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Modelling the potential impact of a tax on fruit juice in South Africa: implications for the primary prevention of type 2 diabetes and health financing

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Abstract

Background South Africa is experiencing a persistent growth in non-communicable diseases. Diabetes is among the top ten causes of mortality, especially among women, which is partly driven by high levels of added sugar consumption and obesity. To reduce obesity rates and the incidence of diabetes, South Africa introduced a tax on sugar sweetened beverages (also known as the Health Promotion Levy (HPL)) in 2018. The tax is applicable to sugar-sweetened beverages but excludes 100% fruit juice. The government is currently considering extending the tax to include fruit juices. This study models the potential health and economic impact of taxing fruit juices at 20% of the retail price of one liter.

Methods To analyze the distributional impact of the tax, this study uses extended cost-effectiveness analysis methodology. Data on price elasticities, healthcare cost, income, fruit juice consumption were sourced from the literature and representative national surveys. The potential impact of the tax on diabetes incidence, prevalence, mortality, and financial benefits were estimated for each income group (lowest, quintile 1 to highest, quintile 5).

Findings We estimate that a 20% tax on fruit juice would avert 156,640 incident cases of type 2 diabetes mellitus over 20 years, with most disease averted occurring among the first- and fifth-income groups. Averted deaths from diabetes would average 2,000 deaths per quintile (for quintiles 1 to 4) and about 2,800 in quintile 5. The improved health resulting from averted incidence and deaths will reduce overall healthcare expenditure by R7.5 billion over 20 years, of which R2.3 billion will occur in the fifth quintile. The South African government will also save about R300 million in subsidizing diabetes-related healthcare cost as a result of prevention; and would raise R8.6 billion in tax revenues per annum. Out-of-pocket expenditure savings will be R303 million and a financial risk protection (money-metric value of insurance) of R4.6 billion over the 20-year period.

Conclusion We conclude that an HPL that significantly raises the retail price of fruit juices would reduce consumption and diabetes-related morbidity and mortality. The tax will also provide significant financial benefits in the form of reduced healthcare costs for both government and households as well as providing financial risk

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protection to individuals. Health taxes are win-win policies that improve population health and generate revenue for governments to fund public health services delivery and thus improve overall health financing activities of the government. Therefore, population level disease prevention measures such as health taxes are important for achieving universal health coverage.

Keywords Diabetes, Health taxes, Extended cost-effectiveness analysis, South Africa, Obesity prevention

Background

The prevalence of overweight and obesity is high in South Africa, and currently one of the highest in sub-Saharan Africa. In 2017, half of South Africans of age 15 years and older were either overweight or obese contributing to the burden of malnutrition [1]. The increase in obesity rates has been associated with a high prevalence of diabetes, hypertension, and many other chronic non-communicable diseases (NCDs), with a growing burden on the healthcare system.

Among South African men, age-standardized prevalence of diabetes increased from 4.7% in 1980 to 9.7% in 2014. During the same period, the prevalence among women rose from 7.7 to 12.6%. In 2021, approximately 4.2 million people were living with diabetes. Diabetes is amongst the top ten underlying causes of death, with an average of 20,000 deaths annually between 2010 and 2018 [2]. In 2018, diabetes was the second (fourth among men and first among women) leading cause of death among the population accounting for about 6% of all deaths [2]. Diabetes was also a major risk factor for COVID-19 hospitalization and mortality in 2020 [3]. The economic burden of diabetes is also huge, estimated to average between R2.7 billion (in 2018) and R29 billion (in 2020) [1, 4, 5]. Although many statistics on diabetes do not differentiate between diabetes types, it is estimated that type 2 diabetes, which can be prevented or delayed, makes up 90% of all diabetes cases worldwide [6]. Indeed a recent study using claims data from two medical schemes in South Africa show the percentage to be 89.3, which is in tandem with worldwide estimates [5].

Unhealthy diets such as consumption of foods and beverages high in sugar is a major risk factor contributing to the high burden of diabetes, particularly type 2 diabetes [7, 8]. Thus, added sugars, found in many beverages and ultra-processed foods, whose consumption is driven by marketing strategies of the beverage industry are a major cause of obesity [9] contributing to the growing burden of non-communicable disease in low- and middle-income countries [10].

Added sugar intake is high in South Africa, rising from about 28 g/day in 2005 to 63 g/day in 2010 among rural men and 44 g/day to 73 g/day among urban men [11]. The change in added sugar intake among women was similar to that of men during the same period, 27 g/day in 2005 to 66 g/day in 2010 for rural women and 47 g/day to 79 g/day to urban women. One of the major sources of added sugar is the liquid sugar from non-alcoholic beverages such as sugar-sweetened beverages and fruit juice (including 100% juice). It is estimated that every 100 ml of 100% fruit juice contains 10.4 g of sugar which compares to the 10.6 g of sugar found in same quantity of carbonated soft drinks [12]. This means that fruit juice consumption contributes to higher sugar intake.

In 2018, South Africa implemented a sugary beverage tax known as the Health Promotion Levy (HPL) as part of strategies to tackle growing obesity and the associated burden of NCDs. The sugar content-based tax excluded beverages containing natural or intrinsic sugars (also known as pure or 100% fruit juice), despite them having a similar sugar content to that of sugar-sweetened beverages. This decision may have been influenced by the notion that 100% fruit juice is a healthier alternative to sugar-sweetened beverages, due to the bioactive compounds in them. However, in February 2022, the government announced its intention to tax fruit juice on grounds that intrinsic natural sugar as in whole fruit has the same impact as sugar-sweetened beverages.

According to South Africa Fruit Juice Association, 100% fruit juice contains no additives and must be sold within 2 h of extraction in the case of fresh fruit juice, or may contain permitted additives in the case of unsweetened fruit juice. These beverages contain no added sugar from sources such as invert sugar or sugar cane. Most of the 100% fruit juices on market shelves are "unsweetened" juice with additives and an average of 10.4 g/100 ml of free sugar [12] which is similar to that found in sugar-sweetened beverages [13].

Systematic reviews and cohort studies show that consuming whole fruit is a better option because greater consumption of fruit juice increases the risk of type 2 diabetes [14–16]. In children below 6 years, fruit juice consumption has been shown to induce weight gain [17, 18]. In a recent study, the American Heart Association found that drinking 100% fruit juice throughout childhood and adolescence increased HbA1c levels in late adolescence among boys, concluding that the risk of type 2 diabetes increases with fruit juice intake [19]. In adults, fruit juice is associated with other non-communicable diseases such as cancers [20, 21], cardiovascular disease mortality [22] and age-related macular degeneration [23]. It also results in weight gain which is a risk factor for diabetes [24]. The presence of dietary fiber, antioxidants, and other nutrients in the fruit's skin and pulp makes

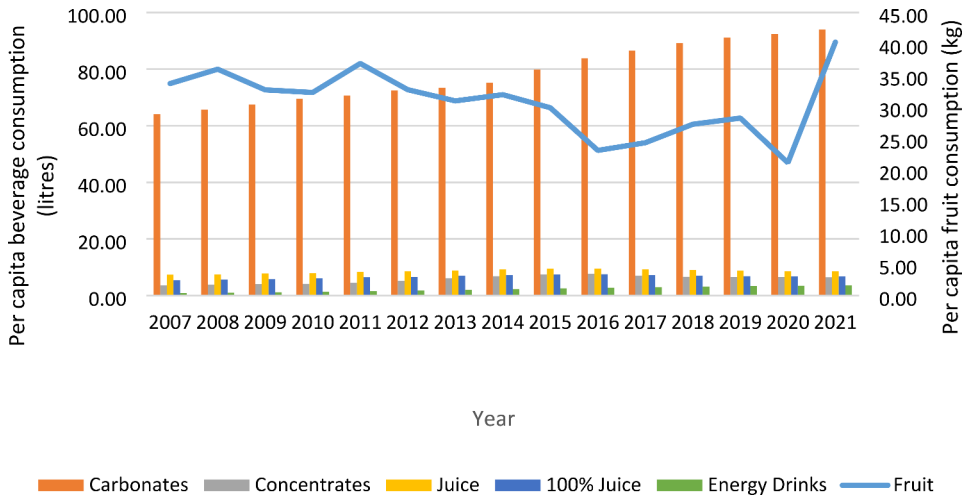

Fig. 1 Annual per capita fruit and beverage consumption in South Africa
Source: FAO [28] and Euromonitor International [29]

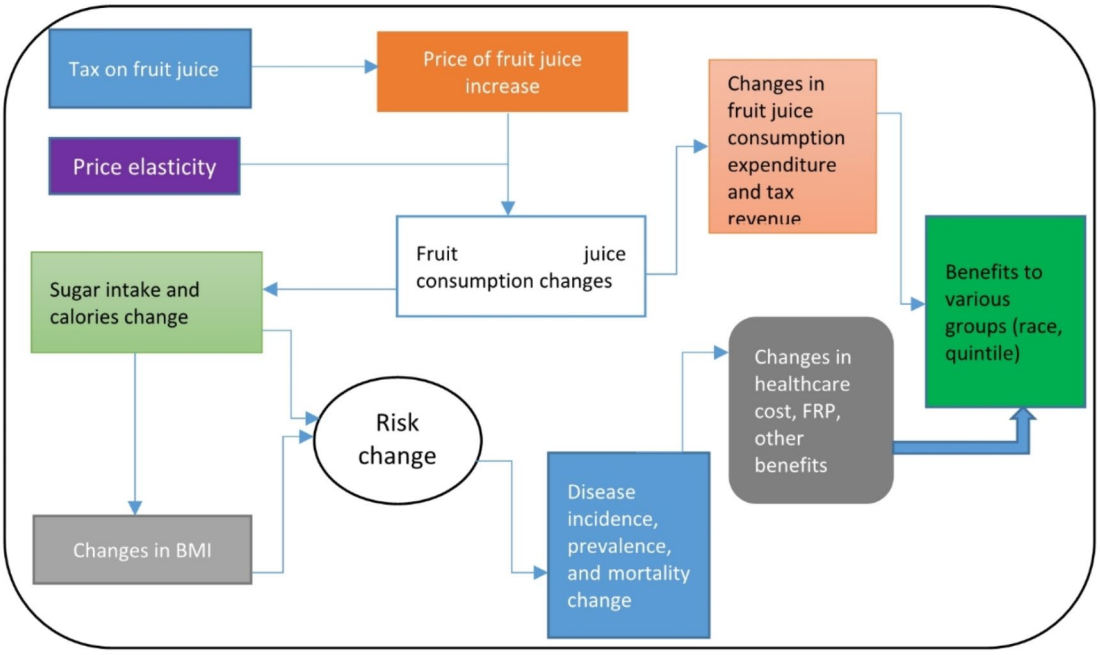

Fig. 2 Conceptual framework of the link between fruit juice taxation and outcomes

whole fruits a healthier option than juice [25], yet whole fruit intake has been generally low in recent years [26]. For instance, whole fruit consumption has been declining since 2006 (see Fig. 1) compared to overall beverage consumption. At the same time, the prevalence of fruit juice consumption averages about 22%. Available evidence shows that between April 2017 and March 2019, approx. 93 million liters of 100% fruit juice were sold in South Africa [27]. Indeed, per capita 100% fruit juice consumption increased from 5.31 L in 2006 to 6.74 L in 2021 (Fig. 1), representing 27% growth in consumption over the period.

On the contrary, findings from a few systematic reviews and meta-analyses found no support for 100% fruit juice and incidence of type 2 diabetes [13, 30], suggesting that the link between 100% fruit juice and obesity as well as chronic non-communicable diseases remain inconclusive [13, 31]. It is important to note that some of the inconclusive studies or those reporting findings in favor of fruit juice consumption are industry funded [31].

Given the health risks associated with fruit juice consumption and the fact that diabetes ranks second among the top 10 causes of death in South Africa, this study seeks to investigate the potential health and economic benefits of taxing fruit juice in South Africa using diabetes as a case study. This is particularly important given that previous studies focused less on fruit juices and the fact that the South African government is considering an expansion of the HPL to other unhealthy beverages.

We aim to establish the potential benefits among different income groups using extended cost–effectiveness analysis methodology. The extended cost-effectiveness analysis approach is important in the South African context, where economic inequalities persist, and the consequences of public policy are not always clear. South Africa's HPL is currently at R0.0221/g of sugar for every 100 mL taxed soft drink, and the first 4 g/100 mL is tax free [32]. This translates to a tax share of 11% (which was initially proposed at 20%) of the retail price per liter of taxed beverages such as carbonated drinks [32]. The benefits of excise tax on unhealthy foods and beverages can only be realized if the tax is sufficiently high [33]. Therefore, our model assesses the potential impact of a 20% tax (as share of the retail price) on health and economic outcomes. As of 2022, countries like Bangladesh, Nepal, Thailand, Cambodia, Tanzania and Malaysia taxed 100% fruit juice using different tax structures [34]. For instance, Bangladesh and Cambodia use ad valorem tax, while Tanzania, Nepal and Malaysia use a volume-based specific tax structure. In Thailand, the tax structure is specific excise based on the sugar content of the juice [34]. However, to our knowledge, no study has simulated the taxation of 100% fruit juice and the associated health implications.

Methods

Analytical Framework

The main reasoning behind the tax-health nexus is that on the link between price and consumption of fruit juice as well as the link between juice consumption and weight gain or Body Mass Index (BMI) through calories. Thus, based on economic theory it is expected that higher taxes will lead to higher retail prices and consequently reduce beverage consumption. The reduction in sugary drink consumption then leads to improved health and better financial outcomes for the population. Figure 1 provides the conceptual framework for our analysis.

Data sources

Our study uses data compiled from several sources. We sourced total population by age and sex from the Stats SA mid-year population estimates for 2022 [35]. Data on height, weight and BMI, income distribution and the subsidized patients were sourced from the National Income Dynamics Survey (NIDS) Wave 5 [36]. Fruit juice consumption data were estimated from All Media and Products Survey (AMPS) [37], assuming each can, bottle, glass or carton contained 330 ml liquid [38]. The AMPS questionnaire asks about the brand consumed in the past seven days. Further checks on these brands indicated the products are labelled as 100% fruit juice. Consumption was estimated by age, sex, and income quintile.

While the overall price elasticity of fruit juice demand (-0.44) has been estimated for South Africa [39], we did not find quintile-specific price elasticity estimates. To this end, price elasticity estimates were assumed such that their average reflects the overall price elasticity estimate for fruit juice in South Africa. Our assumption is based on the premise that people in lower quintiles are more price sensitive than their counterparts in the upper quintiles [40]. Baseline data on age- and sex-specific incidence, prevalence, and case-fatality rates of the disease were derived from DisMod II software package using data from the Global Burden of Disease Study [41]. Mortality probabilities and other lifetable variables were sourced from the World Health Organization (WHO) [42]. The main baseline characteristics and the inputs are shown in Table 1. Analyses are performed for both males and females separately, but the results are combined for both sexes. In 2022, the average ZAR-USD (US Dollar) exchange rate was ZAR14.42 which can be used to convert ZAR values, if needed.

General overview of extended cost-effectiveness analysis

We used a method of extended cost–effectiveness analysis [46]. Extended cost–effectiveness analysis is a policy assessment method, in health economics, for estimating the impact on three major outcomes: (i) health benefits (i.e., the reduction in premature mortality), (ii) private expenditures averted and (iii) financial risk protection afforded by any policy intervention. This methodology allows one to analyze equity effects of interventions, and has been used to study the distributional impact of the sugar-sweetened beverage tax on health and healthcare costs in South Africa [38] and Philippines [10], and also equity impact of tax policy in tobacco control in other countries [47, 48] as well as alcohol taxation [49].

Estimation methods

Beverage tax, price elasticity and consumption Following previous studies [10, 38], we converted the rand value of the HPL to a percentage based on the average retail price of a liter of fruit juice in South Africa. This translated into 6% of the average retail price of a liter of 100% fruit juice. However, we model a 20% tax. While there is no formal recommendation on the beverage tax burden unlike tobacco, conventional economic theory postulates that larger tax and price changes induce substantial changes

Table 1 Summary of main model input parameters

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	Source
Price Elasticity	-0.55	-0.45	-0.42	-0.37	-0.35	Assumed
Per capita income (monthly), R	9119	11,771	17,716	31,612	114,311	[38]
OOP, %	21	18	41	56	82	
Healthcare utilization, %	45	50	65	70	80	
Mean BMI (males)	21.86	22.17	22.59	23.19	24.84	[36]
Mean BMI (females)	26.18	26.90	27.27	27.77	28.08	[36]
Mean consumption, liters per week (males)	0.32	0.42	0.49	0.51	0.79	[37]
Mean consumption, liters per week (females)	0.41	0.45	0.51	0.59	0.81	[37]
Prevalence of Diabetes	10.12%	12.15%	12.23%	13.25%	15.26%	[36]
Prevalence of fruit juice consumption	12%	14%	19%	24%	42%	[39]
H_0 (fully subsidized, 0% OOP)	6.11%					[43]
H_1 (partially subsidized, 30% OOP)	93.89%	100%	100%	100%	1.06%	
H_2 (partially subsidized, 80% OOP)					75.5%	
H_3 (partially subsidized, certain services, otherwise 100% OOP)					23.2%	
Current Tax rate for SSBs (modelled tax rate), ZAR/g	0.0221 (0.083)					[32, 44]
Sugar content per Litre	104					[12]
Expected tax free sugar content/Litre	40					[32, 44]
Retail Price per Litre, ZAR	26.31					[45]

Notes: H_0 to H_3 represent the share of the population that are eligible for subsidies in the public health sector; see the Western Cape Government's website for full details. All prices and incomes are inflation-adjusted to 2022. OOP is out-of-pocket expenditure

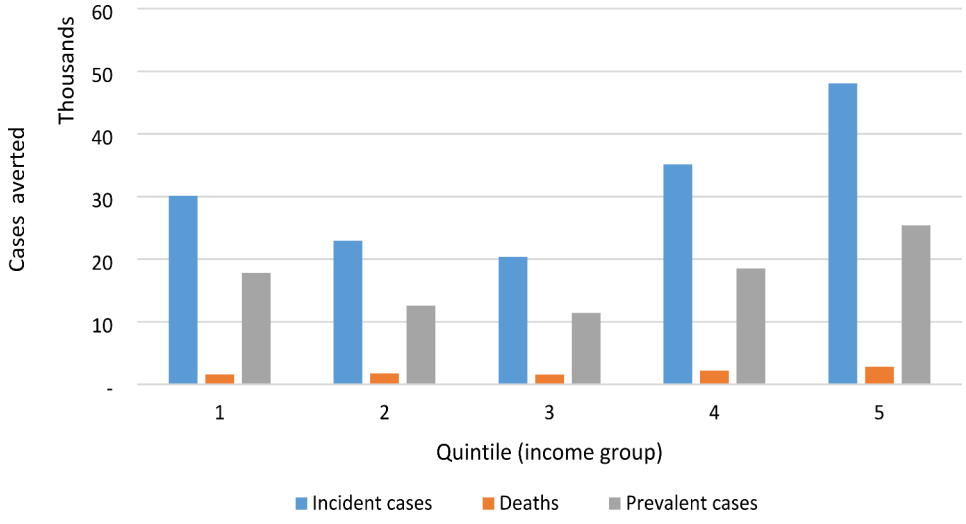

Fig. 3 Health benefits from 20% tax on fruit juice

in consumption to achieve significant improvement in health. Therefore, a tax burden of 17.5–20% is a good start [50]. The percentage change in the retail price was multiplied by quintile-specific price elasticities to obtain the percentage change in quantity of fruit juice consumed. The change in consumption was calculated as [10]:

$$Q_2 = Q_1[(1 + \alpha * \beta)]^{\epsilon_p} \text{ ---------- [1].}$$

Where Q_2 is the new consumption, Q_1 is the old consumption, α is the tax rate (i.e., the tax share of the retail price), β is the tax-passthrough rate, and ϵ_p is the price elasticity.

Changes in fruit juice consumption and type 2 diabetes mellitus occurrence We adapted previously published mathematical obesity models [10, 51, 52] to estimate the effect of reduced consumption of fruit juice on type 2 diabetes incidence overtime (i.e., 2022–2042). The variants of this model have been used to estimate the impact of sugar taxes on non-communicable disease incidence and mortality in South Africa [38, 51, 53] and very recently in Kenya [54, 55]. These obesity models use proportional multi-state lifetable in nature which assumes disease independence in a Markov modelling framework [56]. In the Markov modeling approach, a cohort enter the model at a certain age and then followed over time (using cycle

length) until they exit the model due to death, reaching a defined age or other criteria.

The estimation techniques followed several steps in line with previous studies on the subject. First, change in consumption was converted into change in energy intake and translated into impact on body weight. We assumed that fruit juice has an energy density of 1340 kilojoules (kJ) per liter [51]. Changes in consumption and energy intake was then converted into change in body weight using an energy balance equation that a daily energy change of 94 kJ (an average of 174 kJ for children) was associated with a change of 1 kg in body weight for adults [57]. This assumes that physical activity levels remain unchanged. The change in body weight and average height of individuals in each age-quintile category was used to obtain the change in age-quintile specific BMI. BMI trend was modelled as lognormal distribution over 20 years.

The second step involved translating gradual changes in BMI into incidence of type 2 diabetes mellitus using the potential impact fraction (PIF). Using data on the relative risk of type 2 diabetes mellitus due to a unit increase in BMI and the change in BMI, we estimated the age-and sex-specific PIF using the EpigearXL add-in for Microsoft Excel. The baseline incidence rate was scaled by the PIF to obtain the incidence and mortality rate that will result from extending the HPL to fruit juice. The changes in the incidence and mortality rates following HPL intervention then formed the inputs into the cohort lifetables. The population was simulated from age two to 100 years of lifetime or death (cycle length), whichever comes first [10, 38, 52, 55], to estimate the cohort-specific reduction in type 2 diabetes incidence, premature deaths, and health-care costs over a 20-year period using Erstaz add-in to Microsoft Excel. The study modelled the 2022 mid-year population (starting from as young as age two) for South Africa and then capture the impact of the tax once they turn 25 years and more into the future.

Estimation of health expenditure

Direct medical cost (health expenditure) associated with the reduction in the incidence of type 2 diabetes for both households and government were estimated. Claims data from a medical aid scheme shows an average monthly cost of R657 (R7,884 p.a.) as of March 2021 [58].[1] This cost was constant across age and sex, and it excludes diabetes-related admissions and complications. In 2018, a cost of illness study showed annual healthcare cost of diabetes was R11,156 per patient (inclusive of some complications) [4]. A recent analysis of 2015 and 2016 claims data from two medical schemes serving the public sector shows that the average cost of usage of medical resources per patient rose from R53,216 in 2015 to R60,125 in 2016 (inclusive of complications) [5].

To estimate out-of-pocket (OOP) payments by patients and government expenditure through subsidies to patients, we apportioned the healthcare costs in each income quintile by the level of government financing and co-payment for each quintile. South Africa subsidizes healthcare on a sliding scale. The subsidy ranges from partial to full subsidization depending on the patient's income level, which means that OOP payments can range from 0 to 100% [43]. However, in general, the share of out-of-pocket payments in total healthcare cost ranges from 20% in the bottom quintile to about 80% in the highest quintiles. These OOP payments also provide indication of how much government spends on subsidies on patients. Combining the OOP payments and share of government financing, we estimated the reduction in private health expenditures for households and government expenditure for each case of type 2 diabetes mellitus that is averted.

Financial risk protection

A key component of universal health coverage is financial risk protection, defined as access to all needed quality health services without resulting in any financial hardship for patients or their families [46, 59]. With its regressive nature, OOP expenditures impose a huge burden on many people around the world, and sometimes such expenditures push many into poverty. The extended cost-effectiveness methodology uses three indicators to measure financial risk protection afforded by a policy: averted cases of catastrophic health expenditures (medical expenditures exceeding certain capacity to pay) and poverty as well as money-metric value of insurance [46]. This study uses the last indicator, i.e., money-metric value of insurance (or simply insurance value), to quantify financial risk protection in line with Stéphane Verguet, Jane J. Kim [46]. The insurance value is calculated as:

$$Money-metric\,insurance\,value = E\left(y\right) - \ y^{*}$$

-------- [2];

$$E\left(y\right) = k * m * \left(PCI - OOP_{E}\right)) + \left(\left(1-k\right) * PCI\right)$$

------ [3];

$$y^{*} = k * m * \left(\left(PCI - \ OOP_{E}\right)^{1-r} + \left(1 - k * m * \left(PCI^{1-r}\right)\right)^{\frac{1}{1-r}}\right.$$

-------- [4].

E(y) is the expected income in an uncertain scenario; y* is income under certainty; k is number of incident cases averted; m is the healthcare utilization rate; PCI is per capita income; r is the rate of interest (assumed to be 3%).

Additional tax revenues from fruit juice

We estimated the total change in tax revenue resulting from the tax and calculated the proportion of this change borne by each income quintile. We used fruit juice

[1] R702 (8,424 p.a.) inflation-adjusted to 2022. We used 70% of this private sector fee as the public sector fee.

consumption at the baseline and the mean retail price (R26.31) per liter to calculate the post-policy tax revenue.

Sensitivity analyses

We conducted three univariate sensitivity analyses. First, we reduced the pass-through effect from 100 to 68% and increased it to 120%. The pass-through effect could vary substantially across countries, across retailers within the same country and across time. In some states in the US, for example, retail prices of sugar-sweetened beverages increased by 61% in the first month followed by 93% in the second month [60]. In the early stages of the HPL implementation in South Africa, tax pass through was about 68% for carbonated drinks [39]. A similar analysis of the HPL for taxed fruit juice and nectars has shown an average pass-through of 33%, indicating that the beverage industry absorbs part of the tax in South Africa [27]. It is therefore justified in reducing the tax-passthrough to lower levels. We used a uniform price elasticity measure across all income quintiles by applying a mean price elasticity of −0.44 across all income quintiles.

Results

We report the results from our simulation exercise here, and the results are combined for both males and females. We estimate that overall, each person will pay 0.059% of their income as fruit juice tax. This ranges from 0.016% in quintile 5 to 0.091% in quintile 1 (Table 2). The direct medical cost per patient is estimated to be R5,952. The expected OOP and their share of income for each quintile is estimated as follows: quintile 1 (R1,2450, 1.14%), quintile 2 (R1071, 0.76%), quintile 3 (R2,440, 1.15%), quintile 4 (R3,333, 0.88%), and quintile 5 (R4,880, 0.36%).

Figure 2 presents the quintile-specific health gains from the policy (all results are combined for both males and females). The financial impact, i.e., change in out-of-pocket payments and additional tax revenue for government as well as the financial risk protection afforded by extending the HPL to fruit juice is also provided (Table 2).

Over a 20-year period, a total of 156,640 incident cases of type 2 diabetes will be averted and more than a third of these averted cases will occur in quintile 5 (Fig. 3). The fruit juice tax will contribute to the reduction of diabetes incident cases of about 53,000 within the bottom 40% of the income distribution compared to 83,000 averted cases in the top 40% of the income distribution. This shows that quintiles 4 and 5 will experience the greatest reduction in incident cases relative to other groups. Our results also show that Quintiles 1 and 5 will experience a significant reduction in prevalent cases of about 18,000 and 25,000, respectively.

Aside from the health benefits, the imposition of the tax on fruit juices also yields financial benefits. For example, a reduction in private health expenditure (i.e., OOPs) may also result from the reduced incidence and prevalent cases. Specifically, Table 2 shows that out-of-pocket payments decline by about ZAR 22 million in quintile 2 to about ZAR 193 million in quintile 5. The overall healthcare cost saving is estimated at ZAR 7.5 billion over the period under study.

Implications of the tax for health financing

The financial risk protection afforded by the policy was quantified by the insurance risk value [46]. We estimate that fruit juice tax provides a money-metric value of insurance cover of about ZAR 4.6 billion to the population, with 71% of this cover accruing to members in quintile 5. Members in quintile 1 also receive money-metric value of insurance cover to the tune of ZAR 203 million (Table 2).

Overall, the government saves about ZAR 300 million in subsidies as a result of the policy; a significant part of this savings occurs in quintiles 1, 3 and 4. Government revenue collection from the tax is estimated at ZAR 8.6 billion, 35% of which will come from consumers in quintile 5.

Sensitivity analyses

The results from these analyses show that the health and financial impact of the policy will depend on the extent of tax pass-through and how sensitive consumers are to fruit juice price changes (Table 3). We estimated that at 68% tax pass through, averted incident cases would be approx. 118,000 compared to 157,000 cases under 100% pass-through. Also, an estimated 175,000 incident cases of type 2 diabetes could be averted if beverage

Table 2 Summary of financial gains from a 20% tax on fruit juice

Quintile	Healthcare cost savings (ZAR)	Reduced OOP expenditure (ZAR)	Insurance value (ZAR)	Subsidy (ZAR)	Tax Revenue (ZAR)	Tax, % of income *p.a.*
1	1,435,985,079	22,713,975	203,921,533	57,926,402	1,240,812,287	0.091%
2	1,174,473,239	20,506,362	193,292,252	47,848,179	1,258,380,231	0.084%
3	1,039,903,005	23,654,370	229,434,462	55,193,529	1,344,625,688	0.064%
4	1,618,726,277	43,897,359	689,733,242	102,427,172	1,780,071,170	0.040%
5	2,273,238,201	192,509,893	3,236,363,773	36,347,062	3,016,808,205	0.016%
Overall	7,542,325,801	303,281,960	4,552,745,261	299,742,344	8,640,697,582	0.059%

Notes: results are for both males and females

Table 3 Estimates of the potential effect of 20% tax on 100% fruit juice under different scenarios

Uniform elasticity								
Quintile	**Incident cases**	**Deaths**	**Reduced OOPs**	**Tax Revenue**	**Reduced HC**	**Prevalent cases**	**Subsidy**	**Insurance Value**
1	−25,925	−1,417	-19,558,702	1,265,940,995	−1,259,106,781	−15,649	-49,879,655	175,321,830
2	-19,387	-1,604	-17,308,912	1,260,675,947	−1,032,855,232	−10,934	-40,387,462	162,823,281
3	-31,602	-2,005	-36,678,753	1,339,732,967	-1,479,560,016	-16,741	-85,583,757	358,422,529
4	-36,812	-2,234	-46,011,795	1,757,503,940	-1,689,783,842	-19,380	-107,360,854	723,576,232
5	-62,894	-3,436	-251,914,102	2,967,723,814	-2,879,169,307	-32,380	-47,562,945	4,258,739,719
Overall	-176,621	-10,697	-371,472,264	8,591,577,664	-8,340,475,178	-95,085	-330,774,672	5,678,883,590
68% Passthrough								
Quintile	**Incident cases**	**Deaths**	**Reduced OOPs**	**Tax Revenue**	**Reduced HC**	**Prevalent cases**	**Subsidy**	**Insurance Value**
1	-23,855	-1,342	-17,997,162	1,278,774,846	-1,171,390,810	-14,570	-45,897,331	161,184,570
2	-18,125	-1,568	-16,181,678	1,289,793,698	-976,320,776	-10,210	-37,757,248	152,096,612
3	-20,461	-1,570	-23,748,181	1,375,928,531	-1,039,037,905	-11,368	-55,412,422	230,360,002
4	-20,170	-1,571	-25,211,206	1,816,527,683	-1,033,081,138	-11,432	-58,826,147	392,090,470
5	-35,305	-2,336	-141,407,934	3,075,221,680	-1,747,788,904	-19,392	-26,698,695	2,361,877,146
Overall	-117,916	-8,387	-224,546,161	8,836,246,439	-5,967,619,533	-66,973	-224,591,844	3,297,608,800
120% Passthrough								
Quintile	**Incident cases**	**Deaths**	**Reduced OOPs**	**Tax Revenue**	**Reduced HC**	**Prevalent cases**	**Subsidy**	**Insurance Value**
1	-43,081	-2,056	-32,501,417	1,218,641,341	-1,971,224,013	-24,331	-82,886,864	292,868,095
2	-25,035	-1,828	-22,351,611	1,239,953,439	-1,259,921,217	-13,633	-52,153,759	210,901,361
3	-29,768	-1,925	-34,550,296	1,326,239,611	-1,411,546,496	-15,946	-80,617,358	337,283,788
4	-29,415	-1,934	-36,765,898	1,758,611,027	-1,401,317,070	-15,910	−85,787,096	575,807,724
5	-48,069	-2,833	-192,535,392	2,982,392,922	-2,277,210,516	-25,493	-36,351,876	3,236,801,409
Overall	-175,369	-10,576	-318,704,615	8,525,838,341	-8,321,219,312	-95,314	-337,796,952	4,653,662,377

Notes: negative values signify averted cases (for incidence, deaths, and prevalence) or averted OOP, healthcare and subsidy expenditures (i.e., cost savings). Revenue and insurance benefits received are positive. Expenditures, subsidies, tax revenue and insurance values are in South African Rand (ZAR)

manufacturers over-shift the tax by 20% and would have significant decline in mortality (by 18,000 cases). The distribution of these health and financial gains across quintiles is similar to those in Table 1; Fig. 2 (see Table 3).

Discussion

The burden of diet related NCDs is a growing concern in South Africa. One major risk factor linked to diet-related NCDs and obesity is excessive sugar consumption. Sugar from 100% fruit juice is a risk factor for diabetes and cancers. Studies on excise taxation in other jurisdictions and South Africa have shown that fiscal policies provide enormous health benefits to the population.

This study estimates the distributional impact of taxing 100% fruit juice in South Africa. We found that a fruit juice tax will provide significant health benefits by reducing morbidity and mortality from type 2 diabetes. We found that a larger part of the benefits accrues to the high-income groups. This outcome is expected because the prevalence of fruit juice consumption is about 42% in quintile 5 compared to 12% in quintile 1 [39]. Using data from NIDS Wave5, we found that diabetes prevalence increased with income, ranging from 10% in quintile 1 to about 16% in quintile 5. Previous studies have shown that prevalence of obesity and diabetes is concentrated among the economically better off South Africans [61–63]. This means that extending the HPL to fruit juice significantly benefit people in the high-income group. It also reduces morbidity and mortality among people in low-income group. Therefore, health taxes such as South Africa's HPL addresses health inequalities.

The financial gains from the policy cannot be overemphasized as it reduces private health expenditures among potential patients and overall healthcare cost. Our results also show that taxing fruit juice will reduce government health care subsidies in the long term through disease prevention while collecting additional revenue to fund other public services such as strengthening the public health sector.

Raising revenue is key in health financing, and health taxes such as those on beverage taxes constitute an important source of government revenue. In South Africa, government subsidizes healthcare for about 85% of the population. Therefore, the tax policy also produces significant benefits to government in the form reduction in subsidies and additional tax revenues. Thus, extending the health promotion levy to fruit juice not only prevents type 2 diabetes but also provides financial risk protection to many people. Indeed, the people in low-income groups pay a higher proportion of their income as OOP when sick compared to those in high-income groups. Therefore, policies that prevent diseases and reduce the risk of financial hardship from such diseases, particularly among the poor, are important.

Similar to Saxena, Stacey [38], this study contributes to the growing literature on sugar tax and health in South Africa using the extended cost-effectiveness analysis methodology. By using extended cost-effectiveness analysis, we show that tax incidence alone should not be the only focus when analyzing the impact of a tax policy. Our findings are consistent with earlier studies showing that sugary beverage taxation reduces OOPs and government expenditures (i.e., subsidies) in all income groups. In South Africa, even in the absence of a National Health Insurance (NHI), majority of the people enjoy free healthcare through government subsidies which also means the need for government to generate more revenue to fund these services. Therefore, any policy that reduces morbidity will result in significant savings for the government. At the same time, health taxes also serve as additional revenue stream to governments to finance healthcare.

Limitations

This study is not without limitations. Like all simulation models, the results from this model represent the best estimate of a potential effect when there are no experimental studies. First, our analysis considers no substitution effects. We know from economic theory that an increase in the price of one commodity may push consumers to look for alternatives whose prices have not changed and may increase demand for substitute goods [39]. However, our model did not account for substitution or complementary effects resulting from increased prices of fruit juice. This may result in under or overestimation of the impact of the tax. It is known that sugar-sweetened beverages such as carbonated soft drinks are substitutes for fruit juices. Therefore, increased prices of fruit juices will cause an increased consumption of sugar-sweetened beverages, *ceteris paribus*. In the case of South Africa, however, both sugar-sweetened beverages and fruit juices would be subject to the same tax rate. This will independently reduce demand and hence limit the degree of substitution.

The price elasticity estimate for fruit juice was available for the entire population without any quintile-specific estimate. The price elasticity estimates used may not reflect the actual responsiveness to price changes by various income groups. Further, the model accounts for only type 2 diabetes morbidity and mortality and as such does not consider other obesity-related diseases. Given that sugar consumption and obesity are associated with many non-communicable diseases, the health benefits and the potential financial effects may be underestimated. The analysis of tax revenue is based on the baseline consumption data from the AMPS survey. To the extent that this data is dated is likely to overestimate consumption and tax revenue. It is recommended that future studies address these limitations, if data permits.

Conclusion

Diabetes is one of the major NCDs affecting a significant number of South Africans and accounting for about 6% of all deaths. This study demonstrates that extending the HPL to fruit juice, as one of the essential prevention tools, will contribute to the reduction of diabetes-related morbidity and mortality, reduce OOPs and government expenditures, and provide financial risk protection to many South Africans. Therefore, the health promotion levy is important for both disease prevention and health financing in South Africa.

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Author contributions

Conceived the research: MKB, ET. Data analysis: MKB. Contributed to analysis/materials: MKB, ET, KH, SG. Wrote the first draft: MKB. Provided critical review and edited drafts: MKB, ET, KH, SG. All authors read and approved the final version of the manuscript submitted.

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Data availability

The study uses publicly available data sourced from the references cited in the paper which are available to the public.

Declarations

Ethical approval

Not applicable. No human and/or animal was used as subject.

Consent for publication

Not applicable. No patient was involved in the study and therefore consent for publication is not required.

Competing interests

The authors declare no competing interests.

Consent to participate

Not applicable.

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