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The Likely Fiscal and Public Health Effects of an Excise Tax on Sugar-sweetened Beverages in Kenya

Corné van Walbeek, Senzo Mthembu

May 2022

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Summary

Historically, non-communicable diseases (NCDs) have typically been associated with tobacco and alcohol use. However, in recent decades increased levels of overweightness and obesity, mostly caused by poor eating habits and a sedentary lifestyle, have increased diabetes, cancers, and cardiovascular diseases. There is a general agreement that sugar-sweetened beverages (SSBs) are bad for one's health. As such, measures to reduce their consumption would be expected to positively impact population health.

In this working paper, we develop and report on an Excel-based model, in which we simulate the impact of an SSB tax on the prevalence of overweightness and obesity. The model starts with a baseline scenario, which takes cognisance that a 10 KES specific tax already exists on all soft drinks. A sugar-based SSB tax is then introduced. The tax is levied as an amount per gram of sugar, with or without a tax-free threshold. Other than reducing the demand for SSBs, a sugar-based SSB also creates strong incentives for manufacturers to reformulate their products to reduce the sugar content. The model predicts that the average BMI would decrease across all age groups decreasing the prevalence of overweightness and obesity. The magnitude of the decrease in the prevalence of overweightness and obesity depends on the size of the SSB tax. For realistic and politically feasible values of the SSB tax, the prevalence of overweightness and obesity is expected to decrease by between 5 per cent and 10 per cent.

Should Kenya implement a sugar-based tax on SSBs, over and above the current excise tax on soft drinks, the government should clarify that such a tax aims to enhance public health; raising additional revenue should be a secondary consideration. Also, implementing a sugar-based SSB tax should be part of a more comprehensive strategy to reduce overweightness and obesity, because by itself the impact of the tax is modest.

Keywords: non-communicable diseases, body mass index, fiscal policies, sugar-sweetened beverages, overweightness, obesity, excise tax, SSB consumption.

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Acronyms

BMI	Body mass index
KES	Kenyan Shilling
LMICs	Low- and middle-income countries
NCD	Non-communicable disease
R	South African Rand
SSB	Sugar-sweetened beverages
USD	US Dollar

Introduction

As the battle against communicable diseases is being won in most parts of the world, non-communicable diseases (NCDs) have become relatively more common sources of illness and death. NCDs are primarily lifestyle diseases, most commonly associated with tobacco and alcohol use, but increasingly with poor eating habits and a sedentary lifestyle (WHO 2021). NCDs result in increased health expenditures, premature deaths, and preventable morbidity, and are placing pressure on communities and governments. It is estimated that approximately 71 per cent of annual deaths globally are attributable to NCDs (WHO 2021: 8), and approximately 80 per cent of NCD-related deaths worldwide occur in low- and middle-income countries (LMICs) (Wagner and Brath 2012 and WHO 2021: 11).

Unhealthy food and drink consumption is identified as a major modifiable risk factor for NCDs (Hu and Malik 2010). Escalating body mass indices have been directly and indirectly linked to many NCDs, including diabetes, cancers, and cardiovascular diseases (Agrawal and Agrawal 2016 and WHO 2021). The relationship between nutrition and health is complex. However, some foodstuffs are unambiguously bad for one's health. Sugar-sweetened beverages (SSBs) fall into this category.

SSBs are generally regarded as empty calories, i.e., calories that seem to have no or very little nutritional value. The human body quickly processes empty calories, thus leaving the body feeling hungry again more quickly than usual (Malik, Pan, Willett and Hu 2013). This has been proven to lead to increased incidences of obesity and metabolic syndrome. Metabolic syndrome is a cluster of conditions associated with increased blood pressure (hypertension), high blood glucose levels (impaired glucose metabolism), type 2 diabetes (insulin resistance), excess body fat around the waist (central adiposity), abnormal cholesterol or triglyceride levels (dyslipidemia), chronic liver disease (especially non-alcoholic fatty liver disease), and hormonal disorders (specifically polycystic ovary syndrome) (Schulze, Manson, Ludwig, Colditz, Stampfer and Willett 2004; Davis, Ventura, Weigensberg, Ball, Cruz and Shaibi 2005; Hu and Malik 2010; Malik, Popkin, Bray, Després Willett and Hu 2010; Nseir, Nassar and Assy 2010; Bremer and Lustig 2012). A large number of studies have illustrated the negative consequences of SSB consumption on health and have improved our understanding of how SSBs might affect adiposity (the fact or condition of having too much fatty tissue in the body). Tordoff and Alleva (1990) and Raben, Vasilaras, Møller and Astrup (2002) found that subjects' total energy intake and body weight increased when given sucrose in the form of SSBs for some weeks, but they lost body weight when given non-caloric sweeteners for the same length of time. More recently, studies have found that the consumption of caffeinated SSBs (e.g., energy drinks or colas) is associated with caffeine-related health consequences, including reduced sleep quality and headaches (Al-Shaar, Vercammen, Lu, Richardson, Tamez and Mattei 2017). The overall conclusion of these and other studies is that SSBs are detrimental to people's health.

Improving health through healthy diets is multifaceted and complex. Among other things, it would mean making healthy foods the food of choice, while making unhealthy foods less desirable. This paper considers one aspect of a much larger range of possible options, namely a tax on SSBs. In particular, we present a model which aims to quantify the likely impact of an SSB tax on the levels of overweightness and obesity in Kenya. Section 1 of this paper provides an introductory discussion on fiscal measures to address overweightness and obesity. Section 2 provides an overview of the current situation in Kenya. This includes a discussion of SSB prices, SSB consumption and body mass index in Kenya. Section 3 outlines and explains the model which we use to derive our results. In section 4, we describe the data that we use in the model. Section 5 presents two possible policy interventions in the form of policy scenarios. In section 6 we present the model results for the two policy scenarios. We discuss these results, and the recommendations that follow from them, in more detail in section 7.

1 Fiscal measures to address overweightness and obesity

Within the context of rapidly increasing rates of overweightness and obesity a WHO panel of public health experts in 2016 recommended that governments should impose a tax on sugar-sweetened beverages since ‘appropriately designed taxes on sugar-sweetened beverages would result in proportional reductions in consumption, especially if aimed at raising the retail price by 20% or more’ (WHO 2016: 9). These WHO recommendations are based on scientific evidence, best practice, and the experience of countries that have implemented effective SSB policies that have improved the health of their populations. By 2020, 50 countries, states and cities had introduced SSB taxes, and more were working towards voluntary agreements with manufacturers (World Bank 2020).

Fiscal measures to control NCD-related diseases are well known and have increasingly been implemented to reduce the consumption of harmful products. The WHO has identified several ‘best buy’ interventions that will save lives at modest costs (WHO 2017a). Increasing the excise taxes on tobacco and alcohol are classified as ‘best buys’, while implementing taxes on sugar-sweetened beverages is classified as an ‘effective intervention’ (one step down from ‘best buys’). There is a substantial literature on using tax increases to improve public health. It began with the economics of tobacco control (see IARC 2011, NCI/WHO 2016 for comprehensive reviews) but has subsequently spread to the economics of alcohol policy (WHO 2022, forthcoming) and sugar-sweetened beverages (WHO 2017b). In the tobacco control literature, tax and price policies are widely recognised as the most effective means of reducing the demand for tobacco (WHO 2014; International Agency for Research on Cancer 2011). The literature on the impact of tax and price policies on reducing the demand for SSBs is still developing, but the limited number of studies available indicate that it can be an effective measure (Jou and Techakehakij 2012; Escobar, Veerman, Tollman, Bertram and Hofman 2013; Blecher 2015). Consequently, a sugar tax could be an important element of a country’s NCD control strategy and public health improvement efforts. If the government imposes a tax on unhealthy products, it will change relative prices and encourage (at least some) consumers to purchase the relatively cheaper healthier alternatives.

Compared to other measures used to reduce the demand for SSBs, SSB taxation is inexpensive to implement (WHO 2017a). In fact, as well as decreasing the consumption of SSBs, an SSB tax brings in additional government revenue, making it a win-win policy. In the medium to longer term, it can avert SSB-related mortality and morbidity, which also puts less financial stress on the public health system (Falbe, Thompson, Becker, Rojas, McCulloch and Madsen 2016).

Kenya currently imposes an excise tax on non-alcoholic beverages of 10 shillings (0.10 USD) per litre, irrespective of calorific content. It is a general excise tax that has been imposed since 2018. While the tax generates revenue for the government and reduces the demand for SSBs, especially among more price-sensitive consumers, producers have no incentive to reformulate their beverages to reduce the sugar content. As such, it is a rather blunt instrument and not as effective as it could be. It does not nudge consumers or producers away from high-calorie beverages to low-calorie beverages (Asiki, Wanjohi, Barnes, Bash, Vandevijvere, Muthuri, Kimani-Murage and Holdsworth 2019).

South Africa imposed a tax on SSBs in April 2018. The tax is called the Health Promotion Levy, and specifically targets the sugar content of SSBs. When it was implemented, the tax was levied at a rate of 2.1 cents (about 0.14 US cents) per gram of sugar in excess of the threshold of 4 grams of sugar per 100 ml of beverage. For one litre of carbonated drink, with a sugar content of 11 grams/100 ml, the excise tax would be 0.021 Rand (R) x (11 – 4) x 1000/100 = 1.47 R (= about 0.10 USD). In 2019 the SSB tax was increased to R 0.0221 per gram of sugar above the threshold of 4 grams per 100 ml of beverage. In contrast to an excise tax that is levied on the volume of the beverage, irrespective of the sugar content, the Health Promotion Levy encourages producers to reduce the sugar content of the product. Provisional unpublished research indicates that most producers of carbonated drinks have decreased the sugar content of their beverages by an average of nearly 50 per cent in order to reduce their tax liability (Heneck 2021). The supply response is beneficial to public health, and is a result of the tax structure creating the incentive for producers to reformulate their products to contain less sugar.

In the practical application of an SSB tax, we acknowledge that there are numerous complications, some of which we address here. First, there is no neat categorisation of sugar-sweetened beverages. For example, most people drink tea and coffee, and add sugar. However, unless one places a tax on the sugar itself, it does not make sense to discourage the use of these two beverages by placing a tax on them, as they do not contain sugar in their dry state.

Second, it is difficult to categorise dry products that are added to water or milk to make sugar-sweetened beverages. For example, should Milo, Nesquik, hot chocolate powder, or Game powder be subject to an excise tax?

Third, there is also some controversy about imposing a tax on fruit juices. In their marketing campaigns, fruit juice companies have typically portrayed the product as healthy, given that it is derived from fruit (Escobar *et al*. 2013; Stacey, Tugendhaft and Hofman 2017). However, in practice, most fruit juices are highly engineered products, with a sugar content that often matches that of carbonated beverages (Saxena, Stacey, Puech, Mudara, Hofman, and Verguet 2019; Hofman, Stacey, Swart, Popkin and Ng 2021) Some fruit juices contain added sugar. However, even if the fruit juice is ‘100 per cent fruit juice blend’, it contains a large amount of fructose, derived from a sophisticated process of blending fruit concentrates and denatured fruit juices.

In South Africa, the Health Promotion Levy does not apply to fruit juices, on the grounds that fruit juices are not as bad as carbonated drinks or concentrates. However, public health groups, such as the PRICELESS research unit at Wits University, argue that fruit juices should be subject to an excise tax as well (Hofman *et al*. 2021). In the 2022/2023 Budget Review, the Minister of Finance indicated that the National Treasury is considering an extension of the Health Promotion Levy to fruit juices.

The ultimate aim of an SSB tax is to improve public health, and to reduce premature morbidity and mortality related to the consumption of these products. Given that obesity is directly and indirectly linked to many NCDs, we will use the change in the percentage of people who are overweight and obese as the proximate aim of the SSB tax. A measure often used to determine whether someone is overweight or obese is the body mass index (BMI). The BMI is calculated as the weight of a person (measured in kg), divided by height squared (measured in metres) of that person. A BMI value of less than 18.5 kg/m^2 is regarded as underweight; a BMI between 18.5 kg/m^2 and 25 kg/m^2 is regarded as normal; a BMI of between 25 kg/m^2 and 30 kg/m^2 is regarded as overweight, and a BMI of more than 30 kg/m^2 is regarded as obese.

2 The current situation in Kenya

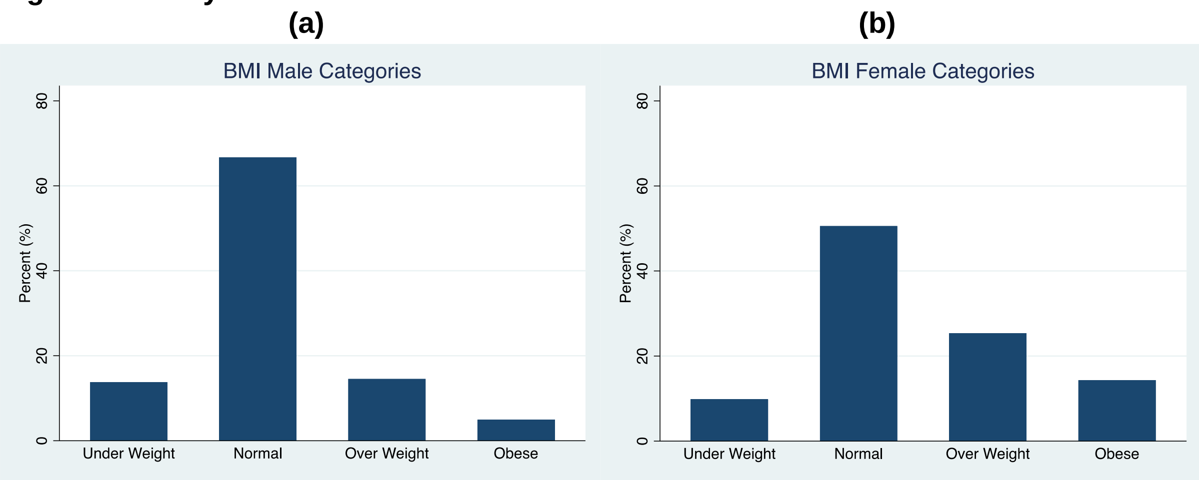
In Kenya, NCDs account for more than 50 per cent of total hospital admissions and over 55 per cent of hospital deaths (Government of Kenya 2021). A proportion of these NCD-related hospital admissions and deaths are associated with a rise in overweightness and obesity rates. In Kenya, as in many African countries, overweightness and obesity rates are substantially higher among women than men. The percentage of Kenyan women who are overweight increased from 25 per cent in 2009 to 33 per cent in 2014 (KNBS, MOH, NACC, KEMRI and NCPD). The recently published National Strategic Plan indicates that 38.5 per cent of Kenyan women were overweight in 2015, compared to 17.5 per cent of men (Ministry of Health 2021: 17).

The National Strategic Plan (Ministry of Health 2021: 17) indicates that 'the country has shown no progress towards achieving the target for reducing obesity among the adult population, with an estimated 11.1% of adult (aged 18 years and over) women and 2.8% of adult men living with obesity'. However, the report notes that Kenya's obesity prevalence is lower than the regional average of 18.4 per cent for women and 7.8 per cent for men. Given the differences in overweightness and obesity between men and women, it is not surprising that one of the guiding principles of the National Strategic Plan is that it should adopt a gendered approach to NCD prevention and control. In this report, we adopt a gendered approach in the empirical analysis.

One of the five main aims of the National Strategic Plan, which focuses on 2021/22 to 2025/26, is to minimise exposure to identifiable risk factors. The main risk factors for NCDs are tobacco use, the harmful use of alcohol, overweightness and obesity, unhealthy diets, physical inactivity, and environmental pollutants, such as agrochemicals, heavy metals and toxins. Given the multifaceted nature of these risk factors, the Strategic Plan indicates that mitigating them will be achieved by strengthening multisectoral interventions. To promote healthy diets, the National Strategic Plan (2021: 30) proposes trans-fat regulation, regulation of the marketing of unhealthy foods and non-alcoholic drinks to children, front-of-pack standards laws, and fiscal policies on SSBs.

Figure 1 below shows the distribution of BMI levels in Kenya in 2015 for both males and females. Approximately 14 per cent of males and 10 per cent of females were classified as underweight. Sixty-seven per cent of males and 51 per cent of females had BMIs that placed them in the normal range. Among males, 15 per cent were classified as overweight (BMI between 25 kg/m^2 and 30 kg/m^2) and 5 per cent were classified as obese (BMI > 30 kg/m^2). Among females, 25 per cent were classified as overweight and 14 per cent as obese. The differences in BMI distribution between males and females in Kenya aligns with the global literature that indicates that more females than males are overweight (Kyallo, Makokha and Mwangi 2013; Mkuu, Barry, Yonga, Nafukho, Wernz, Gilreath, Chowdhury and Harvey 2021).

Figure 1 BMI by sex



Source: Computed using the Kenya STEPwise survey Dataset for Non-Communicable Diseases (Kenya National Bureau of Statistics 2015a).

For both males and females, BMI tends to increase with age, but decreases slightly in old age (60+), as is indicated in Table 1 below. For each age group presented in Table 1, the average BMI of females is higher than that of males, as is to be expected, given the information provided in Figure 1.

Table 1 Average BMI by age group

Age groups	Men	Women	Both sexes
15-29	22.11	23.99	23.22
30-44	23.28	25.94	24.77
45-59	23.72	26.87	25.58
60+	22.63	25.65	24.45

Source: Constructed using the Kenya STEPwise survey Dataset for Non-Communicable Diseases (Kenya National Bureau of Statistics 2015a) (n = 4254).

Since the aim of this paper is to investigate the likely impact of an SSB tax on the prevalence of overweightness and obesity, it is important to understand the SSB consumption patterns in the baseline. SSBs comprise a variety of different beverages, including carbonated drinks (sodas), concentrates, sports and energy drinks, fruit juices, and flavoured milk. Of these, carbonated drinks are by far the most common. In Table 2, some of the most common brand names, as identified by Euromonitor and locally-based colleagues, are shown.

Table 2 SSB and non-SSB categories, and some common brand names in Kenya

Product categories	Most common brands
Sugar-sweetened beverages	
Carbonated soft drinks (sodas)	Coca-Cola, Fanta, Sprite, Schweppes, Krest, Stoney, Tangawizi, Softa, Pepsi
Concentrated drinks/concentrates	Quencher, Highlands, Ribena, Pep Passion, Oros
Sports and energy drinks	Energy Drinks (Lucozade, Carrefour Barbican, Monster)
Fruit and vegetable drinks	Afia, Ceres, Minute Maid, Delmonte, Pick n Peel, Squencher, Yatta, Orchid Valley
Milk-based beverages	Tuzo, KCC, Brookside, Ilara, Molo, Fresha
Non-sugar-sweetened beverages	
Diet carbonated drinks	Coke-zero, Sprite-zero
Bottled water	Aquamist, Alpine Coolers, Kadolta, Kevian, Quencher, Waba, Mineral Water

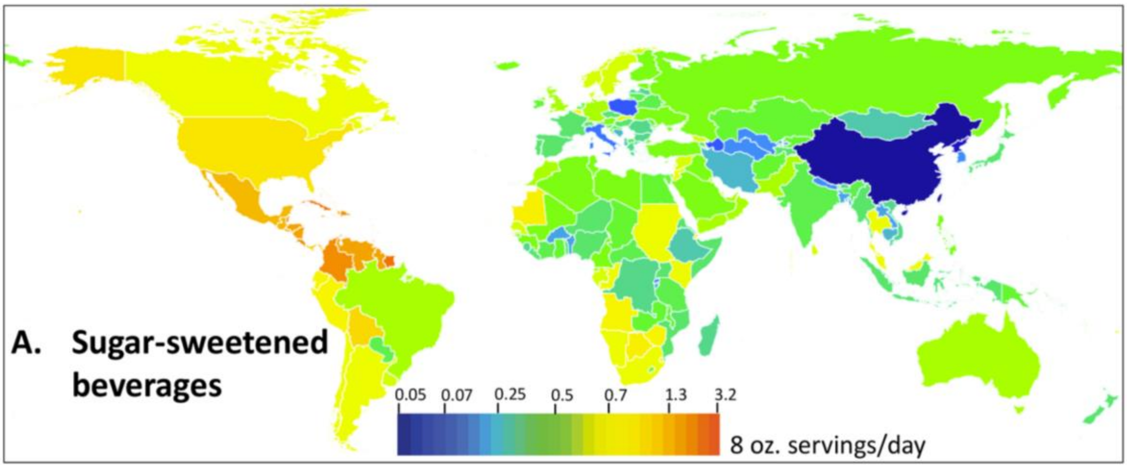
Sources: Euromonitor 2021 edition, Statista 2021.

While there are likely to be some grey areas in discussions about which beverages to include in a tax on SSBs and which not, there is little dispute that (non-diet) carbonated drinks, sports and energy drinks, and concentrates should be subject to a tax. In this paper we focus primarily on carbonated drinks, because that is by far the largest SSB category.

We found two data sources for SSB consumption in Kenya: Euromonitor (2021) and Singh, Micha, Khatibzadeh, Shi, Lim, Andrews, Engell, Ezzati, Mozaffarian and Global Burden of Diseases Nutrition and Chronic Diseases Expert Group (NutriCoDE) (2015). Euromonitor is a well-respected commercial provider of data. The Singh data, which covers the consumption patterns of carbonates and fruit juices for more than half the world's population, is based on nearly 200 different nationally representative or sub-nationally representative diet surveys, and annual food balance information collected by the United Nations Food and Agriculture Organization. It provides per capita consumption data on SSBs, juice and milk, broken down by sex and age group, for 2010.

To provide some international context, the global distribution of per capita consumption of SSBs and fruit juices in 2010, based on Singh *et al*. (2015) data, is shown in Figures 2 and 3. There are substantial differences in per capita consumption of SSBs between countries. Per capita consumption of SSBs in Africa varies substantially between countries. Kenya, together with some countries in Southern Africa, accounts for substantially more SSB consumption per capita than other African countries.

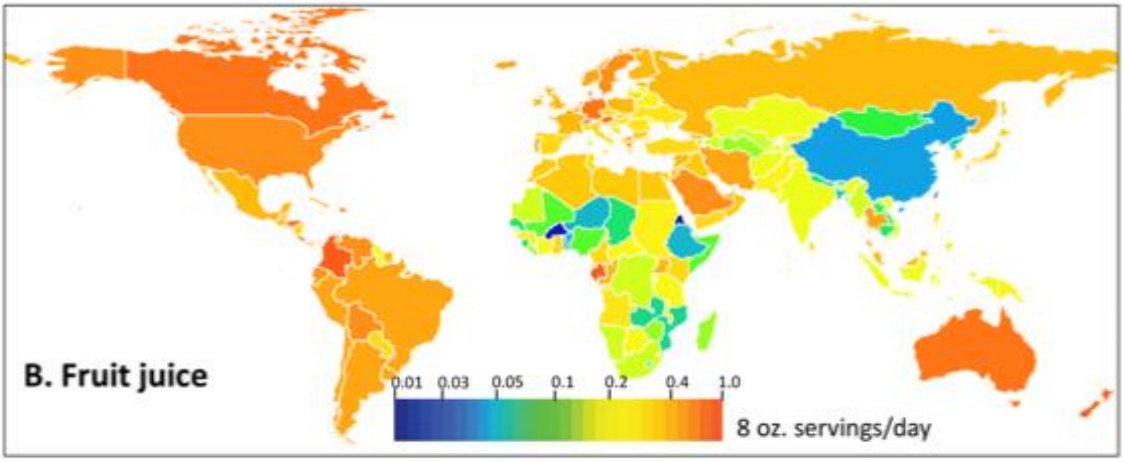
Figure 2 Per capita consumption of SSBs, 2010



Source: Singh *et al*. (2015) CC BY 4.0.

Per capita consumption of fruit juices is lowest in Africa, and there is substantial variation in consumption between countries (see Figure 3). Within Africa, per capita consumption of fruit juices is relatively high in Kenya, on a par with many North African and European countries.

Figure 3 Per capita consumption of fruit juice, 2010



Source: Singh *et al*. (2015) CC BY 4.0.

Singh *et al.* (2015) provided a mean daily consumption, and upper and lower bounds for the daily consumption, of SSBs, fruit juices and milk. We converted the daily imperial-scale numbers into annual metric numbers and reduced the number of age ranges for each sex group from seven to four. The annual consumption data is shown in Table 3.

Table 3 Average consumption (in litres per person per year) of fruit juice, milk, and SSBs in Kenya, 2010

	Juice			Milk			SSBs		
	Mean	Lower bound	Upper bound	Mean	Lower bound	Upper bound	Mean	Lower bound	Upper bound
Female									
15-29	13,0	6,3	24,0	53,5	29,4	97,6	96,7	52,7	166,7
30-44	10,1	5,1	18,6	49,2	27,1	86,1	64,8	35,4	108,8
45-59	8,6	4,4	15,6	50,9	27,6	86,6	42,3	23,3	71,4
60+	8,4	4,3	14,9	61,3	32,4	104,1	30,7	16,4	52,7
Total female	11,1	5,5	20,3	52,7	28,8	93,4	73,0	39,8	124,8
Male									
15-29	10,8	5,3	19,6	47,5	26,8	82,0	106,2	58,7	189,1
30-44	8,3	4,1	15,3	44,0	25,3	76,0	71,1	40,0	124,1
45-59	7,0	3,5	13,0	45,2	25,9	77,7	46,9	26,2	82,0
60+	6,8	3,2	12,4	54,0	30,7	93,7	33,7	19,0	60,0
Total male	9,1	4,5	16,7	46,7	26,6	80,6	80,7	44,9	142,8
Male & female	10,1	5,0	18,6	49,7	27,7	87,1	76,9	42,3	133,6

Source: Singh *et al*. (2015) CC BY 4.0.

According to this data, per capita consumption of juice and SSBs decreases as age increases, while milk consumption remains fairly constant across age groups, and even increases somewhat in old age. Juice consumption is higher among females than males, across all age groups, but SSB consumption is higher among males than among females. The relatively wide margins between the lower and upper bound suggest that there is a high degree of uncertainty about the true level of consumption.

3 The SSB Model

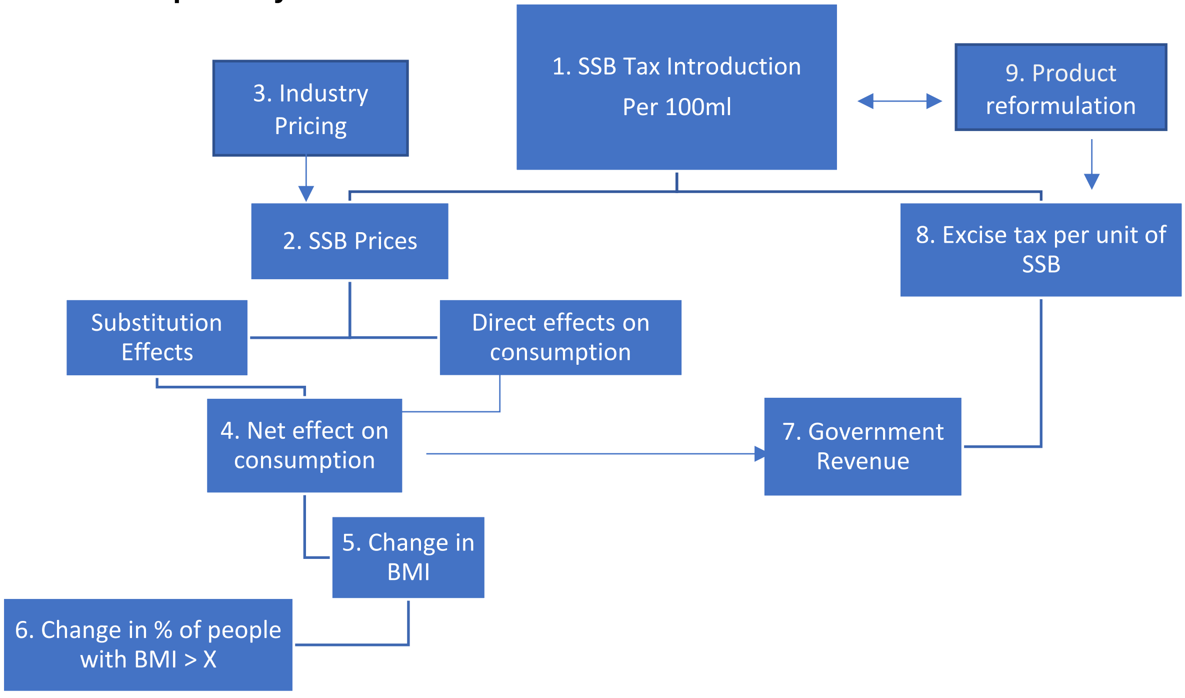
The primary aim of an SSB tax is to improve public health, and to reduce premature morbidity and mortality related to the consumption of SSBs. Given that obesity has been directly and indirectly linked to many NCDs, including diabetes, some cancers, and cardiovascular diseases, as reported by Agrawal and Agrawal (2016) and WHO (2021), we will use the change in the percentage of people who are overweight and/or obese as the proximate aim of the SSB tax.

In this paper we present a mathematical model, populated with appropriate parameters, in which we illustrate the impact of a proposed SSB tax on SSB prices, SSB consumption, government revenue, and the prevalence of overweightness and obesity. This modelling tool uses several economic principles, in particular price and cross-price elasticities, to predict the impact of a tax change on the relevant outcome measures. The model can accommodate a range of tax structures and levels, and it draws on the experience of high-income countries and of other LMICs that have undertaken similar exercises.

The mathematical derivation of the SSB model for Kenya is based on the research team's experience in developing models to estimate the likely impact of a change in the excise tax on tobacco products, the original version of which was published in 2010 (Van Walbeek 2010). Our proposed SSB model is also informed by modelling by Manyema, Veerman, Chola, Tugendhaft, Sartorius, Labadarios and Hofman (2014) and Stacey, Summan, Tugendhaft, Laxminarayan and Hofman (2018) for South Africa, by Andreyeva, Chaloupka and Brownell (2011) and Dharmasena and Capps (2012) for the U.S, and by Lal, Mantilla-Herrera, Veerman, Backholer, Sacks, Moodie, Siahpush, Carter and Peeters (2017) for Australia.

The model's generic structure is summarised in Figure 4 below, which shows the pathway of the impact of an SSB tax on both obesity and government revenue. The numbers in the blocks refer to the discussion below the figure.

Figure 4 SSB tax pathway



Authors' compilation: Model structure.

The model starts with the introduction of an SSB tax on SSB products (1). The SSB tax is expected to increase the retail price of SSBs (2). The industry's pricing strategy determines to what extent the excise tax will influence the retail price (3). For example, the industry can decide to pass the excise tax through fully to the consumers, or it can decide to over-shift or under-shift the excise tax. If the tax is fully passed through, it means that the retail price increases by the amount by which the excise tax is increased, no more and no less. If the tax is over-shifted, the industry increases the retail price by more than the excise tax amount. On the other hand, if the tax is under-shifted, the industry increases the retail price by less than the amount of the excise tax.

In the model, the change in the retail price changes consumer behaviour. The most direct effect, quantified by the value of the (own-)price elasticity of demand, indicates by what percentage consumption is likely to decrease when there is an increase in the retail price of the product in question (4). If one considers all SSBs as one product, as Singh *et al*. (2015) did, then one cannot consider the impact of relative price changes on the various SSB sub-categories, like carbonates, concentrates, or energy and sports drinks.[1]

A reduction in SSB consumption (4) is expected to reduce the average BMI (5), which in turn will reduce the percentage of people who are classified either as overweight or obese (6).

Other than the effect on consumption, an SSB tax has a fiscal effect (7). The total amount of government revenue collected from this tax is the excise tax per volume of beverage multiplied by the volume of the beverage sold after the tax is imposed (8). The volume of the beverage sold after the tax is imposed is less than in the baseline scenario, so the revenue figures need to take account of the decrease in consumption. The amount of excise tax per volume of beverage can also be reduced by the SSB industry through product reformulation (9). In fact, evidence from the United Kingdom and South Africa (Heneck 2021) indicates that an excise tax structure that taxes the amount of sugar in the beverage, rather than the volume of the beverage itself, encourages producers to reduce the sugar content of the beverage, so as to reduce or avoid the SSB tax. The model allows the user to indicate by what percentage the SSB industry is predicted to reduce the quantity of sugar in the product in response to the imposition of the excise tax.

Appendix 1 provides a technical overview of the model, focusing on the mathematical relationships, while Appendix 2 provides a step-by-step explanation on how to use the model. Readers can find the Excel model here.

4 Data

Below, we use Singh *et al*.'s (2015) estimates of per capita consumption of SSBs and fruit juices as the base for the consumption data. For the prices of SSBs and fruit juices, we conducted an internet search of a number of popular Kenyan retail outlets and verified the numbers with colleagues at the International Institute for Legislative Affairs in Kenya. While there are substantial differences in the prices of these products, based on package size, brand, and retail outlet, we agreed that 100 Kenyan Shilling (KES)/litre for SSBs and 200 KES/litre for fruit juices were representative estimates for these two products.[2]

[1] However, if there are clearly identifiable sub-categories of SSBs, there are likely to be substitution effects. Substitution effects are found when the consumption of the product in question is influenced by the change in other products' prices. This is quantified by the cross-price elasticities of demand. The total effect on the consumption of the product in question is the sum of the direct and substitution effects of the various products' price changes.

[2] Data was collected in June/July 2021, when the exchange rate was around 1 USD to 108 KES.

Table 4 Data and sources used in the modelling, based on Singh *et al*.'s consumption data (2015)

Variables	Source	Comment
Body Mass Index (for each sex and age group)	Kenya STEPwise Survey for Non-communicable Diseases Risk Factors (Kenya National Bureau of Statistics 2015a)	See Table 2
Per capita consumption of SSBs, by gender and age group	Singh *et al.* (2015)	Three sets of data: lower bound, mean, and upper bound
Average retail price of SSBs	Internet search, and discussions with International Institute of Legislative Affairs (IILA)	Average price of 100 KES/litre for SSBs and 200 KES/litre for fruit juices
VAT rate	Kenya Revenue Authority	2019 VAT rate announced by the National Treasury Department (16%)
Total population, decomposed by sex and 15-year age groups (15-29, 30-44, 45-59 and 60+)	Kenya National Bureau of Statistics	Total population (aged 15+) in 2019 was 28.9 million
Price elasticity of demand	Estimate based on evidence from LMICs	Price elasticity = -1.1 for SSBs and -1.2 for fruit juice
Industry response (1): reduction in sugar content due to product reformulation	Informed by experience in the UK and South Africa	For SSBs, sugar content decreases by 35% in response to the imposition of the tax; for fruit juice sugar content decreases by 15%
Industry response (2): change in the net-of-tax price	Standard assumption in most modelling exercises	Full pass-through of the excise tax

Source: Author's compilation using different sources.

As an aside, we want to indicate that we faced substantial challenges finding appropriate and consistent consumption data. We accessed many data sources, including Global Data 2016; Kenya National Bureau of Statistics 2015a and 2015b; KNBS, MOH, NACC, KEMRI and NCPD 2015; and Euromonitor 2021. Eventually we settled on Singh *et al*. (2015), because the consumption data was broken down by sex and age group, and the data indicated lower and upper bounds, together with a 'mean' estimate of consumption. Having lower and upper bounds emphasises the fact that there is uncertainty about the veracity of the data, which is academically honest. Furthermore, the fact that the Singh data was based on surveys, rather than sales data, makes the data more encompassing, and acknowledges the fact that Kenya has a sizeable informal economy where large quantities of SSBs and other beverages are sold.

The Singh data indicates that SSB consumption in Kenya is much higher than is indicated by the Euromonitor data (see Table 5). To the extent that the Euromonitor data is a good reflection of actual SSB consumption in Kenya, it is possible that the 'mean' estimate of consumption, and even the lower bound, based on Singh's data, might overstate true consumption. If this is true, the fiscal and health effects of the excise tax will be overstated. We raise this as a possible concern.

Table 5 Per capita annual SSB and other beverage consumption, from two data sources

Product categories	Euromonitor Per capita in year 2020			Singh *et al.* (2015) (mean estimate)
Sugar-sweetened beverages	**Off-trade**	**On-trade**	**Total**	
Carbonated soft drinks (sodas)	10.2	4.8	15.0	76.9
Concentrated drinks/ concentrates	0.1	-	0.1	
Sports and energy drinks	0.06	0.01	0.07	
Fruit and vegetable drinks	1.7	0.3	2.0	10.1
Non-sugar-sweetened beverages				
Diet carbonated drinks	-			-
Bottled water	13.7	1.0	14.6	-

Notes: All numbers are in litres per year, per adult (aged 15+). The Euromonitor data refers to the 2020 edition. The Singh *et al*. data refers to per capita consumption in 2010, but the data is weighted by the population as it was in 2020. The numbers reported are for Singh's (2015) 'mean' estimate of consumption. Singh (2015) reports upper and lower bounds (see Table 3), but these are not shown here.

5 Possible excise tax scenarios for Kenya

Several tax structures are possible. An excise tax on SSBs can either be ad valorem or specific. Many African countries impose an ad valorem tax on products like tobacco and alcohol. An ad valorem tax is based on the value of the product. Much research, mainly on tobacco products, has been conducted into the impact of tax structures on a range of outcomes, and it is evident that specific taxes on tobacco have clear advantages over ad valorem taxes (IARC 2011; WHO 2021). An ad valorem SSB tax would be subject to the same drawbacks as an ad valorem tobacco tax. As such, we do not consider an ad valorem SSB tax a viable option, and we do not discuss it further.

A specific SSB tax can be levied either on the volume of the beverage (as is the case in Mexico) or on the sugar content (as is the case in the UK and South Africa). Currently Kenya levies a tax on the volume of the beverage, at a rate of 10 KES per litre (Wanjohi, Thow, Abdool Karim, Asiki, Erzse, Mohamed, Pierre Donfouet, Juma and Hofman 2021). It is levied on all soft drinks and is not targeted at SSBs. The tax was designed to generate revenue, rather than to discourage SSB use (Wanjohi *et al*. 2021).

A specific sugar-based SSB tax can be structured in several ways. One option is that beverages below a certain threshold level of sugar are not taxed, and that the tax is levied only beyond that level. For example, in the UK and in South Africa, the first 4 grams per 100 ml of beverage are not taxed. In the UK, beverages with a sugar content between 4 grams and 8 grams per 100 ml are taxed at a constant rate, while beverages with a higher sugar content are taxed at a punitive rate. The aim of the punitive rate was to remove beverages with a sugar content above 8 grams per 100 ml completely from the market. In South Africa, beverages are taxed at a certain amount per gram of sugar above the 4 grams per 100 ml tax-free threshold. Again, the aim of the tax is to encourage producers to reduce the sugar content of the beverage.

However, a tax-free threshold is not a requirement for a good SSB tax structure (Stacey, Mudara, Ng, van Walbeek, Hofman and Edoka 2019). When the SSB tax was initially proposed for South Africa, the tax-free threshold was not part of the proposed structure. In the subsequent negotiations, the government agreed to the manufacturers' request for a tax-free threshold.

For the modelling exercise for Kenya, we will consider two tax scenarios, both based on the sugar content of the beverage. In the **first scenario**, we assume that there is no tax-exempt threshold. The tax is levied at a rate of 0.3 KES per gram of sugar. Thus, without product reformulation, the excise tax on 1 litre of SSB, with a sugar content of 10 grams per 100 ml, will be 0.3 x 100 grams = 30 KES.

In the **second scenario** we assume that that the first 4 grams per 100 ml is tax-exempt. Beyond the threshold, the beverage is taxed at 0.6 KES per gram of sugar. Without product reformulation, the excise tax on 1 litre of beverage (with the same sugar content as above) will be 0.6 x (100-40) grams = 36 KES.

A crucial aspect of the subsequent analysis concerns product reformulation. SSB manufacturers have an incentive to reduce their tax liability by reducing the sugar content of their products through product reformulation. The greater the marginal tax rate on an additional gram of sugar, the greater is the incentive to reduce the sugar content. Thus, in scenario 2, where the marginal tax rate is 0.6 KES per gram of sugar, the incentive to reformulate the product is greater than in scenario 1, where the marginal tax rate is 0.3 KES per gram of sugar.

It is impossible to know *ex ante* the amount of product reformulation that will take place, but the experiences of other countries can give some indication. A recent study in South Africa suggests that the average sugar content in SSBs has decreased by nearly 50 per cent since the SSB tax was implemented (Heneck 2021).

Based on this finding, and to be relatively conservative, we assume that SSB manufacturers will decrease the sugar content by 35 per cent in SSBs and by 15 per cent in fruit juices in scenario 1. In scenario 2, where the marginal tax rates are higher, we assume that the sugar content will decrease by 40 per cent in SSBs and by 20 per cent in fruit juices. There are two main reasons for our assumption that the expected decrease in sugar content in fruit juices is lower than the expected decrease in sugar content in other SSBs. The first is that it is technically more difficult to reformulate fruit juices to contain less sugar, compared to SSBs. The second is that, because the price of fruit juice is higher than SSBs, the impact of the excise tax on the price of fruit juice is relatively smaller than on SSBs.

6 Model results

6.1 Baseline consumption and prices, and prevalence of overweightness and obesity

As indicated previously, Singh *et al*. (2015) provide three estimates for per capita SSB and juice consumption for three consumption estimates, or scenarios: a lower bound, a mean, and an upper bound, for various sex-age categories. Note that the SSB consumption of children up to the age of 15 years is not included in this analysis.

In Table 6 we provide a high-level summary of per capita and aggregate consumption of SSBs and fruit juice for the three scenarios. The size of the variations in consumption patterns between these three scenarios indicates that there is substantial uncertainty about the veracity of the consumption numbers in Singh *et al*. (2015). These numbers refer to 2010.

Table 6 Baseline consumption figures

	Lower bound	*Mean*	*Upper bound*
Per capita consumption (litres per year)			
Sugar-sweetened beverages			
Male	44,9	80,7	142,8
Female	39,8	73,0	124,8
Overall	42,3	76,8	133,6
Fruit juice			
Male	4,5	9,1	16,7
Female	5,5	11,1	20,3
Overall	5,0	10,1	18,6
Total of SSBs and fruit juice			
Male	49,4	89,9	159,5
Female	45,3	84,1	145,1
Overall	47,3	86,9	152,1
Aggregate consumption (million litres per year)			
Sugar-sweetened beverages	1223	2219	3861
Fruit juice	144	293	536
Total of SSBs and fruit juice	1367	2512	4397

Source: Singh *et al*. (2015).

Currently, soft drinks in Kenya are subject to a flat excise tax of 10 KES per litre. Based on the ‘lower bound’ scenario, government revenue from this source (for SSBs and fruit juices only) should be 13.7 billion KES (i.e., 1.367 billion litres x 10 KES/litre), if all the taxes are collected. The revenue should increase to 25 billion KES in the ‘mean’ scenario and to nearly 44 billion KES in the ‘upper bound’ scenario. This revenue data is not available to us, but it would certainly provide some guidance as to which consumption figures are roughly correct.

In Table 7 we decompose the retail prices of SSBs and fruit juice into their tax- and non-tax components. Because of the uncertainty about the actual size of the SSB and juice market, we have not calculated the retail prices as weighted averages, but rather present roughly indicative prices, as they are advertised on a number of retail websites. These prices therefore represent only formal outlets.

Table 7 Decomposition of the retail price of SSBs and fruit juice in the baseline scenario

Decomposition of the retail price (per litre)	*SSBs*	*Juice*
Net-of-tax price	76,21	162,41
Existing excise tax	10,00	10,00
VAT	13,79	27,59
Average retail price	100,00	200,00

Source: Kenya National Bureau of Statistics.

Since the ultimate aim of an SSB tax is to reduce the prevalence of overweightness and obesity, we present estimates of these two measures in tables 8 and 9. Since there are substantial sex and age differences in overweightness and obesity, we present separate estimates for males and females, and for four different age categories.

Table 8 Baseline estimates for overweightness and obesity in Kenya

	Overweight (BMI > 25 kg/m^2 and < 30 kg/m^2)		**Obese (BMI > 30 kg/m^2)**	
Prevalence percentage	*Males (%)*	*Females (%)*	*Males (%)*	*Females (%)*
Age group				
15-29	16,7%	29,8%	0,7%	2,3%
30-44	29,8%	48,9%	5,3%	13,2%
45-59	31,6%	54,9%	6,3%	17,7%
60+	22,6%	46,2%	2,4%	9,4%
Weighted average	23,3%	40,6%	3,1%	8,4%
Number of people	*Males (mill.)*	*Females (mill.)*	*Males (mill.)*	*Females (mill.)*
Age group				
15-29	1,10	2,06	0,05	0,16
30-44	1,25	2,10	0,22	0,57
45-59	0,66	1,15	0,13	0,37
60+	0,27	0,69	0,03	0,14
Total	3,28	6,01	0,43	1,24

Source: constructed using base data from Aryeetey, Lartey, Marquis, Nti, Colecraft and Brown 2017; STEPwise, 2015 data; and Mkuu, Barry, Yonga, Nafukho, Wernz, Gilreath, Chowdhury and Harvey 2021.

6.2 Simulation results

For both simulations presented below we assume that the price elasticity of demand is -1.1 for SSBs and -1.2 for fruit juices. These estimates are in line with the international literature (Escobar *et al*. 2013; Stacey *et al*. 2017; and Saxena *et al*. 2019). We assume that there is full pass-through of the excise tax (although the model can handle over- and under-shifting). We also assume that the existing beverage excise tax of 10 KES per litre and the VAT rate of 16 per cent remain unchanged.

SSBs and fruit juices are substitutes, which means that an increase in the price of one increases the demand for the other. To incorporate these effects into the model, the user can set the value of the cross-price elasticities: one for the impact of SSB price changes on the demand for fruit juice and the other for the impact of fruit juice price changes on the demand for SSBs. We are not aware of Kenya-specific estimates of such cross-price elasticities, but have assumed that the value for the two elasticities is 0.1, which is similar to other low-to-middle-income countries (Chacon, Paraje, Barnoya and Chaloupka 2018 and Nor, Thinng, Veerman, Ibrahim, Mohamad and Ibrahim 2021). Should the users feel that this understates the substitution effects, they can simply increase them and run the model again.

6.3 Decomposing the retail price of SSBs and fruit juices

In tables 9 and 10 the simulated results for the different components of the retail price of SSBs and fruit juice are shown for the two tax scenarios. The underlying assumptions, as discussed previously, are shown at the bottom of each table. Had there been no product reformulation, the additional excise tax per litre would have been 30 KES/litre for both SSBs and fruit juices in scenario 1 and 36 KES/litre, again for both products, in scenario 2. However, because of hypothesised differences in the degree of product formulation between the two scenarios, the increases in tax and price in scenario 2 are less pronounced than in scenario 1. It is important to note that these are *hypothesised* differences in product formulation, based on the experiences of other countries; reality might differ if and when a sugar-based excise tax is imposed in Kenya.

Table 9 Simulated change in the retail price of SSBs and fruit juice, scenario 1

Decomposition of the retail price (per litre)	*SSBs*	*Juice*
Net-of-tax price	76,21	162,41
Existing excise tax	10,00	10,00
New excise tax	19,50	25,50
VAT	16,91	31,67
Average retail price	122,62	229,58
Percentage change in the retail price	23%	15%

Assumptions: All sugar is taxed at a rate of 0.3 KES/gram; full pass-through of the tax; reformulation reduces sugar content in SSBs by 35% and in fruit juices by 15%.

Table 10 Simulated change in the retail price of SSBs and fruit juice, scenario 2

Decomposition of the retail price (per litre)	*SSBs*	*Juice*
Net-of-tax price	76,21	162,41
Existing excise tax	10,00	10,00
New excise tax	12,00	24,00
VAT	15,71	31,43
Average retail price	113,92	227,84
Percentage change in the retail price	14%	14%

Assumptions: First 4 grams/100 ml are not subject to excise tax. Beyond the threshold, sugar is taxed at a rate of 0.6 KES/gram; full pass-through of the tax; reformulation reduces sugar content in SSBs by 40% and in fruit juices by 20%.

6.4 Impact of a price change on consumption

An increase in the retail prices of SSBs and fruit juice is expected to decrease the consumption of these two products, in line with the law of demand. In tables 11 and 12 we repeat the baseline consumption figures (as shown in Table 6), and show the simulated per capita consumption estimates after the tax is imposed for the two different scenarios. In the first scenario (where the tax is imposed at a rate of 0.3 KES per gram, with no threshold, and product reformulation is expected to decrease the sugar content of SSBs by 35 per cent and of fruit juices by 15 per cent), the per capita consumption of SSBs is expected to decrease by 20 per cent as a result of the tax-induced increase in the retail price. We only indicate the percentage change for ‘mean’ consumption, as defined by Singh and colleagues, because the percentage changes for the ‘lower bound’ and ‘upper bound’ are nearly identical. Fruit juice consumption is expected to decrease by about 25 per cent, primarily because the demand for fruit juice is hypothesised to be somewhat more price elastic and because more people who currently consume fruit juice are hypothesised to switch from fruit juice to SSBs than the other way around.

Table 11 Consumption analysis, scenario 1

	Baseline			After the tax change			Perc. change
	Lower bound	*Mean*	*Upper bound*	*Lower bound*	*Mean*	*Upper bound*	*Mean*
Per capita consumption (litres per year)							
Sugar-sweetened beverages							
Male	44,9	80,7	142,8	36,1	64,5	114,7	-20%
Female	39,8	73,0	124,8	32,0	58,7	100,2	-20%
Overall	42,3	76,8	133,6	34,0	61,5	107,3	-20%
Fruit juice							
Male	4,5	9,1	16,7	3,3	6,8	12,4	-26%
Female	5,5	11,1	20,3	4,1	8,3	15,4	-25%
Overall	5,0	10,1	18,6	3,7	7,6	14,0	-25%
Total of SSBs and fruit juice							
Male	49,4	89,9	159,5	39,4	71,3	127,2	-21%
Female	45,3	84,1	145,1	36,1	67,0	115,6	-20%
Overall	47,3	86,9	152,1	37,7	69,1	121,3	-20%
Aggregate consumption (million litres per year)							
Sugar-sweetened beverages	1223	2219	3861	982	1783	3101	-20%
Fruit juice	144	293	536	108	219	403	-25%
Total of SSBs and fruit juice	1367	2512	4397	1090	2002	3504	-20%

Assumptions: All sugar is taxed at a rate of 0.3 KES/gram; full pass-through of the tax; reformulation reduces sugar content in SSBs by 35% and in fruit juices by 15%. Price elasticity of demand for SSBs = -1.1 and for fruit juice = -1.2. Cross-price elasticities = 0.1.

In Table 12 the consumption analysis for scenario 2 is presented. In scenario 2 the first 4 grams per 100 ml of beverage are not taxed; sugar in excess of the threshold amount is taxed at 0.6 KES/gram, and because of product reformulation sugar content in SSBs is hypothesised to reduce by 40 per cent and in fruit juice by 20 per cent. Because the price changes in scenario 2 are substantially smaller than in scenario 1, it should come as no surprise that the decrease in consumption is also substantially smaller. SSB consumption is expected to decrease by 13 per cent and fruit juice consumption is expected to decrease by about 18 per cent.

Table 12 Consumption analysis, scenario 2

	Baseline			After the tax change			Perc. change
	Lower bound	*Mean*	*Upper bound*	*Lower bound*	*Mean*	*Upper bound*	*Mean*
Per capita consumption (litres per year)							
Sugar-sweetened beverages							
Male	44,9	80,7	142,8	39,1	70,0	124,4	-13%
Female	39,8	73,0	124,8	34,7	63,6	108,7	-13%
Overall	42,3	76,8	133,6	36,9	66,7	116,4	-13%
Fruit juice							
Male	4,5	9,1	16,7	3,6	7,4	13,6	-19%
Female	5,5	11,1	20,3	4,5	9,1	16,8	-18%
Overall	5,0	10,1	18,6	4,1	8,3	15,2	-18%
Total of SSBs and fruit juice							
Male	49,4	89,9	159,5	42,8	77,4	138,0	-14%
Female	45,3	84,1	145,1	39,2	72,7	125,5	-14%
Overall	47,3	86,9	152,1	40,9	75,0	131,6	-14%
Aggregate consumption (million litres per year)							
Sugar-sweetened beverages	1223	2219	3861	1065	1934	3363	-13%
Fruit juice	144	293	536	118	240	440	-18%
Total of SSBs and fruit juice	1367	2512	4397	1183	2173	3804	-13%

Assumptions: First 4 grams/100 ml are not subjected to excise tax. Above this threshold, sugar is taxed at a rate of 0.6 KES/gram; full pass-through of the tax; reformulation reduces sugar content in SSBs by 40% and in fruit juices by 20%. Price elasticity of demand for SSBs = -1.1 and for fruit juice = -1.2. Cross-price elasticities = 0.1.

6.5 Fiscal and industry effects

The imposition of a sugar-based beverage tax would be expected to have positive fiscal effects, and negative impacts on the SSB and fruit juice industries. In tables 13 and 14 we quantify the likely impact of the two scenarios. In both scenarios the industry's net-of-tax revenue (turnover) is expected to decrease by roughly the same percentage as the decrease in the quantity.[3] This is to be expected because we assume full pass-through of the tax; the net-of-tax price is assumed not to change.

The model indicates that the introduction of a sugar-based beverage tax, on top of the existing excise tax, is expected to increase excise tax revenue by 140 per cent in scenario 1 and by just over 100 per cent in scenario 2. In absolute terms, the increase in the excise tax revenue is greater, the greater the volume of SSB and fruit juice consumed is at the outset (i.e., the upper bound), but in percentage terms the fiscal impact is the same for the different levels of consumption at the baseline.

In both scenarios, VAT revenue is expected to decrease slightly, because total turnover is expected to decrease as the price increases. The decrease in total turnover is driven by the

3 The decrease in revenue is slightly more than the overall decrease in the volume of beverage, because the volume of the more expensive fruit juice is expected to decrease by a slightly larger percentage than the volume of the less expensive SSBs.

fact that the price elasticity estimates used in the models fall in the inelastic range for both SSBs and fruit juices.

Table 13 Quantity and fiscal effects, scenario 1

Baseline	*Lower bound*	*Mean*	*Upper bound*
Quantity (million litres)	1367	2512	4397
Net-of-tax revenue (billion KES)	117	217	381
Excise taxes (billion KES)	14	25	44
Additional excise tax (billion KES)	0	0	0
VAT (billion KES)	21	39	68
Total expenditure (billion KES)	151	280	493
After the tax is imposed			
Quantity (million litres)	1090	2002	3504
Net-of-tax revenue (billion KES)	92	171	302
Excise taxes (billion KES)	11	20	35
Additional excise tax (billion KES)	22	40	71
VAT (billion KES)	20	37	65
Total expenditure (billion KES)	145	269	473
Percentage change			
Quantity	-20%	-20%	-20%
Net-of-tax revenue	-21%	-21%	-21%
Excise tax revenue	140%	140%	141%
VAT	-4%	-4%	-4%
Total expenditure	-4%	-4%	-4%

Table 14 Quantity and fiscal effects, scenario 2

Baseline	*Lower bound*	*Mean*	*Upper bound*
Quantity (million litres)	1367	2512	4397
Net-of-tax revenue (billion KES)	117	217	381
Excise taxes (billion KES)	14	25	44
Additional excise tax (billion KES)	0	0	0
VAT (billion KES)	21	39	68
Total expenditure (billion KES)	151	280	493
After the tax is imposed			
Quantity (million litres)	1183	2173	3804
Net-of-tax revenue (billion KES)	100	186	328
Excise taxes (billion KES)	12	22	38
Additional excise tax (billion KES)	16	29	51
VAT (billion KES)	20	38	67
Total expenditure (billion KES)	148	275	483
Percentage change			
Quantity	-13%	-13%	-13%
Net-of-tax revenue	-14%	-14%	-14%
Excise tax revenue	101%	102%	102%
VAT	-2%	-2%	-2%
Total expenditure	-2%	-2%	-2%

The bottom line of the quantity and revenue analysis is that the fiscus will benefit from a sugar tax. However, relative to other revenue sources, the additional revenue from this source will always be modest, simply because the SSB industry in Kenya is not very large.

6.6 Per capita beverage-based sugar consumption

In the following step we compare the volume of beverage-based sugar consumed in the baseline with the volumes of beverage-based sugar consumed in the two scenarios after the SSB tax is imposed. Per capita beverage-based sugar is the per capita annual volume of beverage consumed, multiplied by the sugar content of the beverages. For the baseline we assume that the sugar content for SSBs and fruit juice is 10 grams per 100 ml. After the imposition of the sugar-based excise tax, the quantity of sugar is decreased through two channels: (1) a decrease in the consumption of SSBs and fruit juices, and (2) a decrease in the sugar content of these two products through product reformulation. The first channel is the demand response; the second is the supply response. The results are shown in Table 15. The first third of the table presents the estimated per capita sugar consumption in the baseline. The second third of the table indicates the simulated results for scenario 1 and the last third indicates the simulated results for scenario 2.

Table 15 Beverage-based sugar consumption (kg per person per year) in the baseline scenario and the two tax scenarios

	Lower bound	*Lower bound*	*Mean*	*Mean*	*Upper bound*	*Upper bound*
Baseline						
Age group	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
15-29	6,40	5,90	10,62	10,97	18,91	19,07
30-44	4,41	4,05	7,11	7,49	12,41	12,74
45-59	2,97	2,77	4,69	5,09	8,20	8,70
60+	2,22	2,07	3,37	3,91	6,00	6,76
Weighted average	4,94	4,53	8,07	8,41	14,28	14,51
After the tax is imposed	***Scenario 1***					
Age group	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
15-29	3,40	3,15	6,23	5,88	11,12	10,25
30-44	2,35	2,17	4,24	4,03	7,45	6,88
45-59	1,59	1,50	2,89	2,76	5,10	4,73
60+	1,19	1,13	2,19	2,14	3,92	3,71
Weighted average	2,63	2,43	4,79	4,52	8,52	7,82
Percentage change						
Weighted average	*-47%*	*-46%*	*-41%*	*-46%*	*-40%*	*-46%*
After the tax is imposed	***Scenario 2***					
Age group	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
15-29	3,41	3,17	6,25	5,91	11,16	10,30
30-44	2,36	2,19	4,26	4,05	7,48	6,92
45-59	1,60	1,51	2,91	2,78	5,13	4,76
60+	1,20	1,14	2,20	2,16	3,94	3,74
Weighted average	2,64	2,44	4,82	4,55	8,55	7,87
Percentage change						
Weighted average	*-47%*	*-46%*	*-40%*	*-46%*	*-40%*	*-46%*

In the baseline the average annual ‘mean’ consumption of beverage-based sugar is 8.07 kg [4.94 kg; 14.28 kg] for males and 8.42 [4.53 kg; 14.51 kg][4] for females. After the tax is imposed, beverage-based sugar consumption is expected to decrease by about 40 per cent [47 per cent; 40 per cent] among males and by about 46 per cent [46 per cent; 46 per cent] among females, for both scenarios 1 and 2. The fact that the decrease in consumption for the two scenarios is so similar is purely coincidental. For scenario 1, the decrease in consumption is driven more by a decrease in consumption of the beverage (i.e., a demand response), while in scenario 2, it is driven slightly more by the reformulation of the product (i.e., a supply response).

Because the decrease in beverage-based sugar consumption for the two tax scenarios is nearly identical, in the subsequent analysis, where we estimate the impact of the decrease on the average BMI and the percentage of people who are overweight and obese, we only consider the tax changes of scenario 1. Had we done the analysis for the tax situation in scenario 2, the results would have been indistinguishable.

4 The first number in the square brackets indicates the lower bound and the second number indicates the upper bound. This convention will be used throughout the report.

6.7 The impact on BMI, overweightness, and obesity

A decrease in sugar consumption would be expected to decrease a person's body mass, holding all other things constant. This relationship is based on the dietetics literature. Our reading of that literature is that, in order to reduce the BMI by one unit (i.e., 1 kg/m^2), a person should permanently reduce their sugar consumption by 10 kg per year (see references in the Introduction). This parameter in the model can be changed for each of the eight gender-age groups. Thus, should more disaggregated and/or more accurate data on this relationship become available, the user of the model can improve the model's ability to predict the impact of a change in beverage-based sugar consumption on average BMI.

In Table 16 we indicate the baseline numbers for the average BMI values, broken down by gender and age group, and the new simulated average BMI values after the tax has been implemented.

Table 16 Baseline and simulated BMI values

Age group	*Baseline Male*	*Baseline Female*	*Lower bound Male*	*Lower bound Female*	*Mean Male*	*Mean Female*	*Upper bound Male*	*Upper bound Female*
Average BMI								
15-29	21,71	23,20	21,41	22,93	21,27	22,69	20,93	22,32
30-44	22,56	24,87	22,35	24,68	22,27	24,52	22,06	24,28
45-59	22,72	25,59	22,58	25,46	22,54	25,36	22,41	25,19
60+	21,92	24,61	21,82	24,52	21,80	24,43	21,71	24,30
Weighted average	22,13	24,17	21,90	23,96	21,80	23,78	21,56	23,50

Unsurprisingly, the reduction in beverage-based sugar consumption reduces the average BMI across all age and gender categories. The decrease is generally larger among younger people than older ones, simply because SSB and fruit juice consumption is higher among the young in the baseline scenario. The imposition of an excise tax on SSBs and fruit juices will decrease younger people's consumption by a greater absolute amount than that of older people.

Using the data in Table 16, together with the standard deviation of BMI for each gender-age group (not shown, but one of the inputs to the model), one can estimate the percentage of people who are overweight (BMI > 25 kg/m^2 but < 30 kg/m^2) and obese (BMI ≥ 30 kg/m^2). The assumption is that BMI is normally distributed.

The percentages of the population who are either overweight or obese are shown in Table 17, and the changes (expressed in percentage points) are shown in Table 18. The baseline numbers indicate that overweightness and obesity are more prevalent among females than males, a point that was made in Table 2 as well. The prevalence of overweightness and obesity tends to increase with age, although there is a slight decrease among people aged 60 and older.

The model predicts that a decrease in beverage-based sugar consumption will decrease the prevalence of overweightness among males from 20.2 per cent to 18.3 per cent [18.9 per cent; 16.9 per cent], i.e., a decrease of 1.9 [1.4; 3.3] percentage points, and among females from 32.2 per cent to 29.6 per cent [30.8 per cent; 27.7 per cent], i.e., a decrease of 2.6 [1.4; 4.5] percentage points. The prevalence of obesity among males is predicted to decrease from 3.1 per cent to 2.7 per cent [2.8 per cent; 2.4 per cent], i.e., a decrease of 0.4 [0.3; 0.6] percentage points, and among females from 8.4 per cent to 7.4 per cent [7.9 per cent; 6.8 per cent], i.e., a decrease of 1.0 [0.6; 1.7] percentage points.

Table 17 Percentage of people overweight and obese in the baseline and the simulation

Age group	*Baseline Male*	*Baseline Female*	*Lower bound Male*	*Lower bound Female*	*Mean Male*	*Mean Female*	*Upper bound Male*	*Upper bound Female*
Percentage of people overweight (BMI ≥ 25 kg/m2 and <30 kg/m2)								
15-29	15,9%	27,6%	14,0%	25,2%	13,1%	23,3%	11,2%	20,3%
30-44	24,5%	35,7%	23,4%	34,9%	23,0%	34,2%	21,9%	33,1%
45-59	25,3%	37,2%	24,6%	36,8%	24,4%	36,5%	23,8%	36,0%
60+	20,2%	36,8%	19,6%	36,2%	19,5%	35,8%	19,0%	35,0%
Weighted average	20,2%	32,2%	18,9%	30,8%	18,3%	29,6%	16,9%	27,7%
Percentage of people obese (BMI ≥ 30 kg/m2)								
15-29	0,7%	2,3%	0,6%	1,9%	0,5%	1,6%	0,4%	1,2%
30-44	5,3%	13,2%	4,8%	12,3%	4,6%	11,6%	4,2%	10,6%
45-59	6,3%	17,7%	6,0%	17,0%	5,9%	16,5%	5,5%	15,6%
60+	2,4%	9,4%	2,3%	9,1%	2,3%	8,7%	2,2%	8,2%
Weighted average	3,1%	8,4%	2,8%	7,9%	2,7%	7,4%	2,4%	6,8%

The prevalence of overweightness (not obesity) is expected to decrease most among young adults (age 15-29), while the prevalence of obesity is expected to decrease most among people in the 30-59 age group.

Table 18 Changes in the percentage of people overweight and obese as a result of the intervention

Age group	*Lower bound Male*	*Lower bound Female*	*Mean Male*	*Mean Female*	*Upper bound Male*	*Upper bound Female*
Percentage of people overweight (BMI ≥ 25 kg/m2 and <30 kg/m2)						
15-29	-1,9%	-2,3%	-2,8%	-4,3%	-4,7%	-7,2%
30-44	-1,1%	-0,8%	-1,5%	-1,5%	-2,6%	-2,5%
45-59	-0,7%	-0,4%	-0,9%	-0,7%	-1,5%	-1,2%
60+	-0,6%	-0,5%	-0,7%	-1,0%	-1,2%	-1,8%
Weighted average	-1,4%	-1,4%	-1,9%	-2,6%	-3,3%	-4,5%
Percentage of people obese (BMI ≥ 30 kg/m2)						
15-29	-0,2%	-0,4%	-0,2%	-0,7%	-0,4%	-1,1%
30-44	-0,5%	-0,9%	-0,6%	-1,5%	-1,1%	-2,5%
45-59	-0,4%	-0,7%	-0,5%	-1,2%	-0,8%	-2,1%
60+	-0,1%	-0,4%	-0,2%	-0,7%	-0,3%	-1,2%
Weighted average	-0,3%	-0,6%	-0,4%	-1,0%	-0,6%	-1,7%

7 Discussion, recommendations and conclusion

This study provides the first evidence about the impact of a sugar-based excise tax on beverage consumption in Kenya. Currently, Kenya imposes an excise tax on soft drinks of 10 KES per litre. The aim of the tax is to generate revenue. It would be inappropriate to call the current excise tax a ‘health tax’ for two reasons: (1) it is levied on all soft drinks and is not specifically focused on sugar-sweetened beverages, and (2) the structure of the excise tax does not create any incentives for producers to reformulate their products to contain less sugar.

To the extent that the Government of Kenya wishes to reduce the consumption of soft drinks (irrespective of whether they contain sugar or not), the current excise tax structure supports this policy. Thus, even though the current tax regime might not meet the criteria of a ‘health tax’, it certainly supports public health. Should the government increase the excise tax amount, the effect of the current tax regime would be enhanced.

Imposing an excise tax on SSBs, *specifically to enhance public health*, is gaining increasing traction around the world. Currently, no country in East Africa has a sugar-based or calorie-based SSB excise tax. South Africa introduced the Health Promotion Levy (HPL) in 2018. This is an excise tax that is levied on the sugar content of SSBs. When the HPL was introduced, the excise tax burden averaged between 10 per cent and 15 per cent of the retail price for most SSBs. However, over time the average tax burden has decreased as producers have been able to reduce the absolute amount of the tax through product reformulation. As a result, the amount of tax revenue has also decreased from about 3.20 billion R (about 230 million USD at the time) in the 2018/19 financial year, to a budgeted amount of 2.15 billion R (about 145 million USD at the time) in the 2021/22 financial year. As the HPL was explicitly levied as a health tax, rather than a source of revenue, this decrease in revenue should be cause of celebration, rather than concern, because it shows that the excise tax is effective in getting producers to reduce the sugar content of their products.

In January 2014 Mexico introduced a 1-peso-per-litre SSB excise tax (equivalent to a 10 per cent price increase). This tax did not target the sugar content specifically, and thus did not create incentives for producers to reformulate their products. Nevertheless, the excise tax resulted in a 12 per cent reduction in purchases of taxed SSBs, within one year of the tax being implemented (Colchero, Popkin, Rivera and Ng 2016). Similarly, France saw a 6.7 per cent decline in the demand for soda in the first two years after a tax of 11 Eurocent per 1.5-litre of SSBs was introduced (Ecorys 2014).

In this report we present a model that policymakers in Kenya can use to determine the possible impact of a sugar-based SSB tax on SSB prices, SSB consumption, and excise tax revenues. The model is a set of relationships that have their foundations in mathematics, economics, and medical science. The parameters of the model are set by the user. Furthermore, the user can set the nature (within limits) and level of the proposed excise tax. The responses by the SSB industry, both in how they pass the excise tax through to the final user and how they are predicted to reduce the sugar content, are variable and can be set by the user. The Excel-based model is an integral part of this report and readers are encouraged to get acquainted with the model. Where readers and users of the model disagree with the assumptions that we used in this paper, we encourage them to change these assumptions in the Excel model, and see how these changed assumptions influence the results.

Should Kenya decide to implement a sugar-based SSB tax, the model indicates that it would increase the retail price of these products, reduce their consumption, and generate revenue. In the absence of compensatory behaviour, the reduced consumption of SSBs is expected to reduce the average body mass index across all gender and age groups and, as a result, the percentage of people who are classified as either overweight or obese is expected to decrease. The magnitude of the decrease in overweightness and obesity rates greatly depends on the magnitude of the tax and of the parameters in the model.

While the model indicates these positive public health outcomes, we want to emphasise that an SSB tax is not an instant cure for the growing obesity epidemic in Kenya. At most, the impact of an SSB tax is modest. Furthermore, as we indicated in section 4, it is possible that the data we used to calculate the baseline consumption figures might overstate the true consumption of SSBs and fruit juices. If that is the case, then the effect of a sugar-based SSB tax on reducing overweightness and obesity might be overstated.

Obesity is a multifaceted phenomenon, that straddles nutrition, exercise and movement, and perceptions. For most people, the contribution of SSBs to their total intake of sugar and/or other unhealthy foods is small.

However, that does not mean that policymakers should throw up their hands and do nothing because the problem is perceived to be too big. Our model clearly shows that an SSB excise tax can reduce the prevalence of overweightness and obesity. Furthermore, there is a general understanding internationally that an SSB tax is ‘low-hanging fruit’ in the fight against obesity. Once an SSB tax has been implemented, it would make sense to target other sugary and/or unhealthy products.

The technicalities of a sugar-based SSB tax are beyond the scope of this report, even though we have alluded to some of these. For example, the decision as to which beverages should be subject to the tax and which should not is largely a political decision, even though from a health perspective it is useful to throw the net as wide as possible. Similarly, whether the tax should have a tax-free threshold or not can be argued either way. But before the technicalities can be discussed there needs to be an in-principle decision about such a tax. This is a political decision.

Our recommendation is simple: policymakers and pro-health groups should seriously consider the introduction of a sugar-based SSB tax in Kenya. It is likely to reduce the prevalence of overweightness and obesity in the country, and will be a source of revenue for the country.

Appendices

Appendix 1 Technical aspects related to the SSB model

Currently, SSBs in Kenya are subject to VAT and a specific excise tax of 10 KES per litre. The current excise tax is imposed irrespective of the sugar content of the beverage. In order to reduce the sugar consumption of the population through both the demand and supply sides, we present a model where the excise tax is dependent on the amount of sugar in the beverage, not just the volume of the beverage.

The model is based on the following key assumptions:

The model consists of an initial baseline equilibrium (the current state), from which we model the impact of an excise tax. The excise tax is a calorie-based tax, in that it taxes the sugar content in the beverage, rather than the volume of the beverage. In line with experiences in countries like South Africa, the model allows a threshold amount of sugar (per 100 ml) to be exempt from the SSB tax. The model allows for different tax rates and for different thresholds.

The tax affects the *demand* for the product through its impact on the price. Given that the proposed tax in the model is levied on the sugar content (not just the volume of the beverage, irrespective of sugar content) the tax could also affect the *supply* side, by reducing sugar content through product reformulation. If the SSB industry responds to the excise tax by reformulating the product, this is predicted to result in bigger health effects.

The demand and supply responses are partially informed by the research literature, other countries' estimates of the price and cross-price elasticities, and engagements with key Kenyan decision-makers.

BMI, for each of the two gender and four age groups, is assumed to be normally distributed. An inspection of histograms for BMI for each gender and age group suggests that this is a reasonable assumption. Each gender and age group's BMI has a different mean and standard deviation. The model takes account of these gender and age differences.

We do not expect the excise tax on SSBs to have a significant impact on the illicit or unrecorded trade in these products. The model does not account for such eventualities.

We model the effect of an SSB tax in a once-off policy change scenario.

Below we discuss some of the technical issues in the model.

i. The impact of a tax change on the price

An increase in the excise tax is expected to increase the retail price. The degree to which this will increase the retail price depends on the industry's price response. In our model the user can change the net-of-tax (NOT) price upwards (if there is over-shifting of the tax), downwards (if there is under-shifting) or keep it the same (if there is full tax pass-through). If the retail price in the base period is represented as:

$$RP_{baseline} = (NOTP_{baseline} + EX_{baseline})(1 + VAT_{baseline}),$$

the retail price, after the excise tax has been imposed and the SSB industry has increased the NOT price by $100\ \alpha$ per cent, will be represented as:

$$RP_{new} = [NOTP_{baseline}(1 + \alpha) + EX_{baseline} + EX_{new}](1 + VAT_{baseline})$$

Note that alpha can be negative (if the tax is under-shifted), positive (if the tax is over-shifted), or zero (if there is full tax pass-through).

ii. Impact of price on consumption

The price elasticities are the estimates of the percentage change in consumption in a particular product when the price of that product (in the case of the own-price elasticity) or the price of another product (in the case of the cross-price elasticity) changes by 1 per cent. Such estimates can be obtained using Kenyan data (if the data is available and allows one to estimate the elasticities), taken from the international literature, or they can be assumed.

a. Own-price elasticity

In the basic theory of economics, two mathematical derivations for the price elasticity are typically used. The *point elasticity* considers the impact of a very small change in the price of the product on the quantity demanded of that product. In the extreme, it is the derivative of the (inverse of the) demand curve, multiplied by the quantity and divided by the price at that point. For product x, for example, this is represented as follows:

$$\varepsilon_{,} P_x = \frac{dq_x}{dp_x} \times \frac{p_x}{q_x}$$

Where p_x and q_x are the price and the consumed quantity of product x, respectively.

For larger changes in price, the point elasticity formulation is inappropriate. For example, if the price elasticity is -0.6 and the price increases by 200 per cent, the point elasticity formulation would suggest that consumption would decrease by 120 per cent. Decreases of more than 100 per cent are mathematically impossible. To resolve such potential problems, we use the midpoint or arc formulation of the price elasticity of demand. The formula for this specification is:

$$Arc\ \varepsilon_d = \frac{Q_2 - Q_1}{Midpoint\ Q} \div \frac{P_2 - P_1}{Midpoint\ P}$$

Where P_1 is the price at baseline, P_2 is the new price, Q_1 is the quantity at baseline and Q_2 is the new quantity. In real-world situations the price change can be substantial. Thus, for the model we use the midpoint formulation of the price elasticity.

b. Cross-price elasticity

Unlike the own-price elasticity, the cross-price elasticity measures how consumption of a good changes when the price of *another* good changes. Cross-price elasticities quantify the substitution effect if prices of different products change. As with the (own) price elasticity, the cross-price elasticity can be mathematically specified in either point and midpoint (or arc) form. We use the midpoint specification for this model.

In principle, if there are *n* categories of SSBs and non-SSBs, there are *(n-1)* possible cross-price elasticities. For each pair of products, there are two cross-price elasticities, i.e., the impact of a change in the price of product X on the consumption of product Y, and the impact of a change in the price of product Y on the consumption of product X. In most cases the cross-price elasticity is positive, as most beverages are substitutes, rather than complements. If the price of product X increases, the demand for most other products would increase, all other factors held constant. If the demand for a product is unaffected by a price change in another product, the cross-price elasticity will be zero.

In a model with very many categories of product, the number of cross-price elasticities will be so large as to become meaningless. In such a case, it would be more useful to set most of the cross-price elasticities equal to zero and to focus on the main relationships only.

However, where the number of categories is small, as is the case in the model that we present in this paper, it makes logical sense to include the cross-price elasticities in the model, because the results are more tractable.

iii. Income elasticity

While the price elasticity gets the most attention in analyses like these, because the change in the price is the mechanism through which behaviour is affected, the demand for the product is also affected by changes in the average level of income. The demand for most products, including SSBs and non-SSBs, increases when households' average levels of income increase. The income elasticity of demand quantifies this effect. The income elasticity of demand indicates by what percentage the consumption of the product changes in response to a 1 per cent increase in income.

For short-term (e.g., one-year once-off) analyses, it is relatively unimportant to consider the impact of income changes, but for longer-term analyses it becomes increasingly important to include the effect of income changes. Often the income effect is approximated by the change in per capita GDP.

iv. Consumption

The user needs to have data on the quantity of each SSB and non-SSB category consumed in the base period, ideally subdivided into gender and age groups. One can still do the analysis with aggregate consumption figures (broken down by category, but not by gender or age groups), but one loses precision in the process.

It seems likely that some groups (e.g., poorer or younger groups) may have different price and cross-price elasticities than other groups. Empirical evidence from other countries suggests that this is the case (Briggs, Mytton, Kehlbacher, Tiffin, Rayner and Scarborough 2013; Finkelstein, Zhen, Nonnemaker and Todd 2010; Finkelstein, Zhen, Bilger, Nonnemaker, Farooqui and Todd 2013; Basu, Vellakkal, Agrawal, Stuckler and 2014). However, to keep the analysis tractable, we do not add this extra layer of complexity to the model, given that it is already quite complex and that we do not have the empirical evidence for Kenya to include this in the analysis.

Once we have data on the base level of consumption, we first calculate the new level of consumption of each category of SSBs, taking into account the impact of the change in the own price (which we assume has changed as a result of the imposition of the tax and the SSB industry's pricing policy) and the change in income. To calculate the new level of consumption, we use the midpoint formulation of the price elasticity formula and re-arrange the formula to solve for Q_{New}. This is then adjusted by the impact of the change in GDP.

$$Q_{New} = Q_{Baseline}\left[1 + \varepsilon_P\left(\frac{RP_{New} - RP_{Baseline}}{RP_{Baseline} + RP_{New}}\right)\right] / \left[1 - \varepsilon_P\left(\frac{RP_{New} - RP_{Baseline}}{RP_{Baseline} + RP_{New}}\right)\right] * \left[1 + \varepsilon_I\left(\frac{GDP_{New} - GDP_{Baseline}}{0.5\,(GDP_{Baseline} + GDP_{New})}\right)\right]$$

Where Q refers to the quantity consumed, ε_P refers to price elasticity, ε_I refers to income elasticity, and RP refers to the income price.

In the second step, we quantify the impact of substitution effects, using the cross-price elasticities. Between any pair of SSB categories, we estimate the change in the consumption of one product as a result of a change in the price of another product. For each effect we use the following formula:

$$Q^X_{New} - Q^X_{Baseline} = Q^X_{Baseline}\left[2\,\varepsilon_{XY}\frac{(P^Y_{New} - P^Y_{Baseline})}{(P^Y_{New} + P^Y_{Baseline})}\right] / \left[1 - \varepsilon_{XY}\frac{(P^Y_{New} - P^Y_{Baseline})}{(P^Y_{New} + P^Y_{Baseline})}\right]$$

Where the superscripts X and Y refer to products X and Y, and where ε_{XY} is the cross-price elasticity of demand (defined as the percentage change in the quantity consumed of product X as a result of a 1 per cent change in the price of product Y). If the cross-price elasticity is positive (indicating that the products are substitutes), then $Q^X_{New} - Q^X_{Baseline}$ will be a positive value, i.e., an increase in the price of product Y will cause an increase in the consumption of product X.

One needs to account for the fact that if one product category (say X) 'gains' from the substitution effect because the price of a substitute product (say Y) is increasing, product Y would 'lose' consumption, over and above the loss of consumption experienced through the impact of the increase in the own price. For example, consider a scenario where the consumption of X and Y is 1000 units each (after the impact of the own-price changes have been taken into account), the price of product Y increases by 20 per cent, and the cross-price elasticity of demand between X and Y is 0.1 (i.e., demand for product X increases by 0.1 per cent for every 1 per cent increase in the price of Y). Given these numbers, the substitution effect associated with the price increase of Y results in an increase in the demand for product X of 1000 x 0.1 x 20/100 = 20 units. The model is programmed in such a way that the 20 unit increase in the consumption of X is a 20-unit decrease in the consumption of Y (after the impact of the change in the own price of Y is taken into account).

If one does not make this adjustment, then the total quantity of beverages consumed will become unrealistically large, as the cross-price elasticity effects would simply increase consumption of each drink category.

v. Fiscal impact

Recall that the excise tax that is being proposed is based on the sugar content of the beverage, rather than simply the volume of the beverage. The SSB industry is able to reformulate the product to contain less sugar, in order to reduce its tax liability. Furthermore, the excise tax on the sugar content can exempt the first X grams per 100 ml of beverage, as is the case in South Africa and some other countries. Thus, the total expected tax revenue from this source is the total volume of taxable grams of sugar, multiplied by the excise tax per gram of sugar.

For each SSB category, the model calculates the post-tax volume of the beverage, taking cognisance of the demand effects, i.e., the impact of the change in the price of that SSB category and the change in the price of other SSB categories. The model also considers the product reformulation response by the producers, where it is assumed that they are able to reduce the sugar content of their product by a certain percentage. The model then calculates the taxable amount of sugar by multiplying the new volume of the beverage by the new taxable sugar content (expressed in grams per litre). The new taxable sugar content is the post-tax actual sugar content, less the tax-exempted sugar content. The expected excise tax revenue is the post-tax volume of the beverage multiplied by the taxable sugar content, which is in turn multiplied by the excise tax per gram.

As an example, assume that the pre-tax volume of SSBs is 1 million litres, and the sugar content is 10 grams/100 ml (= 100 grams per litre). The tax is imposed at 5 KES per gram of sugar, but the first 4 grams/100 grams are exempted. Because of the tax-induced price effect, total consumption is assumed to decrease to 900 000 litres. The excise tax encourages the SSB industry to reformulate the product. As a result, the sugar content changes to 7 grams/100 ml. The taxable quantity is 7-4 = 3 grams/100 ml, or 30 grams/litre. The excise tax amount is 30 x 5 KES = 150 KES per litre of beverage. The total revenue expected is 900 000 litres x 150 KES/litre = 135 million KES.

vi. Health impact

We expect that the imposition of (or increase in) the SSB tax will result in an increase in the price of the product which in turn will result in a drop in SSB consumption. After all, that is the primary aim of the intervention. This decrease in SSB consumption, in turn, will result in a decrease in the mortality risks associated with SSB use. While the medical literature describes the negative health impact of SSBs in detail (in its effect on diabetes, heart and lung disease, oral health, etc.), we focus our attention on body mass index (BMI) as a proxy for the negative health consequences. More specifically, we focus on the percentage of people who are either overweight (BMI ≥ 25 kg/m^2 but < 30 kg/m^2) or obese (BMI ≥ 30 kg/m^2). The percentage of people who cross this threshold (i.e., from ≥ 25 kg/m^2 to < 25 kg/m^2 and from ≥ 30 kg/m^2 to <30 kg/m^2) will be regarded as the public health benefit from the intervention.

We assume that BMI for each age and gender group is normally distributed. While the literature suggests that the log of BMI is roughly normally distributed, the results indicate that, for the Kenyan data we work with, a normal distribution is a good approximation.

In order to link the change in SSB-based sugar consumption to a change in the BMI, we ask the following question: *how many kilograms of sugar (in SSBs) must an average person consume in a year to increase their BMI by 1 kg/m^2?* We assume that the reverse of this statement also applies, namely how many kilograms of sugar per year must an average person reduce their consumption by to reduce their BMI by 1 kg/m^2? We will use a rule of thumb drawn from a range of medical literature that an annual 10-kilogram decrease in sugar is required to reduce BMI by one unit (Briggs 2013; Crino, Sacks, Vandevijvere, Swinburn and Neal 2015; Hall, Sacks, Chandramohan, Chow, Wang, Gortmaker and Swinburn 2011).

Appendix 2 How to use the model

The model is programmed in Excel and consists of two main sheets: an Input sheet and an Output sheet. The third sheet presents the outputs in tables that can be copied and pasted into the Word report. The user can change all the parameters on the Input sheet. The user may not change any of the cells on the Output sheet. All the calculated numbers on the Output sheet are derived from the Input sheet. Readers can find the Excel model here.

The Input sheet

In the Input sheet a number of beverage categories are specified. In the current model two beverage categories are used: (1) SSBs and (2) fruit juice. This number of beverage categories was limited by the data obtained from Singh *et al*. (2015), our preferred data set. In principle, one can include many more SSB and even non-SSB categories if there is sufficiently credible data available for these beverage categories.

The population is subdivided into eight gender-age categories. For each gender, four age categories are identified, i.e., 15-29, 30-44, 45-59 and 60+. Children under the age of 15 years are not included in the model, primarily because their consumption quantities are not available. The size of the population in each gender-age category is obtained from official population statistics.

For each gender-age category, the model requires the user to indicate the average body mass index (BMI), as well as the standard deviation. This data is calculated from the Kenya STEPwise survey Dataset for Non-Communicable Diseases, 2015. For this model, we assume that, for each gender-age category, the BMI is distributed normally. From this one can derive the percentage of people in each gender-age category who are classified as overweight (BMI ≥ 25 kg/m^2 but < 30 kg/m^2) or obese (BMI ≥ 30 kg/m^2).

For each gender-age category, the annual per capita consumption of SSBs and fruit juice is included in the Input sheet. The Singh *et al*. (2015) data also includes consumption data for milk, but this is not included in the model, because it is not appropriate or politically feasible to tax milk. The Singh dataset presents three data points for the consumption of each beverage category: a 'mean', a 'lower bound' and an 'upper bound'. One can think of the 'mean' as the best guess estimate of consumption, based on the surveys and information that were available to the compilers of the Singh dataset. The lower bound and upper bound are self-explanatory. However, a comparison between the consumption numbers obtained from the Singh data (which is primarily based on survey data) and the consumption figures obtained from Euromonitor (which are primarily based on sales data) suggests that the 'lower bound' Singh data is closer to Euromonitor than the 'mean' or 'upper bound' data. In the spreadsheet we indicate all three sets of consumption data, obtained from Singh *et al*. (2015).

For each of the beverage categories, the model requires the following information. Note that all these parameters are the same for each gender-age category, i.e., the model does not allow the user to have different parameter estimates for the different gender-age categories. This is to prevent the model from becoming too complex and intractable.

1. **The average price per litre**: Initially we aimed to use Euromonitor data, but we subsequently looked online for prices sold in supermarkets. We found that there is a high degree of price variation, based on packaging type and outlet. We discussed this with members of the International Institute of Legislative Affairs (IILA) and agreed that an average price of 100 KES per litre of SSB and 200 KES per litre of fruit juice is roughly representative of prices of these two products.
2. **The average sugar content**: This is usually expressed as grams of sugar per 100 ml of the beverage. These values would be obtained from the legally-mandated

nutritional information shown on the packaging. For the baseline we used a value of 10 grams/100 ml for both SSBs and fruit juice.

3. **The own-price elasticity of demand**: This number indicates by what percentage the consumption of the beverage decreases if there is a 1 per cent increase in the price of the product. These estimates would ideally be estimated using local data, but our attempts to estimate these for Kenya were unsuccessful. However, there is a substantial international literature that has investigated this question, and the estimates are broadly similar, typically lying in the range between -0.8 and -2.0 for individual categories. We used an own-price elasticity of -1.1 for SSBs and -1.2 for fruit juice.
4. **The cross-price elasticity of demand between the different beverage categories**: The cross-price elasticity indicates by what percentage the demand for product X increases when the price of product Y increases by 1 per cent. Because SSBs and fruit juice are substitutes, the cross-price elasticity would be positive. These cross-price elasticities are seldom estimated in practice, and hardly ever in low- and middle-income countries. We wanted to account for these possible substitution effects, but did not want them to dominate the results, so we chose a conservative value of 0.1 for the impact of an SSB price change on the demand for fruit juice, and the same value for the impact of a fruit juice price change on the demand for SSBs.

The Input sheet also requires the user to provide parameters regarding the proposed excise tax, as well as how the industry is expected to respond, both in terms of the pricing and in terms of product reformulation.

1. **The excise tax structure**: International experience has shown that an excise tax that targets the sugar content (as is the case in South Africa and the UK), rather than simply the volume of the beverage, irrespective of the sugar content (as is the case in Mexico), creates an incentive for the manufacturers to reduce sugar content by reformulating the constituents of the product. This reaction by the manufacturers enhances the harm-reduction impact of the tax increase. The model is programmed to tax the quantity of sugar in the beverage, rather than the volume of the beverage. Furthermore, following the experience of South Africa and the UK, the model is programmed to exempt a beverage from taxation if the sugar content falls below a certain threshold. In South Africa the first 4 grams per 100 ml of beverage are exempted from the excise tax. For example, if a beverage has a sugar content of 10 grams per 100 ml, only 6 grams per 100 ml will be subject to the tax. In the model, the user can set the threshold value, which is defined as the number of grams per 100 ml of beverage. Furthermore, the user is required to specify the tax amount per gram of sugar above the exempted (threshold) amount. This is specified in KES per gram of sugar.
2. **Industry reformulation response**: As indicated in the previous paragraph, when an SSB tax is imposed, manufacturers have an incentive to reduce the sugar content of the taxed beverage, so as to reduce their tax liability. This is done through product reformulation. A recent study (Heneck 2021) found that, in South Africa, the sugar content of most SSBs has decreased sharply (by 50 per cent or more in most cases) after the SSB tax was implemented in 2018. To allow for this kind of response, the model allows the user to indicate, for each product category, by what percentage they expect the industry to reduce the sugar content. This percentage would be only a guess, but it should be informed by what has happened in other countries where an SSB tax has been introduced.
3. **Industry pricing response**: Before the sugar-based SSB tax is imposed, the retail price consists of the VAT amount (which is levied as a percentage on the net-of-tax price), the specific tax on soft drinks (at 10 KES per litre) and the net-of-tax price. One can determine the value of the net-of-tax price in the baseline by subtracting the two tax components (VAT and the specific tax on soft drinks) from the retail price. The model allows the user to change the net-of-tax price when the additional excise

tax is imposed. The usual assumption is that the industry does not change the net-of-tax price and the retail price increases by the amount of the excise tax and the VAT amount on the excise tax. This is known as full pass-through. In some cases (e.g., when there are substantial competitive pressures in the market) the industry might reduce the net-of-tax price in order to cushion the consumer against the excise tax increase. The retail price would typically increase, but by less than the amount of the excise tax. This is known as under-shifting the excise tax. In other instances (especially where the manufacturing industry is highly concentrated), the industry might increase the net-of-tax price when the excise tax is imposed. It might do so to maintain its profits, by increasing the profit per unit despite a decrease in the volume that it sells. This is known as over-shifting the excise tax. For each of the beverage categories, the user can enter the percentage change in the net-of-tax price.

Recalling that the primary aim of the excise tax is to improve health outcomes, we must link the change in SSB consumption to a change in the number of people who are either overweight or obese. This requires input from the dietetics literature. For each gender-age group, the user must indicate the reduction in SSB-based sugar (expressed in kilograms of sugar per year) that is required to reduce the BMI by 1 kg/m^2. From our reading of this literature, it seems that a 10 kg annual reduction in sugar will result in a permanent average decrease of 1 kg/m^2 in the BMI. We applied this parameter to each of the eight gender-age groups.

The Output sheet

The logic of the Output sheet is as follows. We start off by decomposing the retail price of the two beverage categories into tax and non-tax components. At the outset, the retail price is subdivided into a VAT component, an existing excise tax component, and a net-of-tax component. Recall that the excise tax is a specific tax, levied at 10 KES per litre, irrespective of the sugar content of the beverage. Once an additional (sugar-based) excise tax is implemented, this will change the retail price for each of the SSB categories. This is shown in the second block of the Output sheet.

As discussed in the previous section and in numerous places in the report, a well-thought-out excise tax will create an incentive for the beverage producer to reduce the sugar content of the beverage through product reformulation. Based on the excise tax per gram of sugar, and taking account of the tax-free threshold, and of the fact that the manufacturer is likely to reduce the sugar content of the beverage (as specified in the Input sheet), the model calculates the excise tax amount per litre for each of the two beverages.

The net-of-tax price will change, based on what the user believes is the most appropriate strategy that SSB manufacturers will adopt. The standard assumption is that the net-of-tax price remains unchanged, and that the excise tax is fully passed through to the consumer in the form of a higher retail price. However, the user of the model can allow the net-of-tax price to decrease (in the case of under-shifting) or to increase (in the case of over-shifting) by indicating the percentage change in the net-of-tax price in the Input sheet. These changes will pull through to the Output sheet.

A new retail price is calculated as the sum of the (new) net-of-tax price, the existing specific excise tax, the new sugar-based excise tax and the (new) VAT amount. The VAT amount is levied as the standard VAT percentage on the sum of the net-of-tax price and the two excise taxes.

For each beverage category the model calculates the percentage change in the retail price as a result of the imposition of the new sugar-based excise tax (and possible changes in the net-of-tax price). The imposition of the sugar-based excise tax will typically cause the price of the SSBs to increase, unless the manufacturers decrease the net-of-tax price by so large an amount that the industry fully absorbs the full excise tax increase, a situation which is very unlikely.

A change in the retail price of the various product categories influences the consumption of these products in two ways. Firstly, there is the own-price effect and, secondly, there is the cross-price (substitution) effect. For the first step, the model uses the own-price elasticities from the Input sheet to calculate the new quantity for each of the two product categories. For each product category, the quantity to which the effect of the price change is applied is the weighted average annual consumption, where the weights are determined by the gender-age composition. The model uses the so-called arc (or midpoint) formulation of the price elasticity formula to calculate the new quantity consumed for each beverage category.

The second step accounts for substitution effects. As discussed in the previous section, when the price of product X increases, it will have an impact on the consumption of other product(s). For example, if the price of SSBs increases, it will encourage people to drink less SSBs (the magnitude of which is captured in the own-price elasticity of demand), but to drink more fruit juice. The magnitude of this effect is captured in the cross-price elasticity. Cross-price elasticities will typically be positive because they are substitutes. If there is no relationship between two products, i.e., if an increase in the price of product X has no impact on the consumption of product Y, then the cross-price elasticity between the two products is zero. The user can suppress all cross-price/substitution effects by setting all the cross-price elasticities equal to zero, if he/she feels that this is a better strategy than guessing the cross-price elasticities when these are not available.

Where at least one of the cross-price elasticities is not zero, the consumption of product Y would increase when there is an increase in the price of product X. That increase in the consumption of product Y implies a decrease in the consumption of product X, over and above the effect that the price increase, through the own-price elasticity, has on the consumption of product X. To account for this, we subtract the increase in consumption of product Y, from the already-reduced consumption of product X. Had we not done this, it is possible that, because of the substitution effects, the aggregate consumption of the two product categories could increase when the excise tax is imposed. This is economically and logically nonsensical. Of course, if the user feels that there is too little empirical support for these substitution effects, he/she can switch this off by setting all the cross-price elasticities equal to zero.

To estimate the impact of the excise tax on health outcomes, we first calculate the total annual average consumption of SSB-based sugar for each of the eight gender-age categories before the additional excise tax is imposed. For each product and gender-age category, we calculate the quantity of sugar consumed on average each year, by multiplying the annual quantity of the beverage consumed by the pre-tax sugar content.

After the additional sugar-based excise tax is imposed, we repeat the exercise. In this scenario, the total quantity of sugar consumed is lower than in the baseline scenario for two reasons: (1) the volume of beverage is lower, because the higher retail price has reduced the demand for these beverages, and (2) the sugar content is typically lower, because of the product reformulation that is predicted to take place (which the user can specify in the Input sheet). Comparing the pre-tax and post-tax average SSB-based sugar consumption quantities allows us to calculate the decrease in SSB-based sugar that can be ascribed to the new sugar-based excise tax.

To link the change in sugar consumption to the change in the BMI, we need to know by how many kilograms an average person needs to reduce his/her consumption of SSB-based sugar in order to permanently reduce his/her BMI by 1 kg/m^2. As indicated previously, this is about 10 kg of sugar per year. This parameter value is filled out in the Input sheet. The model allows the user to have different values for each of the eight gender-age categories.

The magnitude of the annual reduction in SSB-based sugar consumption determines the magnitude of the average reduction in the BMI for each gender-age group, according to the relationship described in the previous paragraph. We assume that the standard deviation of the BMI remains unaffected.

As a last step, we first estimate the percentage of people in each gender-age category who are overweight (i.e., BMI ≥ 25 kg/m^2 but < 30 kg/m^2) and obese (i.e., BMI ≥ 30 kg/m^2) in the baseline scenario, assuming that BMI is normally distributed. Then, after the additional tax is implemented, and the drop in SSB consumption decreases the average BMI in each of the eight gender-age categories, we again estimate the percentage of people who are overweight and obese, using the same criteria as in the baseline scenario. The difference in the percentage (and absolute number) of people who move from being overweight (or obese) to being not overweight (or obese) is then regarded as the public health benefit of the intervention.

Being overweight or obese is associated with a variety of illnesses. The medical literature indicates that reducing the number of people who are classified as overweight or obese will result in fewer people contracting those illnesses. We do not venture into this area, but limit our analysis to estimating the number of people who move from being overweight (or obese) to categories with lower BMI.

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