roll out cessation of sugar programmes like that associated with the tobacco cessation programmes? Should we place a tax on sugar consumption? Should we launch a sustained programme of education at every level?

The WHO recommends measures including clear labelling of sugar content, restricting the marketing of food and drink high in free sugars to children, and dialogue with food manufacturers to reduce the amount of free sugars in processed foods. Whatever it is, we cannot wait, but should immediately embark on this worthy struggle because it has the potential to improve universal health and save billions and even trillions in healthcare dollars²⁶.

Conflicts of interest

The author reported no conflicts of interest related to this study.

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