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Background: Non-communicable diseases (NCDs) account for over 30% of disability-adjusted life years in South Africa. Many of the risks associated with NCDs are related to diet, tobacco and alcohol. In South Africa, diets are often not diverse enough and contain too much salt, while tobacco and alcohol consumption remain too high. Thus, NCD risks will continue to grow, unless those behaviours can be altered.

Objectives: In this research, we offer an estimate of the potential reduction in NCD incidence that would arise from an improvement in diet, combined with a reduction in both tobacco and alcohol consumption.

Methods: We apply the PRIME model, which simulates the effect of risk reduction on NCD incidence. The model inputs baseline data related to the population, risky consumption behaviour and NCD incidence. The model allows for counterfactual scenarios altering the risky consumption behaviour to yield revised NCD incidence.

Results: We find that reducing salt, tobacco and alcohol, along with improved fruit, vegetable and fiber consumption would yield a 10% reduction in NCDs from the 2018 baseline. NCD incidence reductions arise primarily from ischemic heart disease (49%), cerebrovascular diseases (33%) and bronchus and lung disease (11%).

Conclusion: South Africa's NCD incidence is high because of relatively poor behavioural choices, despite plans and policies aimed at changing this. South Africa should increase their efforts to reach NCD goals. If the government is able to reduce harmful behaviour, with respect to a number of the underlying consumption choices, NCD incidence is expected to fall precipitously.

INTRODUCTION

Non-communicable diseases (NCDs) such as cancer, type 2 diabetes mellitus, respiratory illnesses (such as chronic obstructive pulmonary disease) and mental health disorders are an increasing global burden.[1] An estimated 41 million people could die prematurely from NCDs, which could cost more than USD47 trillion over the next few decades.[2] NCDs are disproportionately problematic in low- and middle-income countries (LMICs), where over 75% of NCD-related deaths occur and where NCDs are likely to become the biggest cause of death [2,3-4].

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In South Africa, there is a quadruple burden of disease – communicable diseases, NCDs, maternal and child health, and injury-related disorders.[5-7] Furthermore, there is extensive interpersonal violence and, like in many other countries in the region, there is evidence of increasing multimorbidity, which raises both the demand for and cost of healthcare, when health budgets are limited.[8-14] By 2010, NCDs were amongst the top causes of death, with a large share of deaths being premature (i.e. before the age of 60).[15] Relatively recent estimates of NCD burdens suggest that they account for approximately 30% of disability-adjusted life years (DALYs) and nearly two-thirds of catastrophic health expenditure (CHE).[16]

NCDs are commonly associated with socio-environmental and behavioural factors, including tobacco and alcohol use, sedentary lifestyles and unhealthy diets, most of which have become more common in less developed countries.[5-6,17] In this study, we evaluate the potential health improvement that can be derived in South Africa from reductions in NCD behavioural risk factors, such as excessive consumption of salt, tobacco and alcohol, as well as insufficient intake of fiber, fruits and vegetables, analyzing data from 2018 through the lens of the Preventable Risk Integrated Model (PRIME). Although there is some recent evidence of a small reduction in NCD-related deaths, the burden remains high, partly due to associations with antiretroviral therapy, and therefore continues to deserve attention.[18-19]

BACKGROUND AND POLICY CONTEXT

South Africa is amongst the most unequal countries in the world, with a Gini coefficient hovering around 0.69, while 83% of households without at least one employed member experience poverty, which contributes to NCD prevalence.[20-24] There are also inequities in education, malnutrition outcomes and access to food and energy, similar to those related to ill-health.[25-32]

Although access to food and nutrition is unequal, consumption of sugar-sweetened beverages (SSB), packaged and fast foods has increased overall, including amongst the poor.[33] 40% of South Africans consume enough energy, but not enough nutritional quality.[34] This increase in unhealthy consumption has been fuelled by marketing, product placement and the increased availability of high-energy products.[35]

There is also evidence of high salt consumption, which is related to hypertension, an ageing population and, ultimately, increased cardiovascular disease (CVD).[5-6,36] Premature mortality and long-term disability, which affect government health expenditure, labour productivity and economic growth, are obvious problems associated with CVD.[37-38] CVD is also likely to have a significant impact on out-of-pocket (OOP) expenditures, which tend to be higher in lower-income households, rural and underserved communities.[39-40] A modest salt reduction could have substantial health gains. [41-42]

The literature on tobacco consumption and health effects in South Africa captures tobacco-attributable deaths, as well as race-based differences in mortality rates and economic costs associated with tobacco-related diseases.[43-46] While the smoking prevalence has dropped in most countries, it increased from 19% in 2017 to 24% in 2021 in South Africa.[47] Tobacco consumption is mainly driven by male adults, with a smoking prevalence of 39% in 2021. The

increase in smoking prevalence has potentially been fuelled by illicit cigarette trade. Between 2017 and 2021, illicit trade rose from 35% to 54%.[48-49] The illicit cigarette market not only endangers individual health – due to potentially poor cigarette quality – but also constrains the government budget, due to tobacco tax losses. An illicit market share of 54% means that the South African government could double its tobacco tax revenues, if smokers could be convinced to switch to legal tobacco products. Tobacco is responsible for approximately 10% of deaths, while the costs of premature death, morbidity and healthcare are estimated at near 1% of GDP, although larger cost estimates also exist.[43,46,50]

Alcohol consumption in South Africa also tends to be high, and binge and other risky drinking patterns are common. Of particular concern is annual per capita alcohol consumption, which is around 9.5 litres.[51-52] Furthermore, South Africa is one of only nine countries globally with the second-highest (4 out of 5) patterns-of-drinking score. [53] While illicit alcohol trade has not yet reached the levels of illicit cigarette trade, it is responsible for a substantial loss to South Africa's budget. Illicit alcohol trade constituted 22% of the total market in 2020, producing a fiscal deficit of R11.3 billion.[54]

The United Nations High-Level NCD Meeting focused on the potential impact of an increasing NCD burden on LMIC health systems, while the World Health Organization (WHO) has emphasised 'best buys', or cost effective, feasible and inexpensive interventions, that offer large improvements in public health.[55-56] Given that public health spending has not generally met the 15% government budget share proposed in the Abuja Declaration in Africa, and that both health insurance and access to healthcare is incomplete, many costs are likely to be covered by OOP expenditures.[57-61] OOP costs are associated with poor health outcomes especially for the poor, many of whom are elderly and have chronic conditions.[62-64] Thus, there is a need to manage costs, if not at the national level, then at least at the individual level, via prevention.

The government has responded to the NCD threat via its NCD plan, which includes multiple stakeholders and focuses on reducing prevalence, and, therefore, burden.[65-66] Amongst the government's goals and targets are:[32,65]

1. 25% reduction in relative premature mortality (<60 years) from NCDs by 2020
2. 20% reduction in alcohol and tobacco consumption by 2020
3. Salt intake reduction to <5 g per day by 2020
4. 10% reduction in the rate of obesity and/or overweight by 2020
5. 20% reduction in the prevalence of high blood pressure by 2020
6. 10% increase in physical activity prevalence
7. Cervical cancer screening for every woman: three screens per lifetime or every five years for those with an STD, or according to policy for HIV-positive women
8. 30% increase in the share of those able to control their hypertension, diabetes and asthma by 2020
9. 30% increase in screening for mental disorders by 2030

NCD policies are meant to drive behavioural change and eventually reduce NCDs; such policies were generally based on community and public participation, although this does not appear to have affected implementation or NCD prevalence.[67-68] In support of the NCD plan, the

government has enacted a series of reforms meant to reduce tobacco consumption, advertising for unhealthy foods, and the consumption of certain ingredients or components in unhealthy foods, such as fatty acids, salt and sugar.[69] By 2021, 8 policies were designed to affect smoking, a further 7 for alcohol, 8 for unhealthy diets and 5 on inactivity.[68] Thus, NCD policies are in place, but only tobacco control has been at least partially effective, most likely contributing to the small reduction reported in NCD deaths.[18, 68] South Africa is not unique in this regard - NCDs are increasing almost everywhere, especially in LMICs.[53,71-73] Some of the problems are related to limited physical activity, as a lack of green or safe spaces, especially in urban informal settlements, deters outdoor activities.[74]

The country's endeavours were supported by international developments, such as the UN endorsement of the declaration for controlling and preventing NCDs as well as international NCD reduction targets. [56,73] Even though international agreements could be used to support NCD policy, many regulations were not easily implemented due to industry pushback.[75] By 2021, only 13 (6 unhealthy diets, 3 tobacco control and 4 physical activity) of the identified programs had been implemented.[66-87] The government has also been moving, in fits and starts, towards its version of universal health coverage via a national health insurance scheme.[88-89]

In summary, the current governmental approach seems to be rather ineffective to curb behavioural risks and a consequent reduction of NCDs. If the South African government aims to reach its NCD goals and improve the healthcare system, it needs to follow a different harm-based approach. Additional measures do not necessarily require costly interventions but could be built upon consumer education and awareness-raising. If consumers were more conscious about their lifestyles, they might make less harmful choices, i.e. healthier diets, lower alcohol consumption and reduced-risk tobacco products instead of smoking.

METHODS and DATA

We evaluate the potential health improvement in South Africa that can be derived from reductions in NCD behavioural risk factors such as excessive consumption of salt, tobacco and alcohol, as well as insufficient intake of fiber, fruits and vegetables, analyzing data from 2018 through the lens of the Preventable Risk Integrated Model (PRIME).[90] The Preventable Risk Integrated Model (PRIME), an Oxford-developed tool is a publicly accessible scenario modeling tool designed to assess the impact of changes in non-communicable disease (NCD) risk factors on morbidity and mortality. The tool compares real-world baseline data with hypothetical scenarios derived from extensive meta-analyses (counterfactual scenario) or policy prescriptions. The comparison arises from simulating the number of incidences that could be prevented from a change in unhealthy consumption choices.
The simulations are underscored by relative risks derived from the existing literature for each disease, age group, and gender. Using the relative risks, population attributable fractions (PAFs) are calculated in the model, determining the percentage of disease cases potentially preventable under alternative risk factor scenarios. The model compares actual data with an improved hypothetical scenario to estimate the number of avertable incidences. By categorizing complex data into distinct groups and applying PAFs to the incidence count in each, PRIME estimates the impact of modifying risk factors on total morbidity.[90]

PRIME needs three sets of input data for a given year: age and gender distribution of the population, NCD incidence rates for each disease (ICD-10) by age and gender, and risk factor behaviour by age and gender. Below, we describe how the data is developed for the model.

Unhealthy consumption goods

To estimate the average consumption of salt and fiber (and standard deviations to capture the distribution) per gender and age group, data from the Global Dietary Database (GDD) 2018 is used.[91] However, salt intake is underreported in the data, because the metadata only includes added salt used during cooking, whereas the salt added to industrialized products is not considered.[92-93] Therefore, we calculate the total salt consumption based on the assumption that on average, 55% of salt intake in South Africa is from processed food.[93]

Vegetables – not including starches such as potatoes – and fruit intake are calculated from the South African Demographic and Health Survey (SADHS) from 2016. Because the GDD data is aggregated, some information, such as *the percentage consuming <1 fruit/vegetable portions daily*, cannot be calculated.[94-95] The SADHS dataset provides only the number of fruit and vegetable types consumed daily, without specifying the amounts. To address this gap, we utilize the GDD to calculate the average quantity consumed, the standard deviation, and the percentage of individuals consuming less than one portion daily. With the insights from the GDD data, we can determine the average daily consumption of fruits and vegetables in grams. This involves dividing the total consumption by the number of types to estimate the average intake per fruit or vegetable type. We then use these estimates to calculate the daily fruit and vegetable intake for each respondent. This variable enables us to generate the necessary inputs for the PRIME.

The share of current, former, and never smokers, as well as daily alcohol consumption, is also obtained from the SADHS. Regarding current smoking behaviour, we account for both daily and weekly smokers. For alcohol consumption, we consider the number of drinks per day, with the assumption that a standard drink contains 12g of alcohol.[96] These values represent the baseline scenario in the PRIME model.

Although the counterfactual scenarios can be modified in PRIME, we use the policy prescriptions from WHO recommendations for consumption of these goods.[95] Thus, it is assumed that mean South African population consumption behaviour is shifted, but the spread of consumption remains unchanged, such that standard deviations in the counterfactual match the baseline scenario.[97]
For risk reduction in smoking, we follow a different approach. While quitting smoking always remains the best solution for health, convincing all smokers to quit immediately is deemed unrealistic. Additionally, the PRIME model does not allow for a reduction in consumption levels for smoking, unlike for other risk factors, which limits the potential counterfactual scenarios to a reduction in the number of current smokers. To overcome both limitations we follow a more pragmatic approach, wherein we allow a certain share of smokers to switch to less harmful alternatives or quit smoking.

Less harmful alternatives include nicotine-containing products that heat instead of burn nicotine, such as e-cigarettes and heat-not-burn products. Given their recent market

introduction, epidemiologic research is still needed to determine whether less harmful alternatives actually reduce the disease risk associated with smoking and, if so, how substantial this difference is. However, due to the robust toxicological evidence for alternative tobacco products and their increasing attractiveness to consumers, we include these nicotine products in the model. To avoid overestimating their health benefits, we assume a rather conservative risk reduction level of 50% based on toxicological studies and expert opinions.[98-104] These studies were commissioned by governmental authorities or research institutes, applying different methodologies. Most researchers estimate either cancer potencies or biomarkers and make assumptions in terms of health risks based on the difference in these compounds.

For the application of the model, this means that if we assume that half of all smokers switch to alternatives and these alternatives pose half the health risk compared to smoking products, we assume that 25% of smokers have the same relative risks as ex-smokers and 25% remain in their current smoking status.

Population and Incidences

Population data by age and gender is obtained from the World Bank for 2018 in South Africa.[105] However, since the World Bank data aggregates from the age of 80, we have taken the distribution of 80–84-year-olds among 80+ year-olds from the 2011 census, applying it to the World Bank data, assuming the distribution has not changed between 2011 and 2018.[106]

The incidences per disease by age group and gender are obtained from the Global Burden of Disease for 2018.[107] Due to the difference in longevity of cancer diseases (ICD codes C00-C14: Lip, oral cavity and pharynx cancer, C16: Stomach cancer, C25: Pancreas cancer, C18-20: Colorectum cancer, C50: Breast cancer, C64: Kidney cancer, C22: Liver cancer, C53: Cervix cancer, C34: Bronchus and lung), the incidence is calculated using the following formula:

$Total\ I_{cancer,n=10} = I_{cancer} + (Total\ I_{cancer,n-1} * SR_{cancer}), with\ n > 1$, with

Total $I_{cancer,n=10}$ represents the incidence per each cancer for year 10.
Total $I_{cancer,n-1}$ represents the incidence per each cancer from the previous year.
I_{cancer} represents the number of new incidences per year for each cancer.
SR_{cancer} denotes the yearly survival rate, derived from the survival rate per cancer after 10 years.
n is the year for which the incidence is being calculated.[90]

This formula calculates the 10-year incidence of diseases, based on acute and chronic incidences.[108] Chronic diseases, such as cancer, are typically evaluated over a 10-year period. This is because only considering new cases within a given year could potentially underestimate the incidence of these diseases due to their longevity.[109] The formula assumes a consistent decline in the survival rate over those 10 years, presuming that after 10 years, individuals are no longer affected by cancer.

RESULTS

Modelling data

As noted earlier, PRIME requires inputs by age and gender for a variety of (potentially unhealthy) consumption goods, which we captured from the GDD, SADHS and Census.[91,94,106] Table 1 reports simple averages for the baseline for males and females, which were averaged across all age groups (not weighted by population), as well as the counterfactual values, which are based on WHO recommendations and our tobacco risk reduction methods described above. The data suggests that too many South Africans do not eat any fruit or vegetables, although average consumption of fruit and vegetables is in line with recommendations. Furthermore, South Africans consume too much salt and alcohol, but not enough fiber, while too many South Africans smoke. Thus, the differences between baseline and counterfactual consumption are large in many cases.

Table 1. Baseline and Counterfactual Model Values

	Males		Females	
Risk Factors	Baseline	Counterfactual	Baseline	Counterfactual
Fruit (grams/day)	134.88	200.00	151.33	200.00
Pct with < 1 fruit per day	92.39	0	93.69	0
Vegetable (grams/day)	281.47	200.00	238.06	200.00
Pct with <1 vegetable per day	50.51	0	35.21	0
Fiber (grams/day)	21.70	25.00	20.87	25.00
Salt (grams/day)	8.75	5.00	7.99	5.00
Pct low alcohol consumers	62.33	99.00	89.95	99.00
Alcohol (grams/day)	22.97	12.00	13.44	12.00
Pct Never smoked	54.14	54.14	91.43	91.43
Pct Former smoker	7.25	16.90	1.77	3.47
Pct Current smoker	38.61	28.96	6.80	5.10

Note: Averages in grams/day (for fruit and vegetables) are calculated only for those that consume at least one per day, while the alcohol average is only for those consuming alcohol.

Baseline and counterfactual incidence

We begin by describing the baseline population disease incidence; see Figure 1. It shows higher incidence of disease for women, which is primarily due to them making up a larger share of the relatively older population due to lower life expectancy for men, as well as representing all or nearly all cases of cervical and breast diseases (which represents approximately 15% of incidence). Total incidence in the data is 840 908, just over 355 000 for men and 485 000 for women, with the most common incidences being diabetes (20%), Ischaemic heart diseases (12%), chronic obstructive pulmonary disease (8%), breast disease (8%), cervical disease (7%), bronchus and lung disease (5%) and colorectum disease (5%). As we describe below, the counterfactual incidence suggests that male health benefits relatively more from the healthier consumption and behaviour choices underpinning the counterfactual scenario in the PRIME model.

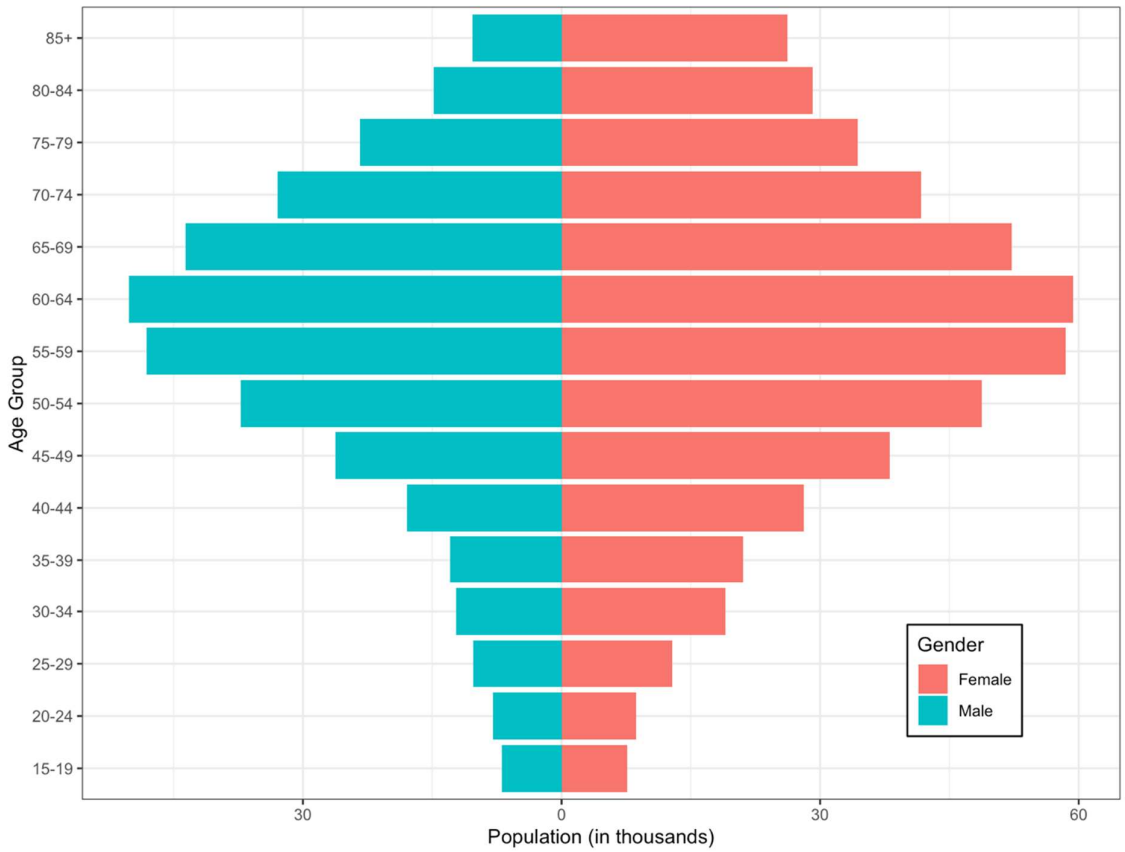

Figure 1. South Africa Baseline Incidence Pyramid (PRIME)

Avertable Incidence

As noted above, there are extensive differences between current South African consumption of salt, fruit, vegetables, fiber, alcohol and tobacco, relative to the recommendations. Inappropriate consumption of those goods has been linked to disease; thus, a revision in consumption towards recommendations could reduce disease. The difference in incidence between the baseline and the counterfactual is presented in Figure 2. We refer to this as avertible incidence, as it arises from reductions in risky consumption behaviour.

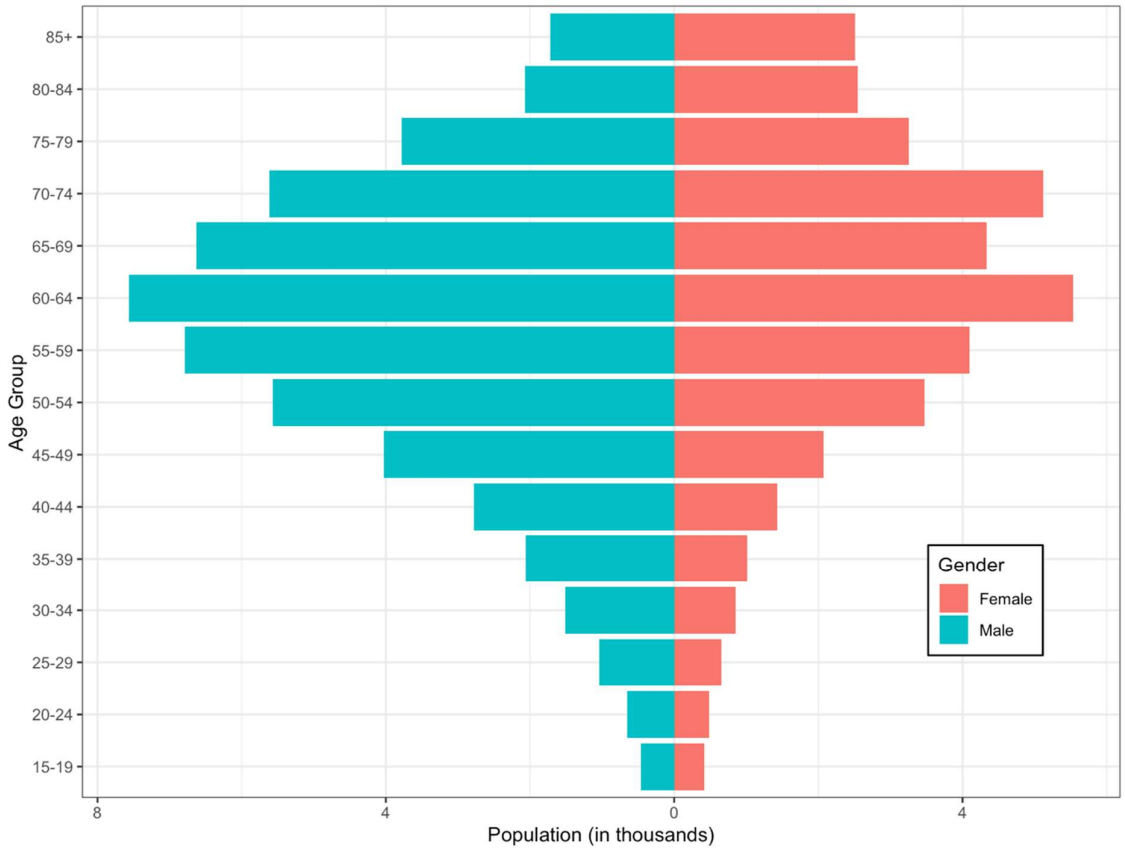

Figure 2. Avertible Incidence Arising from the Counterfactual Scenario (PRIME)

We further dissect Figure 2. Specifically, we present avertable incidence – by disease category – in Figure 3, which also offers insight into the consumption changes needed to make a difference. The total reduction in incidence arising from consumption modifications is close to 80 000; with baseline incidence near 840 900, that represents a decrease near 9.5% from baseline. The reduced incidence falls primarily within ischemic heart disease (49%), cerebrovascular diseases (33%) and bronchus and lung disease (11%).

Under our counterfactual scenario, and the relatively poor consumption of fruits and vegetables in the baseline data, the model finds that 49% of the reduction can be attributed to improved fruit and vegetable intake across a wider swathe of the population, while 21% can be attributed to a reduction in salt intake, 14% to reduction in smoking and smoking risk, and 14% from improvements in fiber consumption.

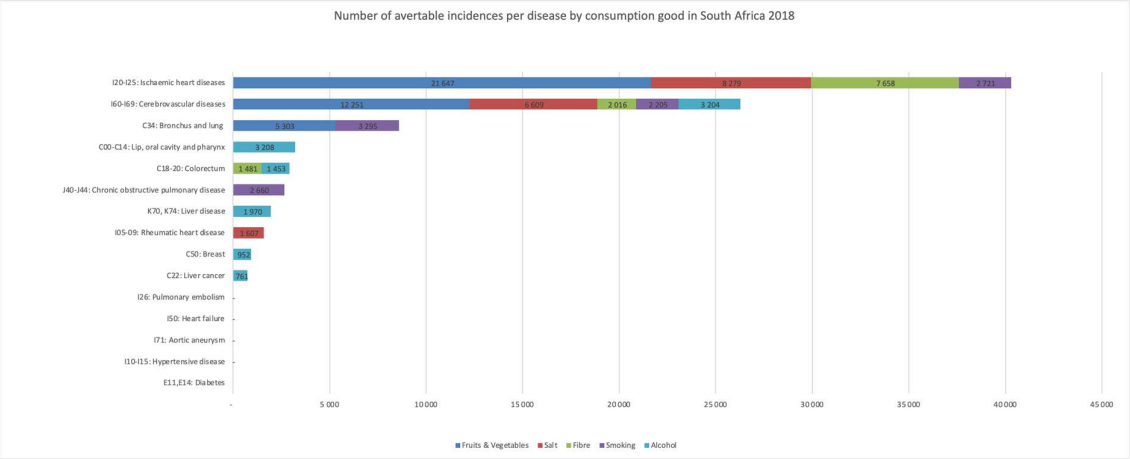

Figure 3. Avertable incidence by disease and risk factor (PRIME)

Given that women disproportionately suffered from disease, while, arguably, men were the worst consumption culprits, we briefly consider the improvements by gender; see Figure 4. The reduction in incidence is dominated by the difference in behaviours by gender; thus, overall, the reduction in incidence is larger for men. For example, the reduction in incidence for smoking risk reduction is 2.7 times larger for men than women. For alcohol, the reduction is 12 times larger for men, while for salt, it is 1.3 times. Thus, there are 44 500 fewer cases for men and approximately 34 700 fewer cases for women, in the counterfactual.

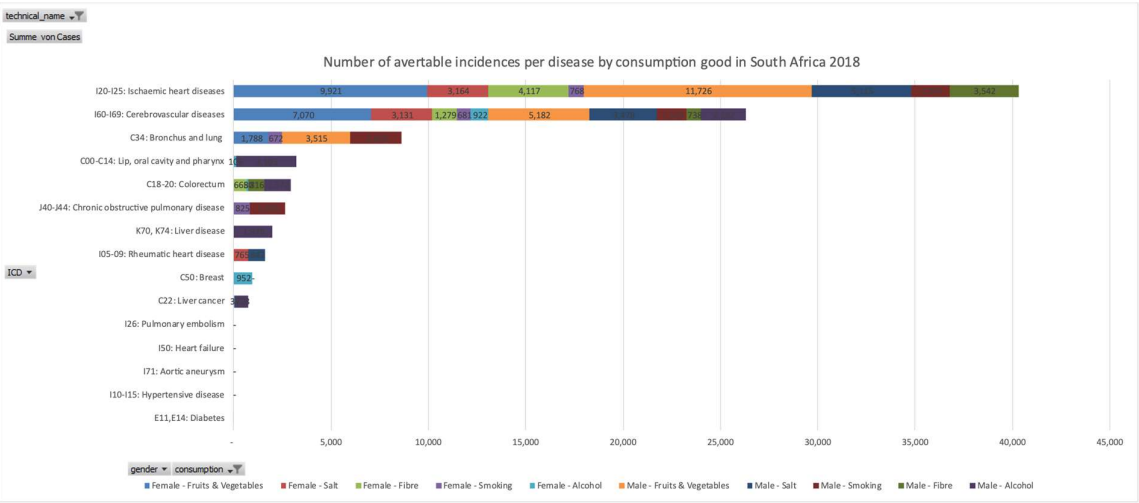

Figure 4. Avertable incidence by disease, risk factor and gender (PRIME)

Finally, we briefly offer insight into the sensitivity of our findings to assumptions related to tobacco consumption. Our initial assumption is based on a 50% risk reduction factor and 50% of smokers switching to less harmful alternatives; see Figure 5, which leads to 10 881 fewer incidences. Doubling the risk reduction factor to 100% – indirectly implying half of all smokers would quit all nicotine products – leads to double the incidence reduction: 21 762 fewer incidences. Relative to the counterfactual avertible incidences, close to 80 000, the overall reduction in incidences would rise to 11% of the baseline, compared to the initially calculated

9.5%. Thus, further progress with regards to smoking cessation would pay substantial dividends.

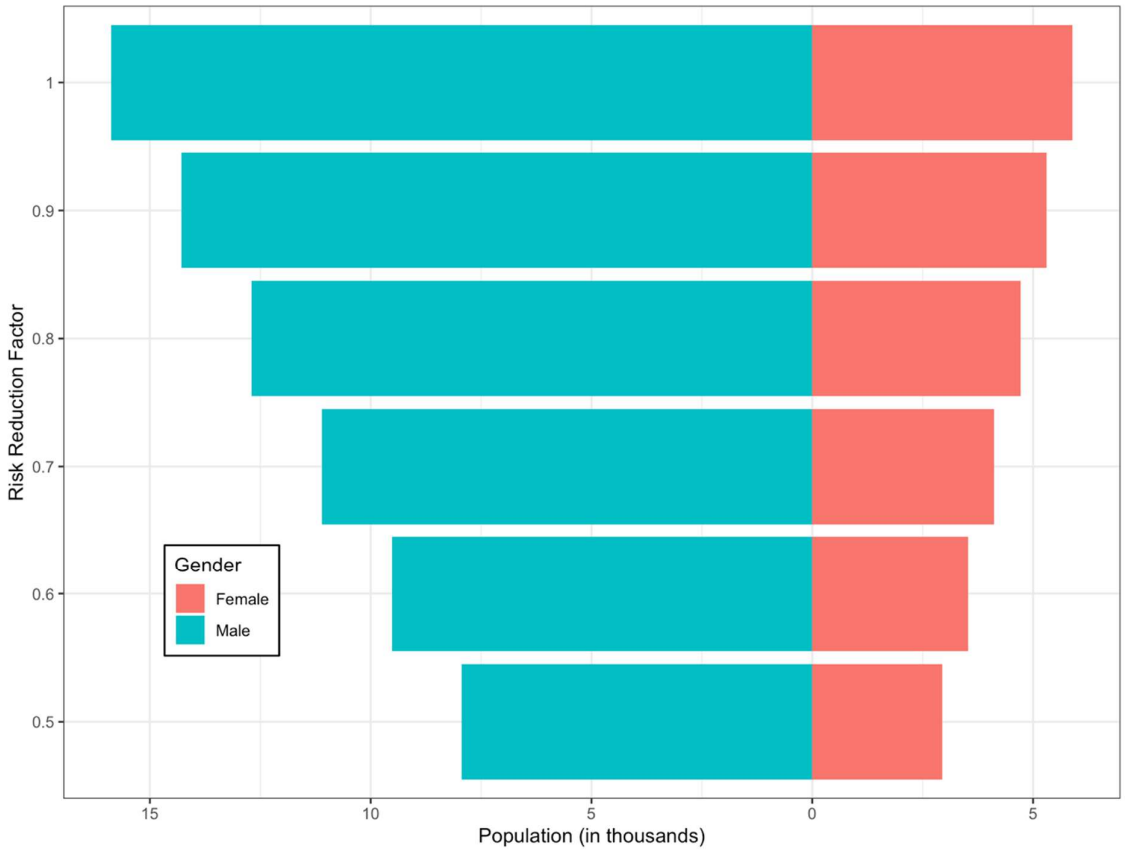

Figure 5 Sensitivity of Incidence to Tobacco Risk Reduction Assumption (PRIME)

CONCLUSION

South Africa is known for its quadruple burden of disease, which includes issues related to communicable diseases, NCDs, maternal and child health, as well as injury-related problems.[5-7] NCDs are a large problem amongst LMICs, while NCDs were amongst the top causes of death in South Africa in 2010; more recent estimates suggest that they account for a large share of the DALYs.[2, 15-16] The government's NCD plan is a response to the threat that NCDs pose on the health of the population, and, by extension, the healthcare system.[32,65-66] Similarly, the government has a variety of policies in place to regulate sugar, salt, tobacco and alcohol, although not all such policies had been fully implemented by 2021.[68-70]

Despite those plans and policies, the initial baseline for our model points to a population consuming too much alcohol and salt, smoking too much, and not consuming enough fruit, vegetables or fiber, which is similar to what the literature has found.[5,6,36,51-53] The model we have applied – the PRIME model – is used to examine the likely impact of reduced NCD risk consumption activities, such as a reduction in tobacco, alcohol and salt or an increase in fruits, vegetables and fiber.[90] The reductions that we assume are in line with WHO recommendations, and match the government's NCD plans.

Our baseline data suggests that NCD incidences are higher for women than for men, primarily due to cervical and breast diseases, despite the fact that NCD behaviours are riskier for men than for women. After applying our counterfactual scenario, we find an approximate 10% reduction in NCD incidence. However, due to the fact that NCD risky behaviour was initially higher for men, they would need to reduce the risks associated with their behaviour by more than women would; thus, we find that NCD incidence falls by more for men than women.

Political action is required to realise the potential gains from a significant reduction in NCD incidence from less harmful consumption. An appropriate policy approach that incentivizes South Africans to reduce unhealthy consumption is crucial to improving public health. This approach does not necessarily require costly interventions. While a change in dietary lifestyle primarily depends on income levels, restricting alcohol consumption and smoking are relatively easy objectives to reach. The illicit share of both products' markets is rather significant. Policymakers could and should do more to control the illicit market. Simultaneously, they should promote less harmful alternatives, such as e-cigarettes, heat-not-burn products, and low-alcohol beverages. Incentivizing less harmful alternatives implies lower taxation compared to their more harmful counterparts. By doing so, consumers would be incentivized to consume those less harmful alternatives, rather than purchasing illicit products of questionable quality. Individual health would improve as a result, reducing NCDs. Additionally, the state treasury could see a much-needed improvement thanks to the partial recovery of South Africa's tax losses from illicit trade.

Key findings:

1. *10% of NCD incidences could be prevented if South Africa's government was able to convince adults to make less harmful consumption choices.*
2. *While a healthier diet often depends on income growth and is difficult to influence for authorities, information- and education-raising campaigns could empower South Africa's citizens to consume more consciously.*
3. *In comparison to complex dietary-influencing measures, alcohol and tobacco are regulatory low-hanging fruits. The government could enforce illicit market restrictions and promote less harmful alternatives with lower tax rates.*
4. *Both approaches could improve public health, thereby reducing NCD cases and compensating for South Africa's tax losses.*

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