The Effectiveness of Sin Taxes on Public Health and Revenue Generation in Tuvalu: Insights from New Zealand.

By

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Abstract

Tuvalu faces a dual challenge of high non-communicable disease (NCD) burdens and constrained fiscal capacity. This thesis investigates whether excise taxes on sugar-sweetened beverages (SSBs), alcohol, and tobacco can improve health outcomes and provide a stable revenue base. Using New Zealand's Pacifica population as a proxy, Household Economic Survey (2006–2019) records were linked to pharmaceutical dispensing, hospitalisation, and mortality data within the Integrated Data Infrastructure. Logistic regression models were estimated to examine whether household expenditure shares on sin goods predict chronic disease medication uptake and mortality. Households in the highest SSB expenditure tier had 36 % higher odds of diabetes-management prescription uptake (OR = 1.36, $p < 0.01$). Cardiovascular medication outcomes showed modest but statistically significant increases in odds, including diuretics (OR ≈ 1.16, $p < 0.05$) and beta-blockers (OR ≈ 1.22, $p < 0.01$). Mortality associations were mixed: SSB-only expenditure was associated with lower odds of mortality among those aged 60+ (OR ≈ 0.75, $p < 0.01$), whereas broader sin-goods measures, particularly those including tobacco, were linked to higher mortality odds (OR ≈ 1.56, $p < 0.01$). Within the Pacifica subsample, effect directions were similar but rarely statistically significant, reflecting smaller sample sizes and contextual constraints. These findings suggest that excise taxes can influence health outcomes, particularly for diabetes management, while mortality effects vary by product scope and population group. Expenditure shares were relatively consistent across income groups, implying a stable fiscal base. However, this study does not estimate price elasticities and therefore does not quantify revenue effects. Because excises are financially regressive, earmarking revenues for health promotion and supporting affordable substitutes are recommended to mitigate distributional concerns. Overall, well-designed excise taxes show conditional promise for improving health outcomes in Tuvalu when paired with broad coverage, adequate rates, and ongoing evaluation.

Attestation of Authorship

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Access to the data used in this study was provided by Stats NZ under conditions designed to give effect to the security and confidentiality provisions of the Data and Statistics Act 2022. The results presented in this study are the work of the author, not Stats NZ or individual data suppliers.

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1. Introduction

Non-communicable diseases (NCDs) are now the leading cause of morbidity and mortality worldwide, contributing to high rates of premature death and escalating health expenditures. The burden is particularly severe in Pacific Island countries such as Tuvalu, where shifts from traditional diets to imported, energy-dense processed foods and sugar-sweetened beverages (SSBs) have accelerated the rise of obesity, diabetes, and cardiovascular diseases. Governments across the globe have increasingly turned to fiscal measures, especially excise taxes on unhealthy products, as a policy tool to discourage harmful consumption and generate revenue for public spending. (Chaloupka et al., 2019).

The economic rationale for such interventions is grounded in Pigouvian theory: taxes can correct for negative externalities, such as higher public health costs associated with poor diets. More recent contributions from behavioural economics emphasise internalities, where individuals underweight or misjudge the long-term costs of consumption due to self-control problems or present-biased preferences. (Lockwood & Taubinsky, 2017; O Donoghue & Rabin, 2006). These frameworks strengthen the case for corrective taxes on goods that are both addictive and harmful, aligning private choices with long-term health and social welfare.

Empirical evidence supports the effectiveness of SSB taxation. Real-world evaluations from Mexico and other jurisdictions show sustained reductions in purchases of taxed beverages following the introduction of excise taxes, with greater declines observed among lower-income households.(Colchero et al., 2017). In Catalonia, a tiered SSB tax was associated with reduced sales of taxed drinks and partial substitution into untaxed, lower-sugar alternatives. This led to a 2.2 per cent reduction in sugar purchases from beverages. (Fichera et al., 2021). The World Health Organisation recommends excise rates of at least 20 per cent to achieve meaningful reductions in consumption. (WHO, 2016).

At the same time, concerns have been raised about regressivity: because lower-income households devote a higher share of their budgets to taxed goods, the financial burden may appear disproportionate. However, evidence suggests that low-income households also show the most significant behavioural responses to price increases, leading to greater health gains over time (Powell et al., 2013; Teng et al., 2021a). In Tonga, for example, repeated household expenditure surveys found that introducing an SSB excise tax reduced soft drink spending while encouraging substitution towards bottled water, with low-income households displaying slightly greater reductions in soft drink expenditure (Teng et al., 2021a). These findings illustrate the dual character of such taxes: while potentially regressive in financial terms, they can be progressive in health outcomes.

Pacific Island experiences offer particularly relevant insights. In the Cook Islands, increased tariffs on sweetened beverages were associated with declines in imports of taxed products, although this was partly reversed when taxes were later reduced (Teng et al., 2021c). Recent survey-based research across multiple Pacific countries highlights that fiscal measures are important for addressing NCDs. However, their success depends on careful design, earmarking, and integration with broader health strategies (Buksh et al., 2023; Walby et al., 2023). These lessons are critical for Tuvalu, which already applies taxes on imported sin goods but continues to face severe NCD burdens and fiscal challenges.

The aim of this thesis is to examine the association between household expenditure on selected 'sin goods' (including sugar-sweetened beverages, alcohol, and tobacco) and health-related outcomes in New Zealand, with a focus on Pacific households as a proxy for Tuvalu. Rather than estimating tax effectiveness or causal health impacts, the analysis provides descriptive evidence on how expenditure patterns are linked to medication uptake, hospitalisation, and mortality indicators. These associations are intended to inform policy discussions on sin tax design in Tuvalu, while acknowledging that population health and fiscal consequences ultimately depend on implementation choices and broader contextual factors.

This thesis uses New Zealand's Pacific populations as a proxy group to provide empirical insights relevant to Tuvalu. New Zealand's Integrated Data Infrastructure (IDI) contains rich linked microdata that enable household expenditure on sin goods to be connected to subsequent health-related outcomes. By leveraging these data, the study generates descriptive evidence that would not otherwise be feasible in a small island context such as Tuvalu.

The remainder of this thesis is structured as follows. Chapter 2 reviews the theoretical foundations and empirical evidence on sin taxes, focusing on global, regional, and equity perspectives. Chapter 3 describes the data sources used, and Chapter 4 presents descriptive statistics. Chapter 5 outlines the methodological approach, while Chapter 6 reports the empirical results. Chapter 7 discusses the findings considering existing evidence and its implications for Tuvalu, and Chapter 8 concludes.

2. Literature Review

2.1 Overview of Sin Taxes

Sin taxes are taxes applied to goods that impose negative health and social costs, such as alcohol, tobacco, and sugar-sweetened beverages (SSBs). Their rationale has evolved from primarily a fiscal instrument to serving a dual role of raising government revenue and improving public health (Chaloupka et al., 2019). While historically many governments levied such taxes mainly to secure revenue streams, they are increasingly employed as corrective tools to alter consumption behaviour and reduce the burden of non-communicable diseases (Wright et al., 2017).

The theoretical basis for sin taxes rests on two complementary ideas. First, following Pigou's classic framework, taxes can internalise negative externalities by embedding the social costs of consumption, such as increased public health expenditures and reduced productivity, into the price consumers pay. Second, behavioural economics highlights the problem of internalities, where individuals misjudge or undervalue the long-term health risks of their choices because of self-control problems or present-biased preferences. In such cases, corrective taxation improves welfare even without externalities, by nudging individuals towards healthier long-term behaviours (Lockwood & Taubinsky, 2017; O Donoghue & Rabin, 2006).

Policy frameworks emphasise that these taxes rarely succeed in isolation. McCoy et al. (2017) conceptualises their contribution through the "Five R's": representation, revenue, redistribution, re-pricing, and regulation, highlighting their role in governance and public health. The WHO (2016) recommends that SSB taxes be set at a minimum of 20 per cent to reduce consumption meaningfully. It notes that earmarking revenues for health programmes or pro-poor initiatives enhances effectiveness and political support.

In practice, well-designed sin taxes are expected to achieve three goals simultaneously: (i) discourage consumption of harmful goods, (ii) provide stable government revenue, and (iii) improve population health outcomes, particularly when revenues are earmarked for preventive programmes. However, the balance between these objectives depends heavily on policy design, enforcement, and political context.

For Tuvalu, the theoretical rationale for sin taxes is especially compelling. As a small island state with high reliance on imported food and beverages, a heavy burden of NCDs, and limited fiscal capacity, corrective taxes serve as both a public health necessity and a vital revenue source. Pacific case studies such as Tonga and the Cook Islands provide empirical illustrations of these principles,

demonstrating how taxation can alter consumption and revenue patterns in contexts closely comparable to Tuvalu (Teng et al., 2021a; Teng et al., 2021c).

2.2 Theoretical Framework

A coherent understanding of sin taxes requires a strong theoretical foundation that explains why governments intervene in the market for goods such as sugar-sweetened beverages (SSBs), alcohol, and tobacco. Economic and public health rationales converge around five pillars: (1) externalities, (2 and 3) internalities and behavioural biases, (4) optimal tax design, and (5) welfare and equity trade-offs. Together, these provide the conceptual scaffolding for evaluating whether such taxes are justified and how they can be designed to achieve their objectives effectively**.**

2.2.1 Externalities

The starting point for sin taxes is the correction of negative externalities. Externalities occur when the consumption of a good imposes costs on others that are not reflected in its market price. In the case of SSBs, these costs are borne mainly by public health systems and society. Excessive intake of added sugars is strongly linked to obesity, type 2 diabetes, cardiovascular disease, and dental caries. These conditions generate substantial treatment costs that, in many countries, are funded through public expenditure. For instance, the WHO (2016) emphasises that diet-related diseases are a leading cause of noncommunicable disease (NCD) morbidity and mortality globally, and that fiscal policies such as excise taxes are among the most cost-effective levers for prevention.

From a Pigouvian perspective, the solution is to impose a tax equal to the marginal social cost of consumption. Brownell et al. (2009) reasoned that this approach was widely applied in the public health domain, noting that the social costs of obesity and diabetes justified a corrective price signal on SSBs. Jackson and Saba (1997) argue that excise taxes on harmful goods are economically efficient when they internalise external costs, raising prices so that consumers face the full marginal social cost of their choices (see also (WHO, 2016)). The logic is simple: without taxation, SSBs are under-priced relative to their actual cost, leading to overconsumption and inefficiency.

The externality rationale is particularly acute in small island developing states (SIDS) such as those in the Pacific. Buksh et al. (2023) Documents how imported sugary foods and beverages

dominate local diets in Tonga and Fiji, generating high rates of obesity and diabetes. The fiscal burden of treating these diseases is severe, given limited public budgets and small tax bases. By internalising externalities, corrective taxation addresses health inefficiency and fiscal sustainability. This explains why WHO (2016) Explicitly recommends excise rates of at least 20 per cent of the retail price to generate meaningful consumption changes and offset health system costs.

Externalities thus provide the first theoretical justification: sin taxes correct a divergence between private consumption and social costs. Without them, consumers are not paying the full price of the harm their choices create for society.

2.2.2 Internalities and Behavioural Biases

While externalities justify taxation on social grounds, a second pillar emphasises internalities: the private costs individuals impose on themselves through biased or myopic decision-making. Consumers often make choices that undermine their long-term welfare, even when those choices do not immediately harm others. Internalities recognise that rational choice assumptions often fail in the presence of addiction or bounded self-control.

O Donoghue and Rabin (2006) model of time-inconsistent preferences shows that present-biased consumers overvalue short-term gratification and undervalue long-term health costs, creating a gap between immediate choices and their own long-run welfare. Applied to SSBs, this means a consumer may choose a sugary drink for immediate taste satisfaction, despite knowing that repeated consumption increases their future risk of obesity and diabetes. These self-imposed costs are not weighed adequately at the decision point, resulting in overconsumption.

Behavioural economics provides further insight into the mechanisms behind internalities, explaining why overconsumption persists even when individuals intend to cut back. This gap between intention and action, sometimes called the self-control problem, is directly addressed by excise taxes, which increase the salience and cost of immediate consumption.

Brownell et al. (2009) argue that this function of taxation positions sin taxes as commitment devices. By raising the upfront price of SSBs, taxes reduce impulsive overconsumption and enable consumers to act more consistently with their long-term intentions.

Moodie et al. (2013) emphasises that such structural interventions are particularly valuable because they do not depend on individual willpower or sustained attention, which are often weak in real-world settings. Instead, the tax automatically shapes behaviour across the population, leveraging salience to shift consumption patterns.

Behavioural insights also extend to addiction. Bossi et al. (2008)'s model how addictive goods create reinforcing cycles of consumption, where present bias and habit formation lead to excessive use relative to the social optimum. These patterns generate welfare losses that consumers themselves would prefer to avoid. Time-consistent taxation improves welfare by internalising self-control problems and externalities accumulated over repeated use in their framework. This logic echoes the broader evidence from tobacco and alcohol, where sustained excise taxation has reduced initiation and dependence.

This framework reframes the role of government: rather than restricting freedom, corrective taxation helps individuals achieve outcomes they would prefer without cognitive and behavioural barriers. For Pacific nations facing escalating NCD burdens, internalities are especially relevant. In such contexts, taxation addresses internalities by counterbalancing present bias and supporting individuals in making healthier decisions.

2.2.3 Information Failures

A separate but related market failure arises from imperfect information. Consumers may underestimate calorie and sugar content, misjudge the health risks of added sugar, and face products that are marketed aggressively with limited nutritional labelling (Buksh et al., 2023). Public health campaigns and nutritional labelling aim to close these gaps, but information alone rarely produces sustained behaviour change. Fiscal measures complement these interventions by making health costs more salient at the point of purchase (Moodie et al., 2013; WHO, 2016).

2.2.4 Optimal Tax Design

The fourth pillar focuses on how sin taxes should be designed to achieve their objectives. Classical tax theory emphasises efficiency: the tax should be set at a level equal to the marginal externality or internality. However, practical design requires attention to tax structure, coverage, and substitution.

At the same time, behavioural perspectives highlight potential pitfalls. If taxes are too narrowly designed, consumers may switch to equally harmful untaxed substitutes, diluting welfare gains. Arnabal (2021) notes that behavioural responses, such as substitution, require careful tax-base design. For example, if powdered juices or low-cost imports are untaxed, consumers may divert spending without improving their health. This insight bridges theory and policy, stressing that the rationale and design of taxation must account for behavioural responses.

Chaloupka et al. (2019) have highlighted how health-motivated excise tax draws on lessons from tobacco and alcohol. Specific excises based on sugar content or volume tend to be more effective than ad valorem rates, because they directly target the harmful consumption component. The WHO (2016) similarly emphasises that design choices such as applying taxes to all categories of SSBs, including juices and energy drinks, are critical for achieving meaningful reductions in sugar intake.

Arnabal (2021)'s theoretical contribution underscores the risk of partial taxation. If only a narrow subset of sugary beverages is taxed, consumers can switch to untaxed alternatives, weakening efficiency and health outcomes. The implication is that the breadth of the tax base is as important as the rate itself. Buksh et al. (2023) reinforces this point in the Pacific, observing that narrow tax bases limited the effectiveness of early fiscal measures in Tonga and Fiji. Broader coverage and clear definitions of taxable products ensure that behavioural responses do not undermine policy intent. Pacific case studies reinforce this principle. In both Fiji and the Cook Islands, incomplete tax coverage and reduced effective rates undermined health objectives by allowing untaxed sugary beverages to re-enter the market (see Section 2.3.3). These experiences highlight that comprehensive coverage and consistent enforcement are critical for sustaining health gains and preventing policy reverting.

Design also intersects with equity. Lockwood and Taubinsky (2017) argue that optimal tax design balances corrective benefits with concerns about regressivity. This means that, beyond setting a high enough rate to shift behaviour, governments must also consider earmarking revenue for pro-poor programs or coupling taxes with subsidies for healthier foods. Such measures enhance both effectiveness and fairness.

In sum, optimal tax design is not just about raising prices. It requires attention to structure (specific vs ad valorem), scope (broad vs narrow base), and accompanying measures (subsidies, earmarking). The theoretical literature agrees that a well-designed SSB tax must address substitution, salience, and equity to achieve its intended corrective effects.

2.2.5 Welfare and Equity Trade-offs

The final pillar recognises that taxation inevitably involves distributional consequences. Even if a tax efficiently corrects externalities and internalities, its welfare implications depend on how the burden is shared across income groups.

Lockwood and Taubinsky (2017) provide a rigorous framework for evaluating this balance. They demonstrate that while sin taxes may be financially regressive, imposing a larger share of income

from poorer households, they can be progressive in health terms, since these same households often consume more of the taxed good and are more responsive to price changes. Evidence from modelling and empirical studies shows that the most significant absolute health gains accrue to high-consuming, lower-income groups, meaning that the welfare gain from reduced consumption can outweigh the financial cost (Brownell et al., 2009; Moodie et al., 2013; WHO, 2016).

This duality reframes regressivity. A narrow focus on tax burden overlooks the corrective benefits of improved health outcomes and reduced long-term expenditures. WHO (2016) highlights that earmarking revenues for health programs or subsidies can further offset regressivity, turning fiscal instruments into equity-enhancing tools. Moodie et al. (2013) similarly argue that integrating SSB taxation into a comprehensive package of NCD prevention measures amplifies both cost-effectiveness and fairness.

Pacific evidence reinforces this perspective. Walby et al. (2023) note that earmarking revenues for community health programs improved the political acceptability of fiscal measures in Tonga and Fiji, helping to counter concerns that the taxes unfairly penalised low-income households. Buksh et al. (2023) echo this point, showing that broader tax bases and revenue recycling enhance both effectiveness and equity.

From a theoretical standpoint, the welfare calculus of sin taxes involves balancing two terms:

- Corrective benefit = reduction in externalities + reduction in internalities + health gains from reduced consumption
- Regressivity cost = disproportionate financial burden on low-income households Optimal policy maximises net welfare by ensuring that the sum of corrective and health benefits outweighs the regressivity cost. This framing is particularly relevant to the present study, which links household expenditure patterns to health outcomes to evaluate whether the associated health improvements justify the tax burden. Where regressivity is a concern, complementary measures such as subsidies, earmarking, or public health investments can tilt the balance in favour of equity. In sum, embedding SSB taxation within a broader suite of preventive measures strengthens both cost-effectiveness and fairness.

2.3 Effectiveness of Sugar-Sweetened Beverage Taxes

The preceding theoretical framework establishes the rationale for sugar-sweetened beverage (SSB) taxation: these measures correct negative externalities, internalities, and behavioural biases, while balancing welfare gains against equity trade-offs. The next question is whether these

conceptual justifications translate into real-world effectiveness. Specifically, do SSB taxes succeed in reducing purchases and consumption of sugary drinks? This section reviews the empirical evidence, beginning with global meta-analyses and systematic reviews, before turning to individual case studies, substitution dynamics, and the experience of Pacific Island countries. Focusing on consumption and purchasing responses distinguishes effectiveness from health outcomes (discussed in Section 2.4) and revenue implications (Section 2.5).

2.3.1 Global Evidence on Consumption Reduction

Evidence from systematic reviews consistently shows that SSB demand is responsive to price, providing strong support for fiscal policy. Andreyeva et al. (2010) Conducted one of the earliest comprehensive syntheses, covering 160 price elasticity studies across foods and beverages. They reported that elasticity estimates varied across beverage categories, with soft drinks around –0.79 and other non-alcoholic beverages closer to –1.21. This range implies that a 10 per cent increase in price reduces consumption by approximately 8–12 per cent. The review emphasised that non-essential, energy-dense drinks are particularly sensitive to price shifts, supporting the case for excises on SSBs.

Powell et al. (2013) reviewed observational and modelling studies of taxes and subsidies. They concluded that small sales taxes of 2–3 per cent were too weak to shift behaviour, explaining the null effects of early U.S. state-level policies. Larger, excise-style taxes of 10–15 per cent or more were consistently associated with reductions in consumption. Notably, the review noted heterogeneity across population groups: youth and lower-income consumers showed stronger responses because SSBs represent a greater share of their diets and are more price sensitive. This distributional pattern directly affects effectiveness and later debates about regressivity.

Andreyeva et al. (2010) systematically reviewed experimental and observational food pricing studies. They found that at least 10 per cent relative price shifts were needed to generate meaningful dietary changes, with substitution toward healthier items observed in laboratory and field settings. Although the review covered a broad set of foods and beverages, its conclusions reinforced the idea that price signals of a substantial magnitude can realign consumption patterns, particularly when healthier substitutes are available.

Teng et al. (2019) The most comprehensive synthesis reviewed 17 real-world evaluations of SSB taxes implemented between 2014 and 2018. Their meta-analysis showed that a 10 per cent tax reduced purchases or dietary intake by an average of 10 per cent. This one-to-one ratio has become a widely cited benchmark. Teng also highlighted important heterogeneity: in Mexico, reductions were concentrated among low-income households, while in Catalonia, substitution toward water

and low-sugar alternatives reinforced the tax's effectiveness. Conversely, in some contexts, substitution was weaker or less healthy. These differences underscore that design and context condition the degree of effectiveness.

Collectively, these reviews confirm that demand for SSBs is elastic, with proportional reductions in consumption following proportional increases in price. They also establish that tax magnitude matters; trivial sales taxes are ineffective, while 10–20 per cent excises consistently alter behaviour.

While systematic reviews provide global averages, case studies reveal how specific tax designs perform. Mexico implemented a one peso per litre excise on SSBs in 2014, equal to roughly 10 per cent of the average pre-tax price. Colchero et al. (2017) evaluated the policy using Nielsen household panel data covering more than 6,000 households across 53 cities, employing a difference-in-differences design that compared taxed and untaxed beverages before and after implementation. They found a 5.5 per cent decline in purchases during the first year, which deepened to 9.7 per cent in the second year. The most significant reductions occurred among low-income households, whose purchases fell by 17 per cent in year two. At the same time, purchases of untaxed beverages, especially bottled water, increased. This case is notable for its scale and persistence: effects were more potent in the second year, countering claims that taxes only yield short-lived behavioural change.

In Catalonia, Spain, a tiered tax was introduced in 2017: €0.08 per litre for drinks with 5–8g of sugar per 100ml and €0.12 for drinks above 8g. Fichera et al. (2021) evaluated the policy using household purchase data and a difference-in-differences design comparing Catalonia with other Spanish regions. They found that household purchases of sugar from SSBs fell by 2.2 per cent overall. While this reduction appears modest compared to Mexico, context matters: baseline consumption in Spain was lower than in Mexico, and the tax design was narrower in scope. Importantly, substitution effects were positive: households increased bottled water purchases and low-sugar drinks. The study illustrates that even smaller measured reductions can still represent meaningful dietary shifts when reinforced by healthier substitutions.

The United Kingdom's Soft Drinks Industry Levy (SDIL), implemented in April 2018, adopted a tiered structure: 18 pence per litre for drinks with 5–8g sugar per 100ml and 24 pence for those above 8g. Wright et al. (2017) described the design rationale, highlighting that the levy sought to raise prices and incentivise manufacturers to reformulate products. Fichera et al. (2021) confirmed empirically that reformulation occurred: many manufacturers reduced sugar concentrations below taxable thresholds, and purchases of high-sugar drinks declined. While reductions in overall sugar intake were smaller than in Mexico, the UK case demonstrates how content-based, tiered designs can achieve effectiveness through consumer behaviour and producer reformulation. The difference between the UK and Catalonia also underscores the role of national scope: as a country-

wide policy with strong pre-implementation signalling, the UK levy prompted proactive industry responses even before enforcement.

The global evidence demonstrates that SSB taxes are effective when designed with adequate magnitude and scope. Systematic reviews converge on an elasticity near -1, showing proportional reductions in consumption with price increases. Mexico's experience illustrates substantial, persistent reductions under a straightforward excise; Catalonia shows that even modest changes can shift behaviour when healthier substitutes are available; and the UK levy highlights how design innovations such as tiered, content-based rates can stimulate reformulation and consumer substitution.

Three lessons emerge. First, low-income households are consistently more responsive, as seen in Mexico and highlighted in systematic reviews. This responsiveness reflects budget constraints and higher baseline consumption, which affect effectiveness and health equity. Second, baseline context shapes measured outcomes: Catalonia's relatively small reduction must be interpreted against lower starting levels of consumption, demonstrating that "effect size" depends on where a population begins. Third, design matters: simple volumetric versus tiered (sugar-content) excise structures, narrow versus broad bases, and pre-implementation signalling affect taxes' performance.

These findings validate the theoretical rationale in Section 2.2: by raising prices, SSB taxes correct externalities and internalities, and empirical evidence shows that consumers respond as predicted. The following subsection examines substitution effects in greater detail, since the ultimate impact of taxation depends on whether reduced purchases of taxed beverages are replaced with healthier options or merely diverted to other sugary products.

2.3.2 Substitution Effects

Effectiveness depends not only on how much taxed SSB purchases fall, but on what consumers switch to instead. Beneficial substitution into water or lower-sugar drinks amplifies health gains, while switching to untaxed sugary products can dilute them.

Global evidence indicates that most consumers do not fully offset SSB reductions with other caloric beverages. In a meta-analysis of real-world taxes, Teng et al. (2019) found no significant increase in untaxed sugary beverage purchases following implementation; some jurisdictions even reported small rises in water consumption. This suggests that observed SSB declines represent genuine reductions in sugar exposure rather than displacement to other sweetened drinks.

Pacific results reinforce this pattern. In Tonga, the 2016–2017 reforms were followed by lower soft-drink expenditure and higher bottled-water purchases, and the subsequent broadening of the tax to sugary juices and sachets closed a major substitution loophole Evidence also demonstrates that narrow excise bases can create substitution pathways into untaxed sugary products rather than healthier alternatives. This pattern is evident in the Cook Islands case, where regulatory gaps and reduced effective rates enabled reversals in taxed-beverage outcomes (see Section 2.3.3). Researchers warned that exempting ASBs risks encouraging unhealthy substitution and recommended comprehensive coverage.

The health effects of artificially sweetened beverages (ASBs) remain contested. Cleghorn et al. (2018) found that ASB consumption lowers calorie intake relative to SSBs in the short run but reported uncertainty regarding long-term impacts on weight and metabolic health. Both ASBs and SSBs contribute to dental erosion, making water the superior substitute.

Policy implication: To maximise health gains, excise structures should apply broadly, covering juices, concentrates, and ASBs and be complemented by measures that make water accessible and affordable. This combination ensures that reductions in SSB purchases translate into meaningful health improvements rather than being offset by unhealthy substitution.

2.3.3 Pacific Evidence on Effectiveness

Pacific Island countries have pioneered SSB excises in low- and middle-income contexts, motivated by high NCD burdens and constrained fiscal capacity. Their experience provides direct lessons for Tuvalu, showing both the potential of excises to reshape consumption and the vulnerabilities of small-state tax systems.

Tonga

Tonga has one of the longest fiscal histories in the region. Excises were introduced in 2013 at T$0.50 per litre, replacing a 15% tariff, and doubled in 2016 to T$1.00 per litre (Teng et al., 2021a). Household survey evidence shows that following these increases, soft-drink expenditure fell while bottled-water purchases rose, consistent with healthier substitution. (Teng et al., 2021a). Import data also confirmed substantial pass-through into prices and reductions in soft-drink imports (Teng et al., 2021a). Local reporting further noted a marked rise in bottled-water output after 2016, though the precise figures vary by source (Walby et al., 2023).

Design changes introduced in the 2016/17 health tax package illustrate risks of loopholes. In Tonga, artificially sweetened beverages (ASBs) continued to be taxed, unlike in some neighbouring countries, but the episode highlights how scope matters for sustaining health gains

(Teng et al., 2021a). Tonga demonstrates both the potential for SSB taxes to shift demand toward healthier options and the fragility of outcomes when tax design leaves categories untaxed.

Fiji

Fiji's taxation history underscores both ambition and volatility. Excises on carbonated drinks were introduced in 2006 and sharply increased in 2011, producing initial declines in taxed beverage imports (Buksh et al., 2023). However, subsequent scope adjustments and enforcement weaknesses allowed reversals, with untaxed sugary beverages regaining market share. Buksh et al. (2023) Highlights Fiji's case shows how narrow bases and limited monitoring capacity erode effectiveness, especially in settings with strong industry influence.

Cook Islands

The Cook Islands introduced tariffs on SSBs in 2002 and 2008, raising them again in 2012. These measures reduced taxed product imports (Teng et al., 2021c). In 2014, the government shifted from tariffs to a sugar-specific excise. The new excise excluded juices, powdered sachets, fountain drinks, flavoured milk, and removed tax from ASBs, lowering the effective rate by roughly 11 percentage points compared to the prior tariff (Teng et al., 2021c; Walby et al., 2023).

The result was a drop in indicator prices and a rebound in sweetened-beverage imports (Teng et al., 2021c). Import data showed increased sales of full-sugar beverages, while low-sugar (including ASB) sales dipped in the first year but rose in the second (Teng et al., 2021c). There was little evidence of substitution into milk or juice, though some movement into bottled water was possible. Researchers explicitly warned that exempting ASBs risks encouraging unhealthy substitution, recommending that excises extend to cover them (Walby et al., 2023).

Cross-cutting Pacific Lessons

Three lessons cut across these experiences. First, initial effectiveness is genuine: Tonga, Fiji, and the Cook Islands recorded measurable declines in taxed-beverage consumption or imports immediately after excise increases. (Buksh et al., 2023; Teng et al., 2021a; Teng et al., 2021c). Second, scope and consistency determine durability: Tonga's broad 2016 coverage strengthened substitution into water. However, experiences in Fiji and the Cook Islands show that narrow bases or reduced effective rates can allow consumption patterns to revert, underscoring that durable impact depends on tax-base breadth and enforcement consistency (see Section 2.3.3). Third, administrative and cultural contexts matter: Walby et al. (2023) Highlights how small states face monitoring constraints, industry lobbying, and cultural preferences that limit the long-run strength of fiscal tools.

From a design standpoint, two points are clear. Taxes need to generate price rises of at least 20 per cent to shift behaviour meaningfully, as WHO (2016) Stresses and earmarking revenues for

health or community programmes strengthen acceptability (Buksh et al., 2023). At the same time, broad coverage including juices, concentrates, and ASBs is essential to prevent unhealthy substitution pathways.

Pacific evidence confirms that excises on SSBs can reduce consumption, but effectiveness is fragile when tax bases are narrow, meaning when only a subset of sugary beverages are taxed, and other high-sugar products remain untaxed because consumers may substitute into untaxed alternatives, or enforcement is inconsistent. These patterns are evidenced in the Pacific: broader coverage in Tonga supported substitution into bottled water (Teng et al., 2021a). These cases show that when tax design is narrow or enforcement is inconsistent, observed gains can erode over time (see Section 2.3.3). Tonga demonstrates success when coverage is comprehensive, with bottled water replacing soft drinks (Teng et al., 2021a), and Fiji shows how loopholes and reversals undo progress (Buksh et al., 2023). For Tuvalu, the lesson is clear: excise taxes are practical tools, but only when paired with a broad scope, consistent enforcement, and integration into wider NCD strategies.

2.3.4 Heterogeneity in Effectiveness

While aggregate evidence shows that SSB taxes reduce purchases, effectiveness is not uniform across all populations or contexts. Responsiveness varies systematically by income level, age group, baseline consumption, cultural context, and tax design. Understanding these heterogeneities is crucial for interpreting global and Pacific evidence and assessing taxation's likely impact in Tuvalu (Powell et al., 2013; Teng et al., 2019).

Income-Based Heterogeneity

The most consistent finding across the literature is that low-income households are more price responsive. Powell et al. (2013) observed that youth and lower-income consumers exhibited stronger demand elasticity than other groups, reflecting the larger budget share devoted to sugary drinks among these populations. This dynamic has been confirmed in Mexico: following the 2014 excise, low-income households reduced purchases of taxed beverages by 17 per cent by the second year, compared to the national average reduction of 9.7 per cent. At the same time, these households increased water purchases, demonstrating stronger responsiveness and healthier substitution pathways (Colchero et al., 2017). This distributional pattern implies that, while excises are financially regressive, they are progressive in health terms because the largest absolute reductions in sugar intake accrue to those at the highest baseline risk (Powell et al., 2013; WHO, 2016). Evidence from the Pacific aligns with this pattern. In Tonga, reductions in SSB expenditure were steeper for low-income groups, who substituted more towards bottled water (Teng et al.,

2021a). Equity analysis from Tonga confirms that these reductions were largest among low-income households, who also shifted toward bottled water, reinforcing that SSB taxes can deliver disproportionately large health gains to disadvantaged groups (Teng et al., 2021a). These findings suggest that fiscal measures can deliver progressive health benefits even if their immediate financial burden appears regressive.

Ethnic Heterogeneity

New Zealand evidence offers a valuable proxy for Pacific populations abroad. Using Household Economic Survey data, Nghiem et al. (2022) showed that Pacifica households devoted higher shares of their food budgets to sugary drinks than other ethnic groups, reinforcing the regressive potential of excises in financial terms. At the same time, given the high rates of obesity and diabetes in these communities, health benefits from reduced consumption could also be disproportionately large.

Age-Based Heterogeneity

Youth populations often show higher responsiveness to price shifts. In the United States, Powell et al. (2013) found that children and adolescents were particularly susceptible to SSB price changes, a finding echoed in global systematic reviews that highlighted greater substitution flexibility among younger consumers (Andreyeva et al., 2010; Teng et al., 2019). By contrast, Pacific evaluations have not yet disaggregated outcomes by age. Studies from Tonga, Fiji, and the Cook Islands report overall reductions but do not provide separate estimates for children or adolescents (Buksh et al., 2023; Teng et al., 2021a; Walby et al., 2023). This gap is significant given the youthful demographics of many Pacific countries, including Tuvalu, where the potential impact of excises on younger consumers may be especially significant.

Baseline Consumption and Cultural Context

Baseline levels of SSB intake also condition effectiveness. In Mexico, where consumption was among the highest globally, even modest excises produced significant absolute reductions in intake (Colchero et al., 2017). By contrast, in Catalonia, where baseline consumption was lower, Fichera et al. (2021) only a modest but statistically significant 2.2 per cent reduction in purchased sugar from SSBs were documented. The more negligible effect reflects the lower starting point, illustrating the need to interpret measured effectiveness against baseline prevalence. In the Pacific, baseline consumption is exceptionally high, reflecting the dominance of imported sugary drinks in local diets (Buksh et al., 2023). This means that absolute reductions can be substantial even when percentage changes appear modest. At the same time, cultural and political factors complicate the picture. Walby et al. (2023) emphasised that sugary drinks are deeply embedded in Pacific social practices, and that industry lobbying and community expectations can constrain policy scope and compliance. Importantly, Walby also noted that framing taxes as health measures

and earmarking revenues can improve acceptability, suggesting that consumer price sensitivity and political legitimacy mediate effectiveness.

Design and Enforcement Heterogeneity

Tax design significantly conditions effectiveness. A simple volumetric excise reduced purchases across all groups in Mexico, with more potent effects among low-income households (Colchero et al., 2017). In Catalonia and the United Kingdom, tiered excises tied to sugar content created price gradients that encouraged consumers to switch to lower-sugar alternatives and incentivised producers to reformulate products (Fichera et al., 2021; Wright et al., 2017). These cases demonstrate how content-based designs magnify effectiveness through both consumer and producer channels. By contrast, narrow or inconsistent application weakens impact. These examples highlight how weak design or enforcement can erode gains even in contexts where consumers are price responsive.

Synthesis and Implications

Systematic reviews converge on an elasticity close to -1, meaning that a 10 per cent price increase produces an approximately 10 per cent reduction in intake (Andreyeva et al., 2010; Powell et al., 2013; Teng et al., 2019). Country evaluations confirm this: Mexico demonstrated sustained reductions across the population and especially among low-income groups (Colchero et al., 2017), Catalonia showed minor but significant effects (Fichera et al., 2021), and the UK's tiered levy spurred both consumer substitution and industry reformulation (Wright et al., 2017). In the Pacific, Tonga illustrates how broad coverage drives healthier substitution (Teng et al., 2021a), Fiji shows how weak enforcement can reverse progress (Buksh et al., 2023), and and the Cook Islands illustrate how reducing effective tax rates can reverse progress, even when coverage remains narrow (Teng et al., 2021c; Walby et al., 2023).

These results collectively show that effectiveness varies across income groups, age cohorts, and ethnic communities. Low-income households are most price responsive, youth display stronger substitution toward healthier options, and Pacific populations have higher baseline consumption and therefore greater potential for absolute reductions. This heterogeneity is central to interpreting likely outcomes in Tuvalu, where youthful demographics and high SSB intake suggest that fiscal measures may yield disproportionately large health gains among the most vulnerable groups.

2.4 Health Outcomes Associated with SSB Taxes

Understanding the health outcomes of SSB taxation is central to evaluating its effectiveness as a public health measure. While theoretical and empirical studies consistently show that taxes reduce

purchases and intake, the ultimate objective is to improve population health by lowering obesity, diabetes, and related non-communicable disease (NCD) burdens. This section reviews the evidence linking taxation to health outcomes along the causal chain: from mechanisms and immediate changes in purchases, through reductions in sugar and energy intake, to impacts on BMI and disease indicators. It also considers Pacific case studies, substitution patterns, the influence of tax design, and the limitations that shape current knowledge.

2.4.1 Why SSB taxes affect health

The theoretical justification for sugar-sweetened beverage (SSB) taxation rests on recognising that excess consumption contributes directly to obesity, diabetes, and cardiovascular disease. Brownell et al. (2009) outlined the epidemiological evidence linking SSB intake to adverse outcomes, noting longitudinal studies where higher consumption raised the risk of obesity and diabetes, alongside short-term trials showing weight gain when participants consumed SSBs compared with non-caloric beverages. These findings make clear that SSBs add considerable "empty calories" without nutritional benefit, thereby increasing risks of weight gain and downstream morbidity (Brownell et al., 2009).This framework proposes taxation to reduce intake and generate public revenue to offset health system costs.

Economic theory strengthens this rationale. O Donoghue and Rabin (2006) demonstrated that when individuals face self-control problems, such as underestimating long-term health risks, corrective taxes can improve welfare by realigning private consumption with social and personal goals. Their model shows that even if only a minority of consumers are affected by self-control failures, well-designed taxes can yield Pareto improvements by reducing the overconsumption of harmful goods. More recent theoretical work has introduced the issue of addiction and time consistency. Bossi et al. (2008) argued that for addictive goods such as SSBs, optimal taxation must account for negative externalities and dynamic consumption patterns shaped by habit. They demonstrated that time-consistent implementation of taxes, in the presence of producer market power, may imply lower rates than standard Pigouvian prescriptions. However, the principle remains: sustained taxation is necessary to control long-term harms.

From a health outcomes perspective, the causal pathway extends from tax-induced price rises to reduced purchases, lower intake of free sugars, reduced energy balance, and, over longer horizons, improvements in obesity, diabetes, and cardiovascular outcomes. Most evaluations consequently measure proximal outcomes (sales, purchases, intake). At the same time, clinical endpoints such as BMI or diabetes incidence require longer follow-up and are typically estimated through modelling or cost-effectiveness analysis. This temporal gap between intervention and measurable

health change frames the current evidence base and will guide the discussion throughout this section.

2.4.2 Immediate and intermediate outcomes

Having established that SSB taxes reduce purchases, this subsection considers whether those reductions translate into measurable changes in sugar exposure, energy balance, and early health indicators. These outcomes represent the first link in the causal chain from taxation to improved population health: purchase changes and substitution patterns are the immediate outcomes, while reductions in sugar and energy intake represent intermediate outcomes that precede BMI, diabetes, and other clinical endpoints.

Evidence from Mexico implies that reduced purchasing leads to lower sugar and energy intake. Colchero et al. (2017) report sustained declines in taxed beverage purchases, 5.5 % in the first year and 9.7 % in the second, alongside a 2.1 % increase in untaxed beverage purchases, suggesting favourable substitution and reduced net sugar exposure. Using these observed changes, simulation models project substantial prevention of obesity and diabetes cases over the next decade, with the most significant relative benefits accruing to low-income households Colchero et al. (2017).

Global modelling studies confirm these mechanisms. The WHO (2016) identifies a 20 % SSB tax as a “best buy” intervention that meaningfully reduces BMI, type 2 diabetes incidence, and cardiovascular risk at the population level. Moodie et al. (2013) similarly argue that fiscal measures achieve health gains by shifting whole-population consumption downward, making them more effective and sustainable than interventions relying solely on individual behaviour change.

Together, these findings show that SSB taxes do more than alter purchasing behaviour: they imply lower population-level sugar intake and initiate improvements in intermediate health markers. While long-term clinical outcomes such as BMI change and diabetes incidence require years of follow-up, the evidence to date indicates that taxes create the conditions for meaningful reductions in obesity and NCD burden.

2.4.3 From intake to sugar and energy reduction

While reductions in purchases of taxed beverages provide the clearest evidence of behavioural change, their public-health relevance depends on whether they reduce net sugar and energy intake after accounting for substitution. Evaluations that measure the nutritional content of purchases and capture both taxed and untaxed beverages show that even modest declines in taxed volume translate into meaningful reductions in total sugar exposure.

In Catalonia, Fichera et al. (2021) used household loyalty-card data covering over 880,000 households and applied a difference-in-differences design comparing Catalonia with the rest of Spain. Their analysis tracked purchases across taxed and untaxed beverages, allowing measurement of substitution effects. They found that the tiered SSB tax reduced household sugar purchases by 2.2 % in the first year. This reduction persisted even after accounting for small increases in purchases of untaxed beverages, including low-sugar colas. This indicates a net reduction in sugar intake and a favourable shift in beverage composition toward lower-sugar options.

Broader evidence from systematic reviews corroborates these findings. Powell et al. (2013) synthesised price elasticity estimates for SSBs (average −1.21) and reported that a 10 % price increase is associated with significant calorie reductions. These studies are based primarily on observed price–quantity relationships from U.S. household and retail scanner data and then use simulation models to estimate changes in energy intake and BMI. They projected that a 10 % price increase would lead to a reduction of about 0.16 BMI units at the population level. Similarly, Andreyeva et al. (2010) reviewed 160 U.S. studies and reported that soft drinks were among the most price-responsive categories (elasticities −0.8 to −1.0), implying reductions in sugar and energy intake. While these reviews include some cross-price elasticities, they note that evidence on substitution into other caloric foods is incomplete, suggesting that a small degree of compensatory behaviour may occur but is unlikely to offset the calorie reductions from lower SSB consumption fully.

Meta-analytic evidence further confirms that net sugar intake falls after SSB taxes. Cleghorn et al. (2018) pooled results from 17 natural experiments and found that a 10 % tax was associated with an average 10 % reduction in taxed beverage purchases and no significant substitution into other sugary drinks. They also reported small but consistent increases in water purchases, supporting the view that SSB taxes lead to healthier beverage choices overall.

Together, these studies demonstrate that SSB taxes reduce dietary sugar and energy intake at the population level, even after considering substitution. While most of the evidence on calorie reduction is based on observed purchase data and nutritional composition, some studies model downstream weight impacts, projecting modest but non-trivial BMI reductions. The consistency of results across observational data, elasticity models, and meta-analyses strengthens confidence

that these intake effects are real and provide a credible pathway to improved health outcomes, which the next subsection explores.

2.4.4 Evidence on health endpoints

Most SSB tax evaluations measure sales, imports, or purchases, not downstream health outcomes such as BMI, diabetes incidence, hospitalisations, or mortality. As WHO (2016) notes, health effects often take years to manifest, so many evaluations rely on models linking sugar exposure to disease risk rather than direct observation. These studies nonetheless provide a coherent rationale for expecting benefits when exposure falls.

Epidemiological evidence consistently associates higher SSB intake with adverse health outcomes. Brownell et al. (2009) synthesised longitudinal cohort studies showing that higher SSB consumption is associated with greater weight gain, increased risk of type 2 diabetes, and elevated cardiometabolic risk. These findings support the expectation that population-level reductions in SSB intake will, over time, improve long-term health trajectories, even though few tax evaluations have yet linked exposure reductions to measured clinical outcomes.

Meta-analysis evidence strengthens this expectation. Teng et al. (2019) reviewed 17 real-world SSB tax evaluations and found that a 10 % price increase reduced purchases and intake by roughly 10 %, with larger effects in low-income groups. Translating these changes into health outcomes, Basto-Abreu et al. (2020) used a dynamic microsimulation model calibrated to nationally representative Mexican consumption data and baseline obesity prevalence, combining observed intake reductions with calorie–weight conversion equations and disease risk functions to project a 0.65 kg/m² reduction in BMI and 1.3 million fewer obesity cases within five years, alongside estimated US $1.8 billion in health-care cost savings. Moodie et al. (2013) reviewed fiscal modelling studies using cost-effectiveness frameworks and found that SSB taxes are highly cost-effective, often ranking among the most efficient NCD prevention policies even under conservative assumptions. These projections assume sustained reductions in intake and constant background risk, but they illustrate the potential magnitude of population-level health gains. WHO (2016) notes that these remain model-based and calls for longer-term evaluations with measured clinical outcomes.

Quasi-experimental evidence provides additional insights. Colchero et al. (2017) applied a difference-in-differences design to Nielsen household purchase panel data, comparing taxed beverage purchases before and after Mexico's 2014 excise while controlling for secular trends. They reported sustained 7–10 % declines in purchases over the first two years post-tax, with the largest reductions among low-income households. These are behavioural outcomes, showing

reduced exposure to added sugar but not directly measuring BMI or disease incidence. Complementary evidence from Catalonia reaches similar conclusions: Fichera et al. (2021) used a difference-in-differences approach with loyalty-card data from over 880,000 households and found small but statistically significant reductions in taxed beverage purchases and a 2.2 % fall in sugar purchased per household per month. Like the Mexican evaluations, these results confirm meaningful exposure reduction but do not report BMI, morbidity, or mortality outcomes, reflecting the short follow-up windows available. Together, these studies strengthen confidence that fiscal measures reduce sugar exposure but underline the continued absence of direct clinical endpoints, reinforcing the importance of model-based projections and motivating research that links tax exposure to observed health outcomes.

Taken together, these findings indicate that SSB taxation reduces population exposure to dietary sugars, and modelling suggests this will lead to lower BMI, reduced diabetes incidence, and fewer NCD cases over time. For Tuvalu, where fiscal capacity is limited and NCD burdens are high, waiting for direct BMI or disease incidence data would delay action. This thesis addresses that evidence gap by linking Pacifica household expenditure patterns to medication uptake, general sickness, and mortality outcomes, providing an early signal of elevated chronic disease risk in high-consuming groups. These results suggest that excise taxation is likely to yield both fiscal and health benefits for Tuvalu if maintained and strengthened, while also highlighting the need for complementary interventions to maximise health gains. Unlike most evaluations that rely on simulated disease projections, this thesis uses linked administrative data to observe pharmaceutical dispensing and hospitalisation outcomes, providing a relatively rare empirical link between household expenditure and health risk.

2.4.5 Pacific evidence

Pacific studies offer region-specific evidence on price and import responses, complementing global findings but still rarely linking tax exposure to measured health outcomes. Recent evaluations from Tonga (Teng et al., 2021a) and the Cook Islands (Teng et al., 2021b) provide complementary evidence from the Pacific and concluded that the magnitude of observed reductions in taxed beverage imports is likely sufficient to yield meaningful health gains if taxes are maintained and strengthened.

Pacific Island Countries (PICs) provide particularly relevant case studies for Tuvalu, where consumption of imported sugary drinks is high, domestic production is limited, and NCD burdens are substantial. In Tonga, excise taxes on sugary drinks were introduced in 2013 and strengthened in 2016. Teng et al. (2021a) analysed repeated household expenditure surveys before and after

these reforms using a quasi-experimental design and found significant reductions in per-capita expenditure on taxed beverages. The largest declines occurred among low-income households, suggesting that higher prices altered purchasing behaviour in a way that could generate equity-enhancing health gains. The study did not measure BMI or NCD incidence directly, making it an exposure-based but not outcome-based evaluation.

Evidence from the Cook Islands provides a complementary perspective. Teng (2021b) conducted an interrupted time-series analysis using import and retail sales data before and after the introduction of SSB tariffs. They found significant declines in taxed beverage imports and retail sales immediately after implementation, followed by partial rebound when tariffs were reduced. This design strengthens causal inference by comparing pre- and post-tariff trends, but no clinical endpoints such as BMI or morbidity were measured. The findings nonetheless show that sustained taxation can meaningfully reduce population sugar exposure.

Reviews of Pacific fiscal policies indicate that SSB excises achieve measurable reductions in consumption (Buksh et al., 2023; Walby et al., 2023). Evaluations from Tonga (Teng et al., 2021a) and the Cook Islands (Teng, 2021b) support this pattern by documenting declines in taxed beverage purchases or imports. Although the magnitude of these reductions is modest, they are sufficient to expect downstream health benefits if policies are maintained over time. Buksh et al. (2023) broadened this perspective by reviewing NCD-related fiscal policies across PICs and found that excise taxes on unhealthy foods and drinks are among the most cost-effective strategies available to governments with constrained health budgets. These studies highlight that, although Pacific evidence rarely extends to direct clinical endpoints, the observed reductions in exposure are consistent with pathways leading to improved population health.

Policy reviews reinforce these conclusions. Walby et al. (2023) systematically reviewed food tax policies across Pacific jurisdictions and summarised evidence from primary studies indicating that SSB taxes were followed by lower purchases or imports of taxed products. The review also emphasised that political and administrative factors shape the durability of these policies, which is an important consideration for small-island governments with limited capacity. Nonetheless, the evidence aligns with international findings: fiscal measures reduce sugar exposure and create favourable conditions for reducing NCD burden over time.

Overall, Pacific case studies confirm that SSB taxation is feasible and effective in small-island economies for reducing purchases and imports of sugary drinks. While health endpoints such as BMI or disease incidence remain unmeasured, these studies establish exposure reduction as a necessary first step reinforcing the need for research, such as this thesis, that links expenditure patterns to observed health outcomes.

2.4.6 Substitution patterns and implications

A central concern in evaluating the health outcomes of SSB taxation is the extent to which consumers substitute taxed drinks with other beverages. Substitution determines whether the reductions in taxed SSB purchases translate into genuine reductions in sugar and energy intake or are offset by increased consumption of untaxed sugary products.

Teng et al. (2019) conducted a systematic review and meta-analysis of 17 real-world SSB tax evaluations and found no significant increase in purchases of other sugary beverages following taxation. Some jurisdictions reported small, non-significant increases in water purchases. These findings suggest that observed declines in SSB purchases largely represent genuine reductions in sugar exposure rather than being offset by switches to other caloric drinks.

Pacific evaluations are broadly consistent with this evidence. Teng (2021b), which highlighted that while overall beverage expenditure fell in response to higher taxes, there was no systematic evidence of substitution toward other sugary products. The Cook Islands case, based on import and sales data, particularly underscored that when tariffs were in place, overall sugary drink availability declined, reinforcing the conclusion that taxes reduced total sugar exposure from beverages rather than displacing demand.

Artificially sweetened beverages (ASBs) are drinks containing non-nutritive sweeteners such as aspartame, sucralose, or stevia. These sweeteners provide a sweet taste but contribute little or no energy, as they are used in very small amounts. ASBs are sometimes referred to as low-calorie or sugar-free beverages. Cleghorn et al. (2018) reviewed the health effects of ASBs and concluded that while they are associated with lower calorie intake compared with SSBs in the short term, uncertainties remain about their long-term health impacts. Some studies report associations with weight gain or metabolic syndrome, but causality remains contested. These findings suggest that substituting SSBs with ASBs may lower sugar intake but does not necessarily confer the same health benefits as substituting with water.

The policy implication is that taxation should be designed to encourage the healthiest substitutions. International reviews recommend pairing SSB taxes with complementary measures, such as making water more accessible and affordable. By signalling water as the preferred substitute and minimising reliance on ASBs, governments can ensure that reductions in SSB consumption deliver the maximum possible health gains.

2.4.7 What determines the health impact size

The scale of health improvements from SSB taxation depends not only on consumer responses but also on the design and implementation of the tax. Evidence consistently shows that the magnitude of health impact varies across contexts, reflecting differences in tax design, rate, coverage, and complementary measures.

One critical factor is the type and level of tax applied. Brownell et al. (2009) argued that specific excise taxes, levied per volume or sugar content unit, are more effective than sales taxes applied at the register. Excises raise shelf prices directly and are more salient to consumers, leading to greater behavioural response. The level of taxation is equally important. The WHO (2016) recommends rates of at least 20% to reduce consumption meaningfully, a threshold reinforced by Wright et al. (2017) in a systematic review of health tax evaluations, which found that smaller increases produce limited behaviour change.

The tax structure also shapes substitution pathways and incentives for product reformulation. Tiered taxes based on sugar content also create incentives for product reformulation, reducing sugar exposure even among consumers who do not change purchasing behaviour. McCoy et al. (2017) highlight this 're-pricing' dimension as one of the 'Five Rs' of health taxes, showing that aligning fiscal tools with health objectives strengthens their effectiveness.

Complementary policies such as earmarking tax revenues for health programmes, public communication campaigns, and improved access to safe drinking water can amplify health gains. WHO (2016) recommends embedding taxes within wider preventive strategies to maximise long-term population health impact.

In summary, the health impact of SSB taxation is shaped by both consumer responsiveness and policy design. Higher excise rates, sugar-based tiering, and integration with wider preventive health measures strengthen expected improvements in obesity and NCD outcomes. These design features are particularly relevant for small-island settings like Tuvalu, where aligning tax design with health objectives is critical for maximising impact.

2.4.8 Limitations and research gaps

Despite growing evidence that SSB taxation reduces purchases and intake, several limitations constrain the ability to assess its long-term health effects. First, most evaluations measure proximal outcomes such as retail sales, household purchases, or self-reported dietary intake rather than direct health endpoints. This reflects the practical challenge that conditions like obesity, diabetes, and cardiovascular disease develop over many years, whereas most tax evaluations have one to three years of follow-up periods. As a result, while sugar and energy intake reductions are

well documented, evidence linking taxes to measurable declines in BMI or NCD incidence remains limited.

Second, existing evaluations often face methodological constraints. In their systematic review, Teng et al. (2019) reported substantial heterogeneity in effect sizes (I^2=97%), underscoring the influence of tax design, baseline consumption, and socio-economic context. Many studies rely on observational designs without randomisation, which, although appropriate for policy evaluation, make it difficult to isolate causal effects from concurrent health initiatives or market changes. In addition, evidence from low- and middle-income countries is less developed than in high-income settings, despite the high NCD burden in these contexts.

Third, substitution effects and industry responses remain areas of uncertainty. While most evidence indicates modest substitution toward water or untaxed beverages, there is limited understanding of how patterns evolve over time or across demographic groups. As seen in tiered tax systems, reformulation by manufacturers also complicates evaluation: reductions in sugar concentration benefit consumers but make it harder to attribute changes in health outcomes directly to taxation. Cleghorn et al. (2018) further highlighted that substitution toward artificially sweetened beverages introduces unresolved questions about long-term health impacts.

Fourth, Pacific evidence is still in its early stages. Evaluations in Tonga and the Cook Islands have demonstrated reductions in expenditure, imports, and sales of taxed beverages, but none yet capture direct health outcomes such as obesity or diabetes prevalence (Teng, 2021b; Walby et al., 2023). This creates a research gap in the regions where NCD burdens are among the world's highest and where fiscal measures may have outsized potential.

Finally, political economy factors shape the sustainability of SSB taxes and the evidence base. Wright et al. (2017) noted that the durability of health taxes depends on how they are framed and whether revenues are earmarked for visible health programmes. Wilson cautioned that modelling assumptions about substitution and consumer adaptation can be contested in policy debates. These considerations influence not only implementation but also the feasibility of long-term monitoring.

In summary, while the evidence that SSB taxes reduce purchases and sugar intake is robust, research gaps remain in linking these changes to long-term health outcomes, understanding substitution and reformulation dynamics, and evaluating impacts in Pacific Island settings. Addressing these gaps will be important for consolidating the evidence base that fiscal policy can deliver sustained improvements in population health. For small-island states such as Tuvalu, where fiscal and health systems face severe constraints, closing these research gaps would directly inform the design and sustainability of taxation as a preventive health measure.

2.5 Fiscal Context and Policy Relevance

Although this thesis focuses on health outcomes, excise taxes also serve a fiscal function by generating predictable revenue streams important for a small, import-dependent country like Tuvalu. Predictable collections can expand fiscal space for health and education, provided rates are well-designed and enforced. A detailed review of revenue stability, tax design options, and distributional considerations is provided in Appendix 4.

Evidence Gaps and Motivation

Evidence from the Pacific remains limited. In Tonga, point estimates suggested greater reductions among low-income households, though these were not statistically significant (Teng et al., 2021a), while Cook Islands evaluations relied on market-level data and omitted household distributional outcomes (Teng et al., 2021c). Regional reviews confirm these gaps, highlighting weak monitoring systems and limited household-level data (Buksh et al., 2023), while policy reviews emphasise that political and administrative factors shape durability (Walby et al., 2023). From a theoretical perspective, welfare incidence remains contested: although financial incidence is regressive, overall welfare may still be progressive if health gains outweigh fiscal burdens (Lockwood & Taubinsky, 2017). Taken together, these empirical and theoretical gaps underscore the need for evaluations that integrate behavioural, health, and welfare dimensions rather than focusing solely on expenditure shares. This study responds to that need by linking Pacifica household expenditure patterns to medication uptake, sickness, and mortality outcomes, providing equity-sensitive evidence that can inform the design and long-term monitoring of sin taxes in Tuvalu.

3. Data

This chapter outlines the data sources, variables, sample selection criteria, and the analysis's relevant assumptions. This analysis uses confidential microdata accessed through the Integrated Data Infrastructure (IDI) of Stats NZ. All results are aggregated, following IDI confidentiality and disclosure protocols.

The analysis draws on multiple datasets linked within the IDI, including household expenditure data from the Household Economic Survey (HES), income data from Inland Revenue, and health outcomes based on hospital discharges and pharmaceutical records. These datasets provide a comprehensive view of income, spending, and diet-related health risks among households in New Zealand. The analysis captures all but focuses primarily on the Pacific population, which serves as a proxy for Tuvaluan households.

3.1 The Integrated Data Infrastructure

The Integrated Data Infrastructure (IDI) database contains individual and household-level administrative data collected by government agencies throughout their operations across various domains, including education, work, income and population. Upon collection by each agency, this data is then provided to Statistics New Zealand, which uploads it to the IDI, where researchers can access and use it for their research projects. The IDI links data at the individual level through a secure anonymisation process using encrypted identifiers. Without a unique identification number, record linkage in the IDI is achieved through probabilistic matching. Stats NZ compares personally identifying variables such as first name, date of birth, gender, country of birth and address to construct an encrypted unique identifier used to link individual-level records across datasets (Stats NZ, 2024). For the HES – the primary dataset used in the analysis, Stats NZ (2024) reports a linkage rate of 95.2% to the IDI spine, with an estimated false positive rate of 1.8%. These figures confirm that HES-based record linkage is of high quality and suitable for population-level research. The IDI undergoes tri-annual refreshes, during which updated data is incorporated. Importantly, each refresh retains previous data versions, ensuring continuity and consistency for researchers working with earlier datasets.

Data access follows strict privacy, security, and governance protocols, and analysis occurs within a secure Stats NZ data lab, with only the output allowed to be extracted from the database after following microdata output guidelines. Since the IDI data is stored in an SQL database, initial

data extraction and preliminary filtering were conducted using SQL queries within the secure Stats NZ data lab.

3.2 Population of Interest

The population of interest for this research includes individuals and their corresponding households surveyed in the Household Economic Survey (HES) between 2006 and 2019. This is a repeated cross-sectional design where different households are surveyed in each wave. Administrative outcomes are linked longitudinally around each interview date, but the HES itself is not a true panel. I constructed the HES spine using all available expenditure survey waves during this period. Specifically, I sourced the 2006–2007, 2009–2010, and 2012–2013 waves from the standard July 2023 IDI refresh and extracted the 2015–2016 and 2018–2019 waves from the ad hoc HES database, also hosted in the IDI. In IDI terms, an "ad hoc" load refers to a simple load of data linked using an existing unique identifier already integrated in the IDI. These datasets are not fully integrated and are typically supplied for one-off projects. Using those identifiers, Stats NZ performs a deterministic link between the new dataset and an existing IDI population. As such, the 2015–2016 and 2018–2019 waves of HES required additional care to ensure alignment with fully integrated data from earlier waves. The ad hoc version includes processed household expenditure variables and internal identifiers not present in the standard refresh. To integrate both sources, I used a concordance table provided by Stats NZ to match snz_hes_uid values (Stats NZ's internal unique household identifier for HES records) and maintain consistent household linkage across datasets. This combined approach allowed me to ensure temporal completeness while preserving data compatibility. According to the HES data, the initial sample included individuals from 27,852 households.

I harmonised the HES variables across all survey waves using Stata. This process involved recoding inconsistent categorical values across years, aligning expenditure item classifications, dropping observations with missing or conflicting identifiers, relabelling household and person-level IDs, and checking for duplicate entries. These steps ensured integrity and internal consistency across the final dataset used for analysis.

I applied a spine-based linkage structure in line with standard IDI protocols. The HES spine served as the base population. I linked person-level administrative data using encrypted identifiers generated by Stats NZ through probabilistic matching. I did not incorporate match weight variables; instead, I treated a successful match to the spine as a valid person-level link.

I linked three major administrative datasets to the HES spine. First, I used the Pharmaceutical Collection (PHARMS), which includes all publicly subsidised medication dispensing events in

New Zealand. I used these data to identify individuals prescribed medications for diabetes and cardiovascular disease, including insulin, oral diabetes agents, beta blockers, and diuretics. Second, I incorporated data from the National Minimum Dataset (NMDS), which contains hospital discharge records coded using the ICD-10-AM classification system(the standard clinical coding system used in New Zealand hospitals to classify diagnoses and procedures). From this, I constructed a general hospitalisation flag by including all discharge events with valid ICD-10 codes, while excluding those explicitly associated with external causes (codes beginning with 'V', 'W', 'X', or 'Y') and surgical complications. This flag, general_sickness, captures a broad spectrum of health-related inpatient events. Third, I included personal income data compiled and cleaned by Stats NZ from Inland Revenue (IRD) sources. This version offers more consistent and reliable values than raw IRD data. I calculated annual personal and household income and grouped individuals into income categories for stratified analysis.

I also extracted demographic information such as age, sex, ethnicity, and household composition from both the HES and IDI demographic tables. I extracted all datasets using SQL and merged them in Stata using Stats NZ's encrypted person-level identifiers.

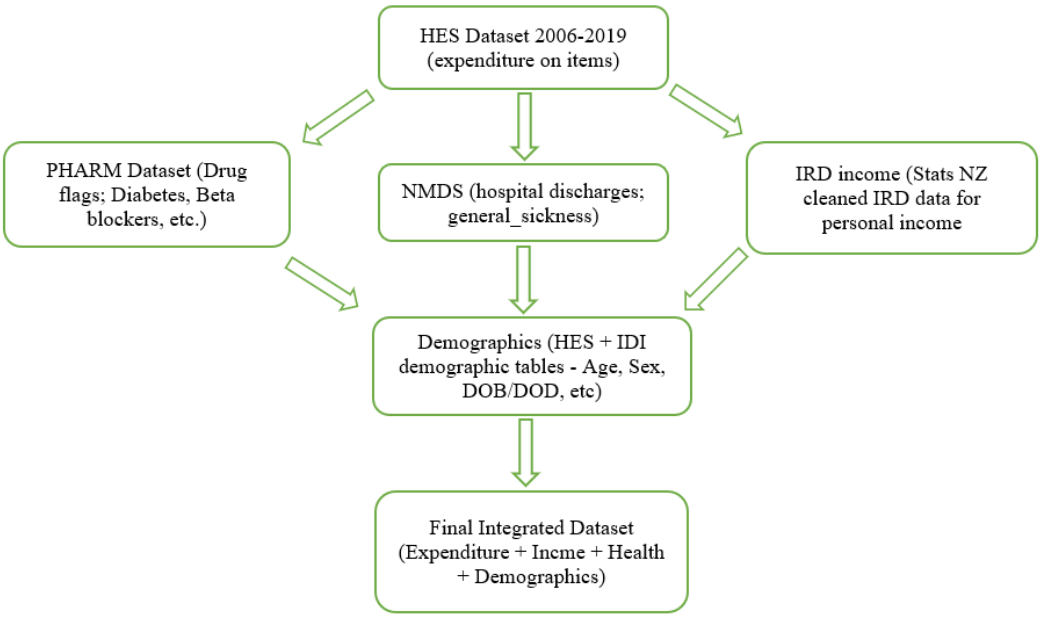
Ethnicity was obtained from Stats NZ administrative ethnicity fields in the IDI and coded into mutually exclusive categories using a prioritised ethnicity classification. Prioritised ethnicity collapses multiple reported ethnic affiliations to a single category by applying a predefined precedence ordering. Consistent with common practice in New Zealand population health reporting, I applied the ordering Māori, Pacifica, Asian, European/Other when assigning individuals to a single ethnic group. For descriptive statistics, I report five categories: European, Māori, Pacifica, Asian, and Middle Eastern/Latin American/African (MELAA) and Other. In the regression models, European serves as the reference category and indicator variables are included for Māori, Pacifica, Asian, MELAA and Other. This structure aligns with standard health inequities reporting in New Zealand and ensures consistency between descriptive and regression analyses.

The construction of the analytical sample involved several linkage and data-cleaning steps, during which some observations were excluded. Records were dropped when (i) individuals could not be linked to the IDI spine, (ii) essential demographic information (age, sex, ethnicity, or household identifiers) was missing or conflicting, or (iii) expenditure or health records could not be reconciled across datasets. These exclusions reflect technical linkage and consistency requirements rather than survey non-response or differential participation, and therefore are plausibly missing at random with respect to household expenditure behaviour.

The final dataset integrates income, health, demographic, and expenditure information for each individual in the sample. This structure provides the foundation for this thesis's regression models

and descriptive analyses. Figure 1 illustrates the structure and linkage process across these datasets

***Figure 1:** Linkage of HES with Health, Income, and Demographic Data.*



3.3 Generated Variables

To prepare the dataset for analysis, I generated a set of derived variables that captured key dimensions of household consumption and individual health outcomes. I constructed all variables using Stata and maintained consistent definitions across all Household Economic Survey (HES) waves included in the study. This process enabled the construction of a harmonised panel of individuals with linked expenditure and health outcome data.

The primary explanatory variables are household-level budget share indicators for products considered 'sin goods.' The HES collects detailed, itemised household expenditure coded to the New Zealand Household Expenditure Classification (NZHEC). For waves with the detailed expenditure questionnaire (available every three years for a subsample of households), spending is captured at a level that allows alcohol and tobacco to be identified directly, and soft-drink purchases to be used as a proxy for sugar-sweetened beverage exposure. This level of granularity supports the construction of the expenditure share variables used in this study. These include sugar-sweetened beverages (SSBs), sugary and high-fat processed foods, and, in some specifications, tobacco. I calculated the proportion of total household expenditure allocated to each category. These shares reflect the household's prioritisation of spending across different consumption types and serve as proxies for exposure to dietary risks. Since the HES collects expenditure data at the household level, I assigned the same expenditure share values to everyone

within the household. This approach enables individual-level analysis while preserving the household-level expenditure data.

Table 1 summarises the primary experimental variables used to measure expenditure on sin goods. It details the cumulative item categories included in each, with a key distinction between `sin_goods_shares` (which includes alcohol but excludes tobacco) and `sin_goods_tobacco_shares` (which includes tobacco but excludes alcohol). For each variable, households were grouped into low, mid, and high categories based on the distribution of their household expenditure shares, using tercile cut points (bottom third, middle third, top third).

Table 1: Experimental Variables Used to Measure Expenditure on Sin Goods

Variable Name	Description	Included Items	Grouping
ssb_only_shares	Share of total household expenditure on sugar-sweetened beverages	Soft drinks, flavored cordials, sweetened juices and energy drinks	Low / Mid / High
ssb_comprehensive_shares	Share on SSBs plus a wide range of sugary and high-fat foods	All `ssb_only_shares` items, plus chocolate, confectionery, sweet biscuits, pastries, sweetened cereals, processed snacks, deep-fried takeaway, ice cream, and high-fat bakery	Low / Mid / High
sin_goods_shares	Share on sin goods excluding tobacco	All `ssb_comprehensive_shares` items, plus alcohol products (beer, spirits, wine); excludes tobacco	Low / Mid / High
sin_goods_tobacco_shares	Share on sin goods excluding alcohol but including tobacco	All `ssb_comprehensive_shares` items, plus tobacco (manufactured cigarettes, roll-your-own tobacco); excludes alcohol	Low / Mid / High

To assess the potential health impacts of sin goods consumption, I created binary indicators for health outcomes using linked administrative data. These indicators were derived from pharmaceutical dispensing records and hospital discharge data. I defined a 48-month observation window, 24 months before and 24 months after everyone's HES interview date, to capture pre-existing and emerging conditions that could plausibly relate to household spending behaviour during the survey.

From the pharmaceutical data, I created indicators for whether an individual received prescriptions for diabetes medications, diuretics, or beta blockers during the observation window. These drugs are typically used to treat chronic conditions influenced by poor diet, such as diabetes and cardiovascular disease. An individual was flagged as having the relevant condition if at least one dispensing event for the relevant medication occurred during the 48-month period. This binary approach captures health system engagement for diet-related illnesses without relying on direct diagnosis data.

For hospitalisations, I constructed a broader measure of overall health. I flagged individuals who experienced any non-accidental inpatient hospitalisation, explicitly excluding admissions for injuries, surgical recovery, or trauma. Although I initially intended to construct condition-specific indicators (e.g., for ischaemic heart disease or hypertension), the rarity of these events across

subgroups led me to consolidate them into a general “sickness” variable. This decision ensured adequate variation for statistical analysis and complemented the medication-based indicators.

I used IRD records that were cleaned and compiled by Stats NZ to measure household income. This curated version aggregates monthly earnings across multiple jobs and job changes, which ensured that the annual totals I used were consistent and unaffected by changes in employment. I calculated household income by summing the annual income of all individuals linked to the same HES household ID for each survey year. I then classified households into three income groups: low-income (bottom 25% of the income distribution), middle-income (26th to 75th percentiles), and high-income (top 25%). These groupings enabled robust subgroup analysis of both health outcomes and consumption behaviour.

Household income was sourced from Inland Revenue Department (IRD) administrative tax records rather than from the HES self-reported income fields. IRD earnings data cover the full fiscal year, capture multiple income streams, and reduce measurement error associated with recall bias, intermittent earnings, and item non-response in survey instruments. Using IRD also avoids truncation of the income window and improves comparability across households, given that the health outcome variables are likewise derived from administrative datasets rather than self-reported measures.

Income was operationalised using tertile categories rather than as a continuous variable. This approach reduces the leverage of extreme high-income observations, facilitates distributional comparisons in descriptive cross-tabulations, and aligns with the study’s focus on relative socioeconomic positioning rather than marginal income effects. Tertile-based socioeconomic grouping is common in health utilisation research and supports clearer interpretation of associations across demographic subgroups.

I sourced data from two versions of the HES: the standard IDI refresh (used for the 2006–2013 waves) and the ad hoc HES database (used for the 2015–2019 waves). To ensure consistent household identification across these sources, I used a concordance table provided by Stats NZ and merged records using the snz_hes_uid. This allowed me to integrate household and individual records across structurally different datasets. During the integration process, I applied recommended data-cleaning procedures. This included removing duplicate records, harmonising variable formats, and excluding observations with conflicting or missing. I did not exclude cases solely because they reported zero income. I also harmonised variable coding across all survey years to ensure comparability.

The final dataset reflects a linkage between robust household expenditure, income, and health outcomes. These constructed variables enabled me to conduct individual-level analysis on the associations between sin goods consumption and downstream health risks. All variable definitions were applied transparently and consistently throughout the sample.

3.4 Policy Variables and Key Assumptions

The analysis uses Tuvalu's official government documents to identify existing tax rates on sin goods, which form the basis for the selection of goods that go into each category. (Government of Tuvalu, 2020). These include ad valorem taxes on sugary drinks, processed foods, alcohol, and tobacco.

The analysis does not directly estimate price elasticities of demand, given the absence of price and quantity data in the IDI. Instead, it adopts elasticity estimates from existing literature, prioritising studies focused on Pacific populations or comparable socioeconomic contexts.

3.5 Limitations and Data Assumptions

This analysis recognises several limitations. First, the IDI does not contain direct price or quantity data, so expenditure shares are used as a proxy for consumption. Second, because HES is collected every three years, annual trends cannot be observed. Third, while expenditure is only a proxy for actual consumption, it remains the most reasonable measure available. Finally, all analyses follow Stats NZ confidentiality protocols, and only anonymised, aggregated results are reported.

3.6 Ethical Considerations

This analysis complies fully with IDI access and ethics requirements. It analyses only de-identified data within secure environments. Including ethnicity variables is justified on policy grounds, given the focus on Pacific communities as a proxy for Tuvaluans. All external sources are cited appropriately. Explicitly analysing Pacific populations is ethically justified due to their disproportionately higher vulnerability to diet-related diseases, such as cardiovascular conditions and diabetes, compared to other groups. Addressing health disparities through targeted policy recommendations requires understanding these communities' unique socioeconomic and dietary behaviours. Given Tuvalu's similar dietary and socioeconomic context, Pacific households in New Zealand provide the most relevant proxy, directly benefiting from policy interventions to improve health outcomes.

4. Data Descriptives

This section presents summary statistics illustrating how expenditure on sin goods relates to four health indicators derived from pharmaceutical data. The patterns discussed here are drawn directly from percentage tables produced in Stata, which link expenditure share tiers to chronic condition flags, disaggregated by demographic controls. Only proportion-based data are used, which aligns with IDI disclosure rules. There is no repetition of variable definitions or data construction; those details are addressed in the preceding chapter.

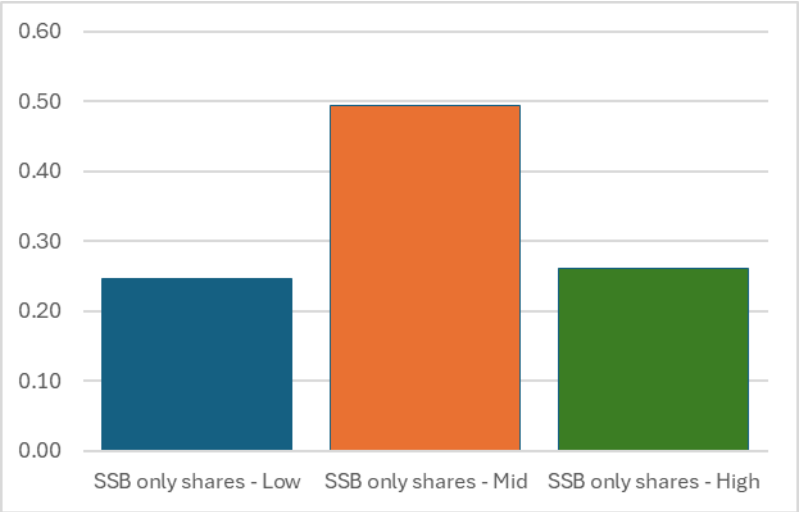
4.1 Sample Characteristics

The Household Economic Survey (HES) is designed to be representative of the New Zealand population. The analytical sample used here includes HES respondents who successfully linked to administrative health and demographic data in the IDI. The ideal way to check representativeness would be to show whether the linked sample, after applying survey weights, looks similar to the wider New Zealand population across key variables such as age, sex, ethnicity and health indicators. Producing this type of weighted comparison requires population reference data and full survey weights, which were not available for this analysis. Given the underlying HES design and the lack of evidence that linkage systematically excludes particular demographic groups, the analytical sample is treated as broadly representative for descriptive work.

The analytic sample includes 27,852 individuals across all HES waves. The age distribution is broad, with the largest single group aged 66 and older (20.1 %). Working-age adults (26–55) make up just over half of the sample (52.4 %), while young adults aged 18–25 account for 11.9 %. Europeans represent 72.7 % of individuals, Māori 10.0 %, Asians 9.8 %, and Pacific peoples 5.3 %.

Expenditure on SSBs is broadly distributed across the population, with 25 percent of households in the low-SSB tertile, 49 percent in the middle tertile, and 26 percent in the high tertile. Younger groups are slightly more concentrated in the medium and high expenditure categories, while the lowest expenditure tertile is more common among the oldest age group.

Figure 2: Distribution of SSB-Only Share Tertiles



Note: Bars show the proportion of households in low, middle, and high SSB expenditure share tertiles across the full sample (percentages rounded to the nearest whole number).

The distributions for the SSB-comprehensive, Sin Goods, and Sin Goods + Tobacco categories follow a similar pattern, with roughly half of households in the middle tertile (results not shown).

4.2 Age-Related Differences in Health Outcomes

Individual outcome breakdowns are presented in Figure 3-Figure 6 to show how medication usage varies by SSB-only expenditure share within each age group. These charts provide a clearer view of age-related differences than aggregate tables that combine multiple subgroups. The figures demonstrate that medication prevalence rises consistently with age, with limited separation between low, medium, and high expenditure share categories.

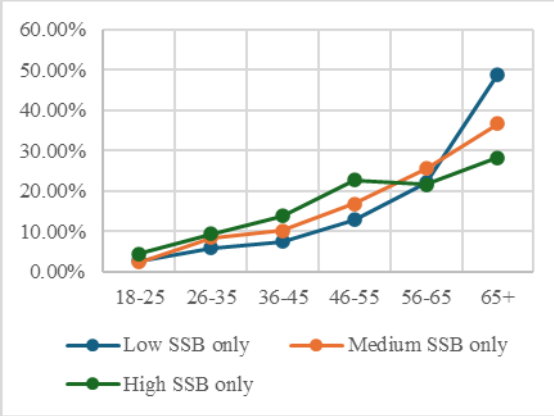


Figure 3: The proportion of individuals flagged for diabetes medication by age group and SSB-only shared.
Diabetes medication prevalence by age group and SSB-only expenditure tertile. The horizontal axis shows six age groups (18–25 through 66+); the vertical axis shows the percentage of individuals flagged. Prevalence rises sharply with age, with only small differences across expenditure tertiles.

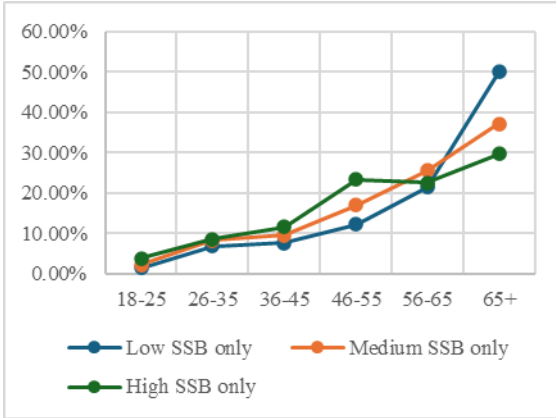


Figure 4 : Rates of diabetes management medication uptake by age and SSB are only shared. *Diabetes management medication prevalence by age group and SSB-only expenditure tertile. Axes as in Figure 3. Uptake increases steadily with age, with no consistent gradient by expenditure share.*

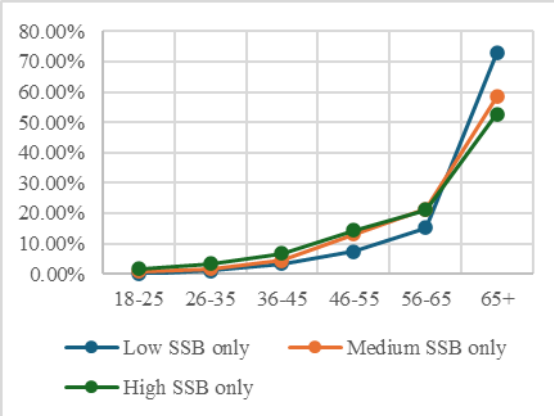


Figure 5: Diuretic prescription prevalence by age group and SSB-only share. *Diuretic prescription prevalence by age group and SSB-only expenditure tertile. Axes as in Figure 3. Differences by expenditure share appear only in the oldest age group, with slightly higher prevalence in low-expenditure households.*

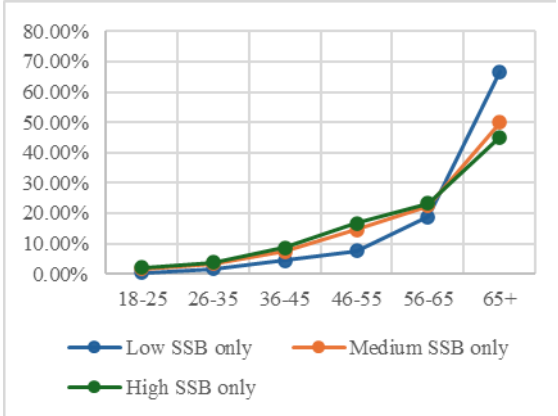


Figure 6: Rates of beta-blocker uptake by age and SSB-only share. *Beta-blocker prescription prevalence by age group and SSB-only expenditure tertile. Axes as in Figure 3. Patterns are similar across groups, with higher prevalence in older adults regardless of expenditure share.*

These figures show that increases in medication use are strongly linked to age, with prevalence highest in the oldest groups. Differences across expenditure shares are minor within each age category, suggesting that expenditure share effects are relatively small compared to age-related patterns.

Figures 2–5 mainly show the strong effect of age on medication use. The slightly higher rates in the low-SSB group are likely because these households are older on average, so they naturally have more prescriptions. These figures describe patterns in the data and should not be read as showing that higher SSB spending is healthier.

Table 2 Age group × health outcome prevalence.

Age Group	Drug Diabetes	Drug Diabetes Management	Drug Diuretic	Drug Beta-blockers
18-25	1.90%	1.18%	0.90%	1.90%
26-35	3.60%	2.58%	1.36%	2.65%
36-45	4.08%	2.72%	2.89%	5.43%
46-55	6.76%	4.88%	7.35%	10.17%
56-65	10.84%	7.73%	14.30%	19.75%
65+	13.37%	9.88%	35.53%	38.43%

Medication uptake rises consistently with age across all outcomes. Minor differences by expenditure appear only in the oldest groups.

Medication uptake rises steadily with age across all outcomes. For diabetes drugs, prevalence increases from 1.9 per cent among those aged 18–25 to 13.4 per cent among those aged 65 and older. Diabetes management medication follows the same pattern, from just over 1 per cent in the youngest group to 8.4 per cent in the oldest. Diuretic and beta blocker usage shows a sharper gradient, with prevalence reaching 35.5 per cent and 38.4 per cent, respectively, in the oldest age group.

4.3 Medication Use by Income Level

Figure 7 presents the prevalence of medication use for diabetes, diabetes management, diuretics, and beta blockers by household income group. Apparent differences are evident across the three categories of income. For diabetes-related drugs, prevalence is highest in the low-income group at just under 10 per cent, compared with around 7 per cent in the middle-income group and about 5 per cent in the high-income group. A similar pattern is observed for diabetes management medication, although overall prevalence rates are slightly lower across all income groups.

For diuretics and beta blockers, the differences are more pronounced. Over 21 per cent of individuals in the low-income group are flagged for diuretic use, compared with around 9 per cent in the middle-income group and just over 5 per cent in the high-income group. Beta blocker use shows the same pattern, with approximately 23 per cent of the low-income group flagged, compared with 12 per cent in the middle-income group and 8 per cent in the high-income group. These descriptive figures show that the prevalence of medication use for cardiovascular and diabetes-related conditions is highest in the lowest income group, with progressively lower shares in the middle- and high-income groups.

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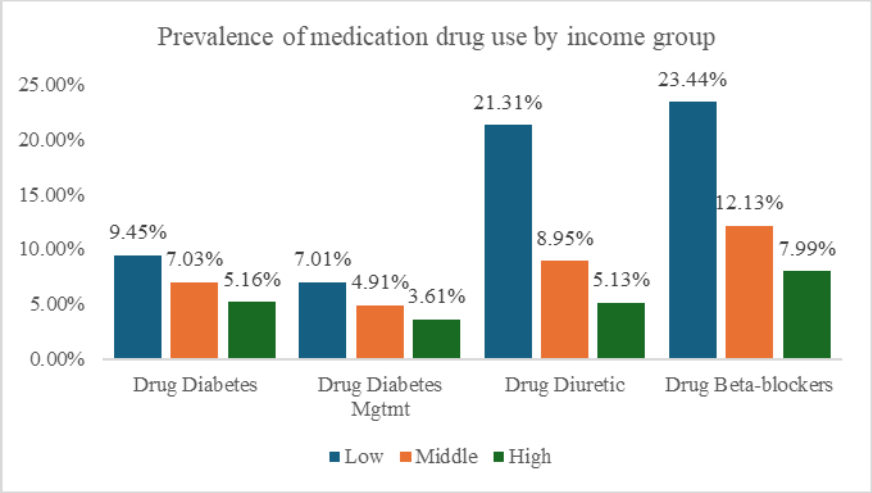
Figure 7: Prevalence of Medication Drug Use by Income Group



4.4 Ethnic Variation in Exposure and Outcomes

Table 3 summarises medication prevalence across all ethnic groups in the sample (European, Māori, Pacific, Asian, and MELAA/Other); no groups are omitted. These categories follow the standard prioritised classification used throughout the study.

Table 3 reports the prevalence of medication use across ethnic groups within the SSB-only expenditure category. Differences are apparent across the four drug outcomes. For diabetes medication, Pacifica records the highest prevalence at 16.6 per cent, followed by Māori at 9.7 per cent, Asians at 8.5 per cent, and Europeans at 6.1 per cent. Diabetes management medication shows the same ordering, with Pacifica at 11.5 per cent, Māori at 6.7 per cent, Asians at 6.5 per cent, and Europeans at 4.4 per cent.

For diuretics and beta blockers, the highest prevalence is observed among Europeans, at 13.5 per cent and 16.5 per cent, respectively. Māori and Pacifica record lower levels for these two drug categories, with prevalence of 9.7 per cent and 11.2 per cent for Māori, and 6.8 per cent and 8.2 per cent for Pacifica. Asian and MELAA groups show the lowest rates overall, with diuretic use below 4 per cent and beta-blocker use between 3 and 7 per cent.

Overall, the table indicates variation in medication use by ethnicity, with Pacifica showing the highest rates for diabetes-related medications, while Europeans record the highest rates for cardiovascular-related drugs. Some of these differences may be partly explained by population structure. Europeans are more concentrated in older age groups, which likely contributes to their higher rates of diuretic and beta-blocker use. Pacifica, by contrast, has a much younger population profile with over half under 25 years of age (Health, 2025), yet still show the highest diabetes

medication prevalence. This pattern is consistent with national evidence of earlier onset of metabolic conditions among Pacific peoples.

Table 3: Medication Use Rates by Ethnicity (SSB-only Expenditure Category)

Ethnicity	Drug Diabetes	Drug Diabetes Management	Drug Diuretic	Drug Beta-blockers
European	6.13%	4.40%	13.45%	16.45%
Maori	9.71%	6.69%	9.71%	11.22%
Pacifica	16.60%	11.48%	6.76%	8.20%
Asian	8.54%	6.46%	3.72%	7.23%
MELAA	0.49%	0.99%	3.94%	2.96%

4.5 Household Composition and Health Risks

Table 4 disaggregates medication prevalence by whether children are present in the household, using the Sin Goods + Tobacco category. The figures show apparent differences in health outcomes between the two groups, with consistently higher prevalence observed among individuals in households without children. This comparison is descriptive and unadjusted. Households without children are typically older, so much of the observed difference in medication prevalence likely reflects age composition rather than child presence per se. We therefore treat these figures as context only.

Table 4: Prevalence of Drug Flags in Households with and Without Children

Child presence in household	Drug Diabetes	Drug Diabetes Management	Drug Diuretic	Drug Beta-blockers
No Children	7.92%	5.64%	14.78%	17.65%
Child Present	5.36%	3.92%	4.03%	6.44%

Individuals in households without children show a higher prevalence across all four outcomes. For diabetes medication, prevalence is 7.9 per cent compared with 5.4 per cent in households with children. For diabetes management drugs, the corresponding rates are 5.6 per cent and 3.9 per cent. The most significant differences appear for cardiovascular-related medications: diuretic prevalence is 14.8 per cent among households without children, compared with 4.0 per cent where children are present; beta blocker prevalence is 17.7 per cent compared with 6.4 per cent.

Overall, the higher rates in households without children should be read as an age-structure pattern, not as evidence that child presence affects health.

4.6 Patterns Worth Noting

Across Figure 3–Figure 6, medication prevalence increases substantially with age, and expenditure-tier differences tend to emerge only in the older age groups. In younger age bands the three expenditure tiers often overlap, while in older groups some separation is visible. These patterns are descriptive and differ by outcome, rather than indicating a uniform gradient across expenditure tiers.

Not all gradients are steep, and not all outcomes follow the same pattern. In some cases, expenditure share groups differ slightly, while the contrasts are more marked in others. The tables confirm that variation in health outcomes exists across expenditure share tiers. These descriptive results provide context for the statistical modelling that follows.

5. Methodology

The analysis proceeds by estimating logistic regression models linking sin goods expenditure categories to binary health and or mortality outcomes:

$$\Pr(Y_{it} = 1) = \Lambda(\alpha + \beta_1 share\_mid_{it} + \beta_2 share\_high_{it} + X'_{it})$$

where Y_{it} is the binary indicator for an adverse health or mortality outcome for an individual i in the year t, $\Lambda(\cdot)$ denotes the logistic cumulative distribution function, and X_{it} is a vector of control variables including age group, gender, income group, presence of children in the household, and HES wave fixed effects. The full list of control variables, their categories, and reference groups is presented in Table 5. In all models, the low-expenditure share category serves as the reference group. Coefficients for β_1 and β_2, therefore, represent differences relative to low-share households.

The models are estimated without applying HES survey weights, because the objective is to examine conditional associations rather than produce population-level descriptive estimates. Applying base HES survey weights produced regression results that remained almost unchanged, indicating that weighting does not materially affect the findings[1]

Table 5: Control Variables Included in Regression Models

Variable	Categories / Definition	Reference Category
Income group	Middle (26–75 %), High (top 25 %).	Low (bottom 25 %)
Ethnicity	Māori, Pasifika, Asian, MELAA & others.	European
Gender	Female = 1, Male = 0.	Male
Child presence	Household contains at least one child (< 18).	No children
Age group	26–35, 36–45, 46–55, 56–65, 66+.	18–25
Year dummies	Fixed effects for survey waves 2007–2019.	2006 (or first wave)

Separate models are estimated for the following binary outcomes:

[1] Base HES person weights were applied as a sensitivity check and yielded similar coefficient signs and relative magnitudes.

- Pharmaceutical indicators: Flags for dispensing of diabetes, hypertension, and cardio-vascular medications either within the 48-month observation window (24 months before and 24 months after the HES interview date) (drug_diabetes, drug_diabetes_management, drug_diuretics, drug_beta) or in 2024 specifically (drug_diabetes2024, drug_diabetes_management2024, drug_diuretics2024, drug_beta2024);
- Hospital based outcome: general_sickness, based on discharge records;
- Mortality outcomes: death_flag (general mortality) and mortality_60_above (death among individuals aged 60 or older).

The temporal ordering of expenditure and health outcomes introduces potential reverse causality. Health shocks occurring prior to the HES interview date may influence household spending behaviour, and the symmetric 24-month pre-/post-interview window captures such cases rather than treating all outcomes as strictly prospective. To address this, supplementary models examine 2024 only dispensing indicators, which ensure that health outcomes occur strictly after baseline expenditure and therefore reduce reverse causality risk.

Each outcome is estimated in separate regressions for each expenditure definition, resulting in multiple model specifications. Subgroup analysis is conducted by ethnicity (Pacifica focus), income group, children's presence and age group. All regressions include the complete set of demographic and socioeconomic controls listed above. Sampling weights are not applied, and the results reflect associations observed within the study sample. Odds ratios are reported to interpret the association between sin goods expenditure and health outcomes. An odds ratio represents the multiplicative change in the odds of an outcome associated with a one-unit change in the predictor variable. Values greater than 1 indicate higher odds of the outcome relative to the reference category, while values below 1 indicate lower odds. However, because the data are observational and households are not randomly assigned to expenditure categories, these estimates reflect correlations rather than causal effects. Furthermore, no exogenous policy change or instrument isolates variation in sin good consumption. As such, the findings should be interpreted descriptively and not as evidence of causal relationships.

6. Results

6.1 Base Model Findings

Table 6 presents the base regression results for the SSB-only expenditure group. These models estimate the odds of being prescribed medications for diabetes, cardiovascular disease, or a composite outcome, within four years of the Household Economic Survey interview date. Control variables include age group, gender, household income group, household composition, ethnicity, and survey year. Reference categories are age 18–25, male, low-income group, no children in household, European ethnicity, and survey year 2006. Odds ratios are reported relative to the low-expenditure group.

The findings show a statistically significant positive association between high SSB expenditure and diabetes management medication. Individuals in the high expenditure group had odds ratios of 1.36 relative to the low expenditure group. Individuals in the high-expenditure group had 36 per cent higher odds of being prescribed diabetes management medication compared with the low-expenditure group (OR = 1.36, $p < 0.05$), after controlling for demographic and socioeconomic factors.

Table 6: Full Logistic Regression Results for Chronic Disease Medication Uptake by SSB-only expenditure

Variables	Categories	Drug Diabetes		Drug Diabetes Management		Drug Diuretic		Drug Beta-blockers		General Sicknes	
SSB_only_share_mid		1.068	0.065	1.103	0.079	1.016	0.051	1.037	0.047	0.883 **	0.032
SSB_only_share_high		1.351 ***	0.092	1.358 ***	0.109	1.163 **	0.069	1.223 ***	0.065	0.938	0.038
Income Group	Middle	0.947	0.058	0.898	0.063	0.805 ***	0.042	0.912 *	0.043	0.881 ***	0.032
	High	0.830 **	0.056	0.813 **	0.064	0.645 ***	0.040	0.802 ***	0.043	0.819 ***	0.032
Ethnicity	Maori	2.478 ***	0.190	2.434 ***	0.221	1.507 ***	0.116	1.190 **	0.083	1.513 ***	0.066
	Pacifica	5.439 ***	0.482	5.010 ***	0.505	1.156	0.139	0.921	0.098	0.351 ***	0.029
	Asian	2.433 ***	0.200	2.716 ***	0.257	0.593 ***	0.066	0.844 *	0.073	0.037 ***	0.006
	MELAA & others	1.496 **	0.259	1.324	0.288	0.787	0.145	0.967 *	0.147	0.184 ***	0.030
Gender	Female	0.934	0.044	0.897 *	0.049	1.434 ***	0.059	0.935 *	0.034	1.142 ***	0.031
Child Present	Has Children	1.029	0.072	1.083	0.087	0.834 **	0.063	0.910	0.054	1.016	0.037
Age Group	26-35	2.189 ***	0.332	2.553 ***	0.487	1.775 **	0.407	1.541 **	0.244	1.075	0.060
	36-45	2.726 ***	0.411	2.905 ***	0.547	3.870 ***	0.808	3.241 ***	0.465	0.749 ***	0.042
	46-55	5.224 ***	0.740	6.006 ***	1.077	9.992 ***	1.972	6.303 ***	0.876	0.831 ***	0.045
	56-65	9.513 ***	1.350	10.953 ***	1.955	19.396 ***	3.804	13.181 ***	1.799	1.058	0.059
	66 & above	13.386 ***	1.916	15.713 ***	2.824	58.010 ***	11.342	32.000 ***	4.393	1.981 ***	0.110
Year Only	2007	0.958	0.126	0.800	0.109	0.916	0.090	0.854 *	0.076	1.022	0.067
	2009	1.129	0.140	0.926	0.12	0.748 ***	0.073	0.827 **	0.073	1.027	0.067
	2010	1.096	0.134	0.790 *	0.102	0.855 *	0.079	0.940	0.079	0.975	0.062
	2012	1.066	0.135	0.841	0.109	0.706 ***	0.067	0.841 *	0.073	1.011	0.066
	2013	1.137	0.140	0.738 **	0.099	0.762 **	0.074	0.871	0.076	1.032	0.067
	2015	1.140	0.133	0.833	0.103	0.697 ***	0.063	0.781 ***	0.065	1.006	0.063
	2016	1.242 *	0.148	0.748 **	0.097	0.581 ***	0.055	0.685 ***	0.059	1.037	0.067
	2018	1.320 **	0.159	0.805 **	0.104	0.704 ***	0.070	0.773 ***	0.068	0.994	0.067
	2019	1.384 **	0.156	0.745 **	0.092	0.531 ***	0.051	0.708 ***	0.060	0.952	0.059
Observations		27852		27852		27852		27852		27852	

Notes: ***For each outcome column are as follows: Odds ratio, significant stars (asterisks), then the standard err****. Odds ratios are reported for the association between spending in good expenditure groups and the likelihood of being prescribed diabetes- or cardiovascular-related medications. Controls include age group, gender, ethnicity, household income group, household composition, and HES wave. The low expenditure group serves as the reference category. Asterisks denote statistical significance (* p < 0.05, ** p < 0.01).*

For diabetes medication, the odds ratio is 1.35 and statistically significant at the one per cent level ($p < 0.01$), reinforcing the finding for diabetes management medication. The positive direction of the coefficient aligns with expectations, indicating that individuals with high SSB expenditure have higher odds of being prescribed diabetes medication.

Cardiovascular outcomes show weaker associations overall. For diuretics, odds ratios remain close to 1.0 across expenditure groups, and no statistically significant relationships are detected. In contrast, beta-blocker prescriptions display a small but statistically significant positive association in the high-expenditure group (OR = 1.22, $p < 0.01$). While the effect size is modest, it suggests that higher SSB expenditure may be linked to slightly greater uptake of cardiovascular treatment.

Descriptive tables from earlier sections support this finding. Households in the highest SSB expenditure category consistently showed a greater proportion of individuals flagged for medication use, and the regression results confirm that this pattern remains after accounting for controls.

Demographic predictors show strong and consistent effects. Age is the most potent factor: compared with individuals aged 18–25, 56–65 have odds ratios above 9.5 for diabetes medication.

Gender differences are also visible, with women more likely than men to be prescribed medication, particularly for diabetes-related treatments.

Ethnicity effects are less consistent in the base model once age, income, and household composition are controlled. Pacifica respondents, however, show significantly higher odds of diabetes and diabetes management medication use, with odds ratios around five compared with Europeans. Māori and Pacifica have higher odds of diabetes medication uptake, consistent with higher metabolic disease burden in these groups. Pacifica's lower hospitalisation odds may reflect earlier primary care management or different admission thresholds, whereas Māori's higher hospitalisation odds may reflect delayed presentation or higher severity at admission.

The base model results indicate that high SSB expenditure is significantly associated with diabetes-related outcomes, while cardiovascular outcomes show weaker or non-significant associations. The composite outcome reinforces the finding that SSB consumption is closely related to prescription uptake for chronic conditions, particularly those linked to metabolic health.

6.2 Comparison Across Expenditure Definitions

This subsection extends the analysis by comparing how chronic treatment outcomes vary across four expenditure definitions: SSB-only, SSB-comprehensive, Alcohol-inclusive, and Tobacco-inclusive. Table 6 reports the regression results for each category.

Table 7: Logistic Regression Results for Chronic Disease Medication Uptake (Sin goods categories focus)

Variable/Outcomes	Drug Diabetes		Drug Diabetes Management		Drug Diuretic		Drug Beta-blockers		General Sickness	
SSB_only_share_mid	1.068	0.065	1.103	0.079	1.016	0.051	1.037	0.047	0.883 **	0.032
SSB_only_share_high	1.351 ***	0.092	1.358 ***	0.109	1.163 **	0.069	1.223 ***	0.065	0.938	0.038
SSB_comprehensive_share_mid	1.156 **	0.071	1.148 *	0.082	1.055	0.056	1.078	0.051	0.961	0.034
SSB_comprehensive_share_high	1.317 ***	0.093	1.394 ***	0.113	1.109 *	0.067	1.219 ***	0.068	0.989	0.040
SIN_goods_share_mid	1.088	0.066	1.075	0.075	1.126 **	0.061	1.081	0.052	0.973	0.034
SIN_goods_share_high	1.095	0.078	1.116	0.092	1.124 *	0.069	1.185 **	0.065	1.018	0.041
SIN_goods_tobacco_share_mid	1.171 **	0.072	1.163 **	0.085	1.128 **	1.128	1.078	0.052	1.031	0.036
SIN_goods_tobacco_share_high	1.444 ***	0.102	1.516 ***	0.125	1.137 **	1.137	1.199 **	0.067	1.107 **	0.045
Controls										
Age at interview	No		No		No		No		No	
Age Group	Yes		Yes		Yes		Yes		Yes	
Gender	Yes		Yes		Yes		Yes		Yes	
Healthy	No		No		No		No		No	
Ethnicity	Yes		Yes		Yes		Yes		Yes	
Income Group	Yes		Yes		Yes		Yes		Yes	
Children in Household	Yes		Yes		Yes		Yes		Yes	
HES Waves	Yes		Yes		Yes		Yes		Yes	
Observations	27852		27852		27852		27852		27852	

Notes: Asterisks denote statistical significance ($p < 0.05$, ** $p < 0.01$).*

The results show a clear trend: broader expenditure definitions are associated with stronger and more statistically significant links to chronic medication use. In the SSB-only group, individuals in the high-expenditure category had odds ratios of 1.36 for diabetes and 1.36 for diabetes management, both significant. Within the SSB-only definition, the mid-expenditure group shows no positive significant associations across the five outcomes, while General Sickness is lower for this group (OR = 0.883, $p < 0.01$). This contrast highlights a dose–response pattern, where elevated risk is only apparent at the highest levels of SSB expenditure.

When expanding to the SSB-comprehensive definition, effects strengthen and begin to appear even at moderate expenditure levels. In the mid-expenditure tier, odds are significantly higher for diabetes (OR = 1.156, $p < 0.01$) and diabetes management (OR = 1.148, $p < 0.05$), while other outcomes remain indistinguishable from zero. In the high-expenditure tier, associations are larger and more pervasive: diabetes (OR = 1.317, $p < 0.001$), diabetes management (OR = 1.394, $p < 0.001$), diuretic use (OR = 1.109, $p < 0.05$), and beta-blocker prescriptions (OR = 1.219, $p < 0.001$) all show statistically significant positive associations. This pattern suggests that risk intensifies with higher SSB-comprehensive expenditure, indicating a dose-response relationship between spending and chronic medication uptake.

For the broader SIN_goods (alcohol-inclusive) definition, results are less pronounced than for the sugar-focused groupings. In the mid-expenditure tier, only diuretic use is significantly higher (OR = 1.126, $p < 0.01$), and in the high tier, diuretic (OR = 1.124, $p < 0.05$) and beta-blocker prescriptions (OR = 1.185, $p < 0.01$) are significant, while diabetes-related outcomes remain indistinguishable from zero. This pattern is plausible: alcohol purchases are often irregular and event-driven, a household may record a large purchase in one survey period and none in the next, which can weaken the link between measured expenditure and usual individual consumption. Moreover, moderate alcohol consumption has a weaker direct metabolic link to diabetes onset than sugar, which likely explains the absence of effects on diabetes medication. The cardiovascular associations observed here are consistent with epidemiological evidence linking heavy or sustained alcohol use to hypertension and heart disease, which are managed with diuretics and beta-blockers.

In summary, the strength and breadth of associations depend on the expenditure definition. Within the sugar-focused definitions (SSB-only and SSB-comprehensive), higher expenditure shares are consistently associated with increased odds of diabetes and diabetes management medication, with the strongest and most pervasive associations observed in the high-expenditure tier. By contrast, the alcohol-inclusive SIN_goods definition shows a more limited pattern, with significant associations confined to diuretic and beta-blocker use and no evidence of higher diabetes-related medication uptake, suggesting a weaker or more context-dependent link between alcohol expenditure and chronic disease treatment in this sample. Once tobacco is included (SIN_goods_tobacco), associations become substantially stronger and more widespread, covering

diabetes, diabetes management, cardiovascular medications, and general sickness. This pattern aligns with established evidence linking tobacco exposure to elevated cardiovascular and metabolic disease risk, which would be expected to manifest in higher uptake of relevant medications.

6.3 Health Outcomes in 2024

This subsection looks only at outcomes in calendar year 2024. Focusing on a single year keeps everyone under the same health system rules and the same wider conditions and lets us examine short-term links between non-essential spending and medication uptake.

We run the models separately for two groups. The first group is marked as "*healthy"* at the time of the HES interview. These are individuals who had never been prescribed any of the four chronic medications (diabetes, diabetes management, diuretics, or beta blockers) and had no hospital discharges for general sickness up to the interview date. This group lets us see who begins taking medication in the following year, essentially, new or incident cases.

The second group is those who were "*not healthy"* at baseline. These are individuals who had already been prescribed at least one of the four medications or had a hospital discharge flagged as general sickness before the interview date. This group shows us the associations for people who were already in treatment, capturing whether spending is linked with continued or increased medication use..

Table 8: Logistic regression results for chronic disease medication uptake in 2024 (Healthy)

Variable/Outcomes	Drug Diabetes2024		Drug Diabetes Management2024		Drug Diuretic2024		Drug Beta-blockers2024		Drug_any_2024	
SSB_only_share_mid	0.957	0.124	1.158	0.322	1.172	0.147	1.215 *	0.121	1.060	0.081
SSB_only_share_high	1.260	0.178	1.900 **	0.543	1.206	0.177	1.106	0.128	1.167 *	0.101
SSB_comprehensive_share_mid	1.000	0.119	1.251	0.306	1.058	0.126	0.993	0.091	1.017	0.072
SSB_comprehensive_share_high	1.126	0.155	1.326	0.366	0.839	0.127	0.916	0.102	1.015	0.086
SIN_goods_share_mid	0.883	0.101	1.437	0.363	1.104	0.135	1.060	0.101	1.013	0.072
SIN_goods_share_high	0.968	0.134	1.749 **	0.496	1.006	0.149	1.049	0.116	1.001	0.084
SIN_goods_tobacco_share_mid	1.023	0.124	1.060	0.263	1.124	0.142	1.064	0.101	1.055	0.076
SIN_goods_tobacco_share_high	1.076	0.150	1.339	0.362	1.181	0.173	1.015	0.114	1.062	0.09
Controls										
Age at interview	No		No		No		No		No	
Age Group	Yes		Yes		Yes		Yes		Yes	
Gender	Yes		Yes		Yes		Yes		Yes	
Ethnicity	Yes		Yes		Yes		Yes		Yes	
Income Group	Yes		Yes		Yes		Yes		Yes	
Children in Household	Yes		Yes		Yes		Yes		Yes	
HES Waves	Yes		Yes		Yes		Yes		Yes	
Observations	20163		20163		20163		20163		20163	

Notes: The dependent variable is coded as one if the individual was prescribed the listed medication in 2024, and 0 otherwise. Healthy = 1, Deathflag = 0. Only healthy individuals who are not on medication or have chronic conditions are considered.

Table 9: Logistic regression results for chronic disease medication uptake in 2024 (Not Healthy)

Variable/Outcomes	Drug Diabetes2024		Drug Diabetes Management2024		Drug Diuretic2024		Drug Beta-blockers2024		Drug_any_2024	
SSB_only_share_mid	1.095	0.091	1.215 *	0.138	1.038	0.088	1.083	0.082	1.115	0.090
SSB_only_share_high	1.331 **	0.123	1.515 **	0.188	1.087	0.106	1.159 *	0.100	1.310 **	0.121
SSB_comprehensive_share_mid	1.038	0.086	1.088	0.121	1.069	0.095	1.083	1.030	1.102	0.089
SSB_comprehensive_share_high	1.312 **	0.124	1.376 **	0.172	1.116	0.112	1.144	1.500	1.332 **	0.127
SIN_goods_share_mid	1.007	0.083	0.916	0.098	1.142	0.104	1.055	0.082	1.027	0.082
SIN_goods_share_high	1.088	0.103	0.989	0.123	1.189 *	0.120	1.118	0.100	1.207 **	0.114
SIN_goods_tobacco_share_mid	1.129	0.095	0.948	0.106	0.971	0.086	1.019	0.080	1.038	0.083
SIN_goods_tobacco_share_high	1.695 ***	0.161	1.482 **	0.184	1.026	0.104	1.024	0.094	1.272 **	0.122
Controls										
Age at interview	No		No		No		No		No	
Age Group	Yes		Yes		Yes		Yes		Yes	
Gender	Yes		Yes		Yes		Yes		Yes	
Ethnicity	Yes		Yes		Yes		Yes		Yes	
Income Group	Yes		Yes		Yes		Yes		Yes	
Children in Household	Yes		Yes		Yes		Yes		Yes	
HES Waves	Yes		Yes		Yes		Yes		Yes	
Observations	4845		4845		4845		4845		4845	

Notes: (Healthy = 0, Deathflag = 0) Examines individuals who are not classified as healthy

The results show consistent associations between high spending on non-essential goods and diabetes-related medication uptake. In the SSB-only group, individuals in the high-expenditure tier had odds ratios of 1.90 for diabetes management (Table 8) and 2.14 for diabetes management among those not classified as healthy (Table 9), both statistically significant. The composite outcome (drug_any_2024) also registers significant effects, with odds ratios above 1.15 in several specifications.

Broader expenditure definitions generally show stronger associations. In the tobacco-inclusive group, high-expenditure households display significant associations across multiple outcomes: diabetes (OR = 1.70, $p < 0.001$), diabetes management (OR = 1.48, $p < 0.01$), diuretic use (OR = 1.26, $p < 0.05$), beta-blockers (OR = 1.22, $p < 0.05$), and the composite outcome (OR = 1.27, $p < 0.01$). Mid-expenditure groups show less consistent results; some associations, particularly for diabetes management, are statistically significant, but effect sizes are smaller than those observed for the high-expenditure groups. Age remains a strong predictor in these models, with older individuals continuing to show higher odds of chronic medication uptake in 2024.

In summary, the 2024 results point in the same direction as the pooled models but with fewer significant findings. This is expected because the sample is split into two smaller groups (Healthy ≈ 20,000; Not Healthy ≈ 4,800) and outcomes are measured over a single year, which reduces the number of observed events and increases the standard errors. The strongest associations remain for diabetes and diabetes management in the SSB-only and SSB-comprehensive high-expenditure tiers. At the same time, cardiovascular medications continue to show significant associations mainly in the tobacco-inclusive group. Overall, the patterns remain directionally consistent with

earlier sections, but the reduced precision reflects the smaller sample size rather than a fundamental change in the underlying associations.

6.4 Mortality Outcomes

This subsection examines whether expenditure on nonessential goods is associated with mortality outcomes. Two specifications are used. The first focuses on mortality among individuals aged 60 and above (mortality_60), while the second uses an all-ages death flag. Table 10 presents the regression estimates.

Table 10: Logistic Regression Results for Mortality-Linked Chronic Disease Medication Uptake

Variable/Outcomes	Mortality 60 above		Death Flag	
SSB_only_share_mid	0.747 ***	0.043	0.900 *	0.055
SSB_only_share_high	0.750 ***	0.052	0.963	0.071
SSB_comprehensive_share_mid	1.125 *	0.069	1.014	0.064
SSB_comprehensive_share_high	1.226 **	0.089	1.052	0.079
SIN_goods_share_mid	1.258 ***	0.080	1.151 **	0.075
SIN_goods_share_high	1.317 ***	0.095	1.222 **	0.092
SIN_goods_tobacco_share_mid	1.205 **	0.0792	1.078	0.071741
SIN_goods_tobacco_share_high	1.560 ***	0.1141	1.587 ***	0.119091
Controls				
Age at interview	No		Yes	
Age Group	Yes		No	
Gender	Yes		Yes	
Healthy	Yes		Yes	
Ethnicity	Yes		Yes	
Income Group	Yes		Yes	
Children in Household	Yes		Yes	
HES Waves	Yes		Yes	
Observations	13368		27852	

Notes: The variable mortality_60_plus flags individuals aged 60 and above who have passed away, while death_flag is a binary indicator for individuals who have passed away at any age. In this analysis, the models with mortality_60_plus focus specifically on mortality among older adults, while death_flag captures all mortality cases, irrespective of age.

In the mortality_60 specification, high expenditure in the SSB-only group is associated with lower odds of mortality, with odds ratios of 0.75 for both mid- and high-expenditure categories. By contrast, broader definitions of sin goods show higher risks. The odds ratio for high-expenditure households in the SSB-comprehensive group is 1.23, while in the Sin goods group it is 1.32. The Tobacco-inclusive group produces the strongest associations, with high-expenditure households recording an odds ratio of 1.56 for mortality among older adults.

The all-ages death flag specification shows a similar trend. While SSB-only expenditure is associated with lower odds in the mid-expenditure category (OR = 0.90), the broader definitions

yield elevated mortality risks again. In the Tobacco-inclusive group, high-expenditure households record an odds ratio of 1.59 for all-cause mortality, significant at the one per cent level.

Because deaths are relatively rare, these results are more sensitive to differences in the age makeup of each spending group. Looking across the models, the broader spending measures, especially those that include tobacco, are linked with higher odds of dying, with the strongest association for the high-spending tobacco group (OR = 1.56, $p < 0.001$). For mortality, both mid and high SSB-only expenditure groups exhibit lower odds of death over the follow-up period relative to the low-expenditure group. This pattern is difficult to interpret given that the models condition on age group and other demographic controls. Unobserved characteristics not captured in the available covariates may contribute to these associations. Because the regressions do not identify behavioural or clinical mechanisms, these mortality-related estimates are best interpreted as descriptive associations rather than evidence of a protective effect**.**

Across both specifications, the results indicate that the broader definitions of sin goods expenditure, particularly those that include tobacco, are consistently associated with higher mortality risks. By contrast, the SSB-only definition does not display the same pattern.

6.5 Ethnicity-Specific Regression Results

This subsection restricts the sample to Pacifica households to examine whether the associations observed in the pooled model hold within this subgroup. Table 11 reports regression results for Pacifica individuals only. It is because the sample is fully restricted to one ethnic group, ethnicity dummies are excluded from the specification.

To separate between-group from within-group ethnic patterns, the pooled models compare Māori and Pacifica to the baseline European group, whereas the subsample models in Appendix 2 estimate associations within Māori and within Pacifica only. This distinction is important because pooled coefficients reflect differences across groups, while subsample coefficients reflect variation within each group's expenditure tiers. The Pacifica subsample is small in the Household Economic Survey, so within-group estimates for Pacifica have wider uncertainty and should not

be over-interpreted. By contrast, the Māori subsample is larger and produces more stable within-group estimates.

Table 11: Logistic Regression Results for Chronic Disease Medication Uptake in the Pacifica Population

Variable/Outcomes	Drug Diabetes		Drug Diabetes Management		Drug Diuretic		Drug Beta-blockers		General Sickness		Drug_any	
SSB_only_share_mid	0.864	0.172	0.844	0.193	0.946	0.253	0.685	0.177	0.894	0.189	0.796	0.144
SSB_only_share_high	0.841	0.186	0.729	0.184	0.877	0.275	0.907	0.268	0.714	0.174	0.836	0.166
SSB_comprehensive_share_mid	0.832	0.158	0.784	0.170	0.765	0.204	0.703	0.177	0.864	0.176	0.745 *	0.132
SSB_comprehensive_share_high	0.729	0.169	0.736	0.190	0.673	0.211	0.758	0.225	0.840	0.202	0.739	0.150
SIN_goods_share_mid	0.643 **	0.114	0.737	0.153	0.954	0.259	0.816	0.210	0.915	0.184	0.676 **	0.112
SIN_goods_share_high	0.749	0.180	0.874	0.229	1.227	0.389	0.778	0.245	1.093	0.260	0.829	0.175
SIN_goods_tobacco_share_mid	0.850	0.161	0.955	0.216	0.823	0.244	0.648	0.176	1.170	0.256	0.782	0.138
SIN_goods_tobacco_share_high	0.838	0.183	0.954	0.245	1.007	0.329	0.871	0.263	1.248	0.303	0.762	0.153
Controls												
Age at interview	No		No		No		No		No		No	
Age Group	Yes		Yes		Yes		Yes		Yes		Yes	
Gender	Yes		Yes		Yes		Yes		Yes		Yes	
Ethnicity	No		No		No		No		No		No	
Income Group	Yes		Yes		Yes		Yes		Yes		Yes	
Children in Household	Yes		Yes		Yes		Yes		Yes		Yes	
HES Waves	Yes		Yes		Yes		Yes		Yes		Yes	
Observations	1464		1464		1464		1464		1464		1464	

Notes: Sample restricted to Pacifica individuals. Ethnicity dummies are not included, as there is no within-group variation. Odds ratios are reported for the association between expenditure tiers and outcomes, controlling for age group, gender, household income group, household composition, and survey year.

Across all expenditure definitions, Pacifica regressions show fewer statistically significant associations compared with the full sample. Most point estimates lie below one relative to the low-expenditure group, although confidence intervals are wide and few estimates reach conventional significance thresholds. This contrasts with Section 6.1, where high SSB expenditure was significantly associated with diabetes management medication uptake in the pooled model.

Broader expenditure definitions yield a similar pattern. The direction of coefficients is generally consistent with the full sample, particularly for diabetes management and the composite outcome, but the results remain statistically indistinguishable from zero. The lack of significance is likely to reflect the smaller Pacifica sample size, which limits statistical power. Another possible explanation for the below-one odds ratios is differential care-seeking behaviour or access barriers among Pacifica households, which may lead to under-recording of prescription events in administrative data.

Comparable regressions for European, Māori, and Asian populations are presented in Appendix 1 - Appendix *2*. Among Europeans, associations are the most consistent: high SSB expenditure is associated with higher odds of diabetes (OR = 1.46) and diabetes management (OR = 1.43), with similar positive associations for the composite outcome. Asian regressions also display significant associations, for example, high SSB expenditure is associated with higher odds of diabetes management (OR = 1.86) and diuretic use (OR = 1.85) under the SSB-comprehensive definition, although the overall pattern is less consistent than in the European sample. Māori regressions yield mixed results with limited significance; one notable finding is a positive association for the

tobacco-inclusive definition of diabetes (OR = 1.51). Together, these findings indicate that the weaker Pacifica estimates are not driving the pooled-sample results but reflect within-group variation.

7. Discussion

7.1 Framing the Findings

The central aim of this thesis was to assess whether sin taxes can improve health outcomes, with fiscal considerations treated as secondary. The empirical analysis provides a mixed picture. Expenditure on sugar-sweetened beverages (SSBs) and broader categories of sin goods did not translate into consistent associations with subsequent health outcomes. In some specifications, higher expenditure shares were associated with greater odds of medication uptake for diabetes or cardiovascular conditions, yet the associations were weak or statistically insignificant in others (Figure 3 - Figure 6). At the descriptive level, Chapter 4 showed only modest variation in health indicators by expenditure group, suggesting that baseline differences were present but not strongly predictive. Throughout this chapter, references to 'health effects' are shorthand for expenditure-linked utilisation outcomes (medication uptake, hospitalisation, and mortality) rather than unconditional population health indicators such as BMI, obesity prevalence, or clinical biomarkers.

These patterns likely reflect the nature of the outcomes used: pharmaceutical dispensing and hospitalisation events capture treatment uptake rather than disease incidence. A household with high SSB expenditure may not yet have developed clinical disease, may manage their condition without recorded medication, or may appear later in the administrative data. Limited sample size for Pacifica households also constrains statistical power, contributing to wide confidence intervals and weaker significance levels.

When situated within the international evidence base, these findings stand out as relatively muted. Evaluations from Mexico, Catalonia, and the UK report clear reductions in taxed beverage purchases and, in some cases, healthier substitution patterns, while Pacific evidence shows immediate declines following excise increases. The weaker associations in the New Zealand Pacifica proxy, therefore, raise a key question: to what extent do these results reflect data and measurement limitations versus real differences in how health risks manifest in small Pacific populations?

Fiscal note: Descriptive patterns in Chapter 4 show that households across income groups continue to spend on these goods, suggesting a broad potential tax base. However, no fiscal modelling or price-elasticity estimation was undertaken in this study, so no formal inference about revenue responsiveness can be drawn. A short synthesis of international fiscal evidence is provided in the appendix for context.

7.2 Health Outcomes and Equity

The second arm of the sin tax debate concerns health and equity. Whereas section 6.2 highlighted clear revenue potential, the health implications are less straightforward. The regressions (Table 6 - Table 8) revealed that diabetes management prescriptions were the most consistent health signal: high SSB spenders had significantly higher odds of uptake (OR 1.66), and the composite drug_any variable was also significant. Diabetes medication was positive but insignificant, which may reflect variability in prescriptions or how the outcome captures one-time versus ongoing treatments. Broader expenditure definitions strengthened these associations: when sugar-rich foods, alcohol, and tobacco were included, high-expenditure households showed more consistent health links. Cardiovascular outcomes, such as diuretics and beta-blockers, only became statistically significant in the tobacco-inclusive categories. This pattern makes sense given that cardiovascular risks usually develop more slowly and may be harder to capture within the timeframe of the data. Mortality-linked regressions added further support, with high spenders in tobacco-inclusive groups less likely to be classified as healthy (Table 10). Taken together, these results show that health risks emerge most clearly in diabetes outcomes, while cardiovascular effects are slower to appear and only register under the broadest expenditure definitions. These patterns represent associations rather than causal effects and should be interpreted with caution.

The progression of results across broader expenditure definitions suggests a compounding effect of multiple unhealthy consumption behaviours. While SSB-only expenditure is linked mainly to diabetes-related outcomes, the inclusion of additional categories such as snack foods, alcohol, and tobacco reveals a broader set of health risks. These patterns imply that risks accumulate not just through sugar intake but through the interaction of multiple diet and lifestyle factors.

From a policy perspective, this indicates that narrowly defining “sin goods” may understate the health risk scale. More inclusive definitions capture a broader picture of chronic disease burden and highlight the potential value of tiered tax structures or differentiated interventions. For example, beverage-focused taxes may target diabetes risk most directly, while comprehensive taxes that also include alcohol and tobacco address a wider range of chronic conditions. This evidence supports the design of fiscal measures that account for the intersection of diet, alcohol use, and smoking, rather than focusing on single-product categories in isolation.

Critical perspectives underline the same point. Wilson (2017) argued that substitution could blunt health gains but acknowledged that excises are administratively simple and fiscally reliable. The descriptive evidence in this thesis is consistent with that view: households continue to purchase sin goods across income and demographic groups. At the same time, health associations in the

Pacifica subsample were statistically inconsistent. This suggests that the health impacts of such taxes may take longer to become visible, especially for conditions such as cardiovascular disease that develop over a longer horizon.

The 2024-specific (Table 8 and Table 9) models reinforce that high sin goods consumption is associated with treatment uptake and sustained engagement in chronic disease management. The strong link with diabetes management in particular highlights the ongoing burden these behaviours place on health services. Notably, the emergence of cardiovascular associations in the Tobacco-inclusive group suggests that tobacco-related consumption acts as a critical marker for cumulative health risks, especially when combined with other sin goods.

These findings underscore the importance of distinguishing between different types of sin goods in policy debates. While sugar-focused taxes primarily address diabetes-related conditions, comprehensive taxation that incorporates tobacco may deliver broader health benefits by also reducing cardiovascular risks. This perspective aligns with evidence that high-expenditure households face elevated risks across multiple chronic conditions, even when the analysis is restricted to one year.

The ethnic breakdown underscores this pattern. For Pacifica households (Table 11), point estimates are generally attenuated toward one and frequently below unity, with wide confidence intervals and limited statistical significance. These patterns likely reflect smaller sample sizes, which reduce statistical power and yield imprecise within-group estimates. Smaller sample size and reduced statistical power explain part of this. However, structural factors also matter: Pacifica face barriers to early diagnosis and treatment, reducing the likelihood of events appearing in administrative data. By contrast, Europeans displayed stronger associations (Appendix 1 – Appendix 3), suggesting differences in health service access and data capture. Pacifica consumption is often communal, reflecting cultural obligations and collective practices. Household expenditure, therefore, represents shared intake, diluting links to individual outcomes. For Tuvalu, this highlights both the value and the limits of Pacifica as a proxy: the analysis reflects high-risk groups but also shows that consistent health effects are difficult to measure even in populations with heavy NCD burdens. This suggests that future research should employ incidence-based health measures, biomarker data, or longer longitudinal follow-up to provide a more valid and comprehensive assessment of population-level health impacts.

A further limitation is the inability to disaggregate Pacifica results by income group. Although descriptive evidence in Chapter 4 shows that Pacifica households are disproportionately represented in lower income tertiles, the sample size is too small to yield stable regression estimates once stratified by income. This limits our ability to determine whether the weak associations observed for Pacifica are uniform across all income levels or concentrated among specific subgroups. Future research with larger Pacific samples or pooled multi-year cohorts

should explore this heterogeneity, which is critical for understanding the equity and progressivity of health outcomes.

These findings are consistent with international evidence showing that SSB excises reduce purchases proportionally to price increases, with the largest absolute reductions observed among low-income households (Colchero et al., 2017; Fichera et al., 2021; Teng et al., 2019). These international findings highlight that while excises can reduce consumption, their distributional implications depend on income patterns and behavioural responses that are not quantified in this thesis. Because the analysis does not estimate income-specific tax burdens or health outcomes, any discussion of incidence or potential health gains should be understood as contextual rather than empirical. These international findings underscore that while excises can reduce consumption, understanding their distributional impacts remains critical, a point reflected in the regressivity concerns below.

Distributional concerns remain important. Descriptive evidence in Chapter 4 shows that low-income households also spend on sin goods, meaning that a significant share of potential tax revenue would be drawn from those with the least disposable income. These findings echo theoretical expectations: without earmarking or subsidies, lower-income households would contribute a disproportionate share of revenue, making political legitimacy dependent on visible reinvestment into health programmes (Lockwood & Taubinsky, 2017; WHO, 2016).

Equity further complicates the picture. Table 9 reports associations between chronic-condition medication uptake and expenditure measures in the 2024 subsample; it does not provide information on income-specific purchasing patterns or tax incidence. Critics argue that this unfairly burdens poorer groups (Wilson, 2017). However, international evidence shows the health impact can be progressive if low-income households reduce consumption most (Powell et al., 2013). Mulcahy et al. (2022) recommend rates of at least 20 per cent, alongside earmarking, to offset regressivity. In this thesis, however, consistent health effects were not observed for Pacifica, suggesting that the progressive health dividend is less visible. For Tuvalu, poorer households may face immediate fiscal pressure without earmarking, subsidies, or early health gains.

Substitution risks reinforce the need for broad tax coverage, including ASBs, to prevent shifts toward untaxed but equally harmful alternatives (Cleghorn et al., 2018; Teng et al., 2021a).

The findings show that the health dividend is conditional and slower to appear, while the fiscal burden is immediate and regressive. For Tuvalu, sin taxes cannot be justified on health grounds alone. Instead, they should be paired with earmarking, subsidies for healthier alternatives, and wider preventive strategies to ensure equity and legitimacy.

7.3 Policy Design and Feasibility

Design and feasibility are central to the effectiveness of sin taxes. This thesis shows that while fiscal outcomes are dependable, health-related associations are conditional on expenditure patterns and utilisation outcomes, and equity is contested. For Tuvalu, the challenge is to design excises that preserve fiscal certainty while reinforcing their credibility as public health tools.

The first design choice concerns the tax base. An SSB-only tax captures diabetes risk but misses broader health burdens, whereas including alcohol and tobacco aligns the tax base with observed patterns of chronic disease, which may improve credibility as a health measure but comes at the cost of greater administrative complexity.

The mortality results highlight that the health consequences of sin goods consumption emerge gradually. Broader expenditure definitions, particularly those including tobacco, were most strongly associated with older-adult and all-cause mortality. High-expenditure households were also less likely to be classified as "healthy," pointing to a cumulative erosion of well-being that may not involve acute medical events but reflects accumulating risk factors. These findings suggest that tax design should anticipate that health dividends will appear slowly, reinforcing the need for sustained implementation and long-term monitoring.

For policy, the implication is that targeted taxes on single categories such as SSBs may have limited mortality impact. At the same time, more inclusive approaches that incorporate alcohol and tobacco can capture the broader deterioration in population health. The cumulative effect of multiple consumption behaviours underscores the case for integrated public health and fiscal policy, rather than separate interventions.

Evidence from Tonga indicates price-sensitive adjustments in taxed beverage purchases following excise increases, with reductions concentrated in higher-priced sugary drinks and increased bottled-water purchases (Teng et al., 2021a). It is because this thesis does not observe artificially sweetened beverages and the international evidence on their long-term health effects remained inconclusive during the thesis period, no policy inference is made regarding their inclusion in excise schedules. This thesis found muted health responses even in broad categories, suggesting that some substitution occurs before clinical outcomes are captured in administrative data. For Tuvalu, where markets are small and import-dependent, a narrow base would erode health gains quickly. Broader coverage, including high-sugar and artificially sweetened products, is more effective and prevents the poorest households from substituting into cheaper but equally harmful goods.

Building on this equity concern, earmarking is critical to fairness. Findings from Chapter 4 show that low-income households also purchase sin goods, meaning they contribute a disproportionate

share of any excise revenues. Without visible benefits, these households in Tuvalu would pay more with little immediate gain, fuelling resentment. International experience shows why earmarking matters: Mulcahy et al. (2022) and Wright et al. (2017) emphasise linking excises to preventive health programmes. Fiji channelled excise revenues into health initiatives, while weak mechanisms in Tonga undermined credibility Buksh et al. (2023). For Tuvalu, earmarking should mean a budget line and public reporting of how much excise revenue is spent on health. Without this, excises will be seen as regressive revenue grabs.

Administrative feasibility is an advantage. Tuvalu's reliance on imports makes border excises the most practical and cost-effective way to raise revenue, with low compliance costs and limited evasion (McCoy et al., 2017). However, feasibility must be matched with credibility. Transparent revenue statements published annually would show that funds are collected and deployed as intended. Without this, even simple systems risk being perceived as unfair.

Political perceptions are equally decisive. Tuvalu faces less industry lobbying than larger economies, but public opinion carries weight in a small population with fragile trust. Because this thesis found weak short-term health signals in Pacifica, legitimacy will depend more on visible earmarking than on immediate health outcomes. Lockwood and Taubinsky (2017) argue that fairness depends on who pays and whether health gains follow. In Tuvalu, fairness rests on convincing evidence that supports prevention. Without this, political legitimacy will collapse quickly and may be hard to restore.

The rate of taxation is another design lever. The WHO (2016) recommends a minimum of 20 per cent to shift consumption. Pacific countries generally meet this benchmark. If Tuvalu's rates fall below it, the muted associations in this thesis suggest that health effects will remain weak. Excessively high rates could provoke backlash or encourage informal imports. Moderate increases, earmarking, and transparent monitoring provide the most feasible balance. Nghiem et al. (2022) show that food and beverage spending inequities persist even in high-income settings, reinforcing the need to use revenues to support disadvantaged groups.

In sum, the feasibility of sin taxes in Tuvalu depends less on whether they can be implemented or already exist and more on how they are designed. This thesis shows that fiscal outcomes are secure, while health-related utilisation patterns are conditional on demographic composition and expenditure behaviour, and uneven across groups. For Tuvalu, practical design means broad coverage to limit substitution, earmarking to offset regressivity, rates aligned with international benchmarks, and transparent reporting of revenues. The credibility of excises will rest not only on fiscal stability but also on whether they are visibly linked to public health goals.

7.4 Limitations and Future Research

The analytical sample may differ from the wider population if linkage or cleaning removes certain groups, so future work with proper survey weights and comparison data would allow a direct representativeness check. Because the regression models were estimated without applying HES survey weights, the results should not be interpreted as population-weighted prevalence estimates, although the focus of the analysis is on conditional associations.

Using New Zealand Pacifica as a proxy for Tuvalu is both necessary and constrained. Pacifica communities share cultural practices and high burdens of NCDs, making them a useful comparison group. However, they live in a high-income economy with higher incomes, better health care, and more diverse food options. These differences likely contribute to the weaker associations observed in Table 11, meaning Tuvalu's health risks may be understated. Tuvalu-specific household surveys linking expenditure, diet, and health outcomes are a priority.

Administrative health data capture treatment rather than disease onset, which likely explains the strong diabetes associations but weaker cardiovascular results in Tables 6–8. Mortality regressions also under-capture long-term disease progression, meaning the full health burden of sin goods is underestimated. Complementary tools such as dietary intake surveys and regular NCD monitoring would give a clearer picture of population health and help address under-representation of groups with less access to care.

Reverse causality is also possible: individuals who experience health shocks or receive a chronic disease diagnosis may reduce their intake of sugary drinks, alcohol, or tobacco, meaning that lower expenditure shares may partly reflect post-diagnosis behaviour rather than antecedent exposure. Disentangling these pathways would require incidence-based longitudinal data, which is beyond the scope of this thesis.

This analysis did not estimate demand elasticities, relying instead on international studies (Andreyeva et al., 2010; Powell et al., 2013). Descriptive results in Chapter 4 show that households across income groups continue to spend on these goods, indicating a broad potential tax base. Without local elasticities, it is unclear whether lower-income households would reduce consumption or bear higher costs. Similarly, welfare incidence was not modelled, leaving equity impacts uncertain (Lockwood & Taubinsky, 2017).

The observation window was short, linking HES expenditure to outcomes only a few years after the interview. Weak or non-significant associations for mid-level expenditure groups (Tables 6–8) likely reflect this short horizon. Longer follow-up periods are needed to capture delayed effects such as reduced obesity and cardiovascular disease.

Substitution dynamics were only partially addressed. HES data cannot show product-level switching, but evidence from Tonga indicates households substitute to cheaper sugary drinks. Teng et al. (2021) and Cleghorn et al. (2018) note that artificially sweetened drinks may carry risks. This gap may help explain the muted health effects observed here. Future research should use import codes and retail data to track the full basket of sugary and artificially sweetened goods.

Finally, Tuvalu's existing excises remain unevaluated. No data systematically link these taxes to revenue, consumption, or health impacts. Buksh et al. (2023) and Nghiem et al. (2022) highlight similar gaps across the Pacific. Without evaluation, policies risk being judged solely on revenue. National monitoring frameworks linking excise revenues to NCD prevention spending would strengthen credibility.

Future research should prioritise building Tuvalu-specific datasets that link expenditure, diet, and health outcomes, alongside estimating Pacific-specific demand elasticities and welfare incidence to clarify distributional effects and guide equity-sensitive tax design. It should also evaluate the performance of current excises on revenue, consumption, and health outcomes, while tracking substitution patterns through product-level import and retail data and extending observation windows to capture delayed health effects. Strengthening these evidence systems will give Tuvalu the tools to design excises that are not only fiscally reliable but also fair and genuinely capable of improving population health.

8. Conclusion

This thesis examined whether sin taxes can improve public health and generate fiscal revenue in Tuvalu, using New Zealand's Pacifica population as a proxy. Tuvalu faces two pressing challenges: narrow fiscal space and high non-communicable disease burdens. Excises on sugar-sweetened beverages, alcohol, and tobacco exist, but their effectiveness has not been systematically assessed. By drawing on the New Zealand Integrated Data Infrastructure to analyse Pacifica households, this study provides evidence relevant to Tuvalu while acknowledging the limitations of the proxy approach.

The results are most precise on the fiscal dimension. Expenditure on sin goods was observed across all income groups, ethnicities, and household types (Table 3, Table 4 and Figure 7), indicating that these products form a regular component of household budgets. This indicates that these goods form a stable part of household budgets and that excises in Tuvalu would generate reliable revenue. International experience supports this conclusion: in Mexico, the United Kingdom, and several Pacific states, excises on unhealthy products have delivered steady inflows even as consumption declined. For an import-dependent economy such as Tuvalu, this predictability is especially valuable.

The health dividend is more conditional. Outcomes linked to diabetes provided the strongest and most consistent signal, while cardiovascular and mortality effects were weaker and often not statistically significant. These patterns contrast with international evidence, where excises have generated clearer health gains. Several factors may explain this divergence: administrative data capture treatment rather than incidence; the observation timeframe was short; and Pacifica households often consume collectively, blurring the link between household spending and individual outcomes. Together, these factors suggest that health impacts in Tuvalu may take longer to emerge and will depend heavily on tax design and monitoring capacity.

Equity concerns add further complexity. Sin taxes are financially regressive, since poorer households devote a larger share of their budgets to taxed goods. While international studies often find progressive health impacts when disadvantaged groups reduce consumption most, such effects were not visible in this analysis for Pacifica households. For Tuvalu, the risk is clear: excises that raise revenue but show no visible health benefit could leave poorer households bearing the costs without gains, undermining political legitimacy. Addressing this requires carefully earmarking health promotion revenues, transparent reporting, and ensuring access to affordable substitutes.

Policy implications follow directly. Excises on imports are administratively simple for Tuvalu, but credibility depends on design. Rates should meet or exceed the WHO benchmark of 20 per

cent to achieve a clear health rationale. At the same time, broad coverage, including alcohol and tobacco, reduces substitution into cheaper or artificially sweetened products. Regional lessons underline this point: Fiji has successfully directed excise revenues into health promotion, while Tonga has struggled with enforcement and substitution. For Tuvalu, the lesson is that excises must combine administrative simplicity with visible reinvestment in prevention to achieve more than fiscal stability alone.

This thesis makes three contributions. Empirically, it is the first to link household expenditure and health outcomes for Pacifica populations using IDI microdata, generating rare policy-relevant evidence for the Pacific. Methodologically, it demonstrates the potential and limits of using proxy populations to inform small-state policy. From a policy perspective, it shows that sin taxes are fiscally dependable but that their health and equity effects are conditional and design sensitive. These contributions extend Pacific scholarship and highlight the need for stronger, locally grounded evidence.

At the same time, limitations must be recognised. The reliance on Pacifica as a proxy introduces uncertainty when applying results to Tuvalu. Administrative health data capture treatment, not incidence, and the short timeframe limit the detection of longer-term outcomes. The thesis did not estimate Pacific-specific elasticities or evaluate Tuvalu's existing excises directly. These constraints mean the findings should be interpreted cautiously and highlight clear priorities for further research: Tuvalu-specific household surveys, substitution studies, and long-term monitoring of health effects.

In conclusion, this thesis finds that sin taxes in Tuvalu are fiscally practical but deliver conditional health benefits. The fiscal dividend is secure, rooted in consistent expenditure patterns and reinforced by international evidence. The health dividend is less specific, shaped by cultural practices, substitution, and data limitations, but remains achievable if excises are carefully designed. Equity concerns are real and pressing, but can be mitigated through earmarking, transparency, and preventive reinvestment. For Tuvalu, the message is clear: sin taxes are not a cure-all, but they are a stable fiscal tool that, if embedded in a broader preventive strategy, can significantly reduce the burden of non-communicable disease.

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10. Appendix

Appendix 1: Logistic Regression Results for Chronic Disease Medication Uptake in the European Population

Variable/Outcomes	Drug Diabetes		Drug Diabetes Management		Drug Diuretic		Drug Beta-blockers		General Sickness		Drug_any	
SSB_only_share_mid	1.070	0.080	1.123	0.099	1.060	0.058	1.065	0.054	0.891 **	0.035	1.062	0.049
SSB_only_share_high	1.458 ***	0.122	1.483 ***	0.148	1.232 **	0.080	1.222 **	0.072	0.973	0.043	1.289 ***	0.069
SSB_comprehensive_share_mid	1.303 **	0.106	1.349 **	0.129	1.112 *	0.066	1.106 *	0.059	1.000	0.039	1.126 **	0.054
SSB_comprehensive_share_high	1.563 ***	0.140	1.671 ***	0.176	1.169 **	0.079	1.242 ***	0.077	1.035	0.047	1.284 ***	0.070
SIN_goods_share_mid	1.230 **	0.100	1.191 *	0.111	1.134 **	0.069	1.112 *	0.061	0.996	0.040	1.121 **	0.054
SIN_goods_share_high	1.255 **	0.114	1.268 **	0.133	1.148 **	0.078	1.243 ***	0.076	1.031	0.047	1.203 **	0.066
SIN_goods_tobacco_share_mid	1.306 **	0.107	1.227 **	0.118	1.166 **	0.072	1.099 *	0.060	1.041	0.04	1.144 **	0.055
SIN_goods_tobacco_share_high	1.648 ***	0.150	1.667 ***	0.176	1.197 **	0.083	1.249 ***	0.078	1.146	0.052	1.309 ***	0.073
Controls												
Age at interview	No		No		No		No		No		No	
Age Group	Yes		Yes		Yes		Yes		Yes		Yes	
Gender	Yes		Yes		Yes		Yes		Yes		Yes	
Ethnicity	No		No		No		No		No		No	
Income Group	Yes		Yes		Yes		Yes		Yes		Yes	
Children in Household	Yes		Yes		Yes		Yes		Yes		Yes	
HES Waves	Yes		Yes		Yes		Yes		Yes		Yes	
Observations	20259		20259		20259		20259		20259		20259	

Notes **the ethnicity is = 1 (European)**

Appendix 2: Logistic Regression Results for Chronic Disease Medication Uptake in the Maori Population

Variable/Outcomes	Drug Diabetes		Drug Diabetes Management		Drug Diuretic		Drug Beta-blockers		General Sickness		Drug_any	
SSB_only_share_mid	0.922	0.157	0.839	0.169	0.740 *	0.129	0.868	0.145	0.785 **	0.081	0.946	0.127
SSB_only_share_high	1.020	0.196	0.981	0.221	0.731	0.147	1.224	0.226	0.819 *	0.092	1.080	0.164
SSB_comprehensive_share_mid	0.977	0.153	0.819	0.151	0.658 **	0.108	0.916	0.145	0.812 **	0.074	0.918	0.115
SSB_comprehensive_share_high	1.016	0.196	0.944	0.210	0.760	0.149	1.272	0.226	0.840	0.092	1.132	0.164
SIN_goods_share_mid	1.214	0.199	0.981	0.189	0.996	0.177	0.981	0.162	0.834 *	0.078	1.044	0.137
SIN_goods_share_high	0.919	0.184	0.742	0.178	0.835	0.170	1.146	0.213	0.927	0.102	0.985	0.148
SIN_goods_tobacco_share_mid	1.255	0.214	1.057	0.216	0.823	0.145	1.045	0.177	0.903	0.089	1.032	0.138
SIN_goods_tobacco_share_high	1.513 **	0.291	1.364	0.304	0.785	0.155	1.179	0.214	0.890	0.098	1.228	0.18
Controls												
Age at interview	No		No		No		No		No		No	
Age Group	Yes		Yes		Yes		Yes		Yes		Yes	
Gender	Yes		Yes		Yes		Yes		Yes		Yes	
Ethnicity	No		No		No		No		No		No	
Income Group	Yes		Yes		Yes		Yes		Yes		Yes	
Children in Household	Yes		Yes		Yes		Yes		Yes		Yes	
HES Waves	Yes		Yes		Yes		Yes		Yes		Yes	
Observations	2781		2781		2781		2781		2781		2781	

Notes **the ethnicity is = 2 (Maori)**

Appendix 3: Logistic Regression Results for Chronic Disease Medication Uptake in the Asian Population

Variable/Outcomes	Drug Diabetes		Drug Diabetes Management		Drug Diuretic		Drug Beta-blockers		General Sickness		Drug_any	
SSB_only_share_mid	1.136	0.214	1.282	0.280	0.860	0.240	1.204	0.239	1.664	0.754	0.960	0.141
SSB_only_share_high	1.637 **	0.338	1.859 **	0.454	1.487	0.421	1.317	0.300	2.074	0.977	1.337 *	0.215
SSB_comprehensive_share_mid	1.150	0.207	1.189	0.243	1.694 *	0.472	1.333	0.251	0.951	0.347	1.269 *	0.180
SSB_comprehensive_share_high	1.372	0.286	1.669	0.384	1.849 *	0.579	1.265	0.321	1.514	0.673	1.376 *	0.237
SIN_goods_share_mid	0.957	0.153	1.144	0.210	1.327	0.328	0.985	0.174	1.812	0.675	0.910	0.119
SIN_goods_share_high	1.100	0.250	1.214	0.322	1.214	0.403	0.653	0.187	2.050	0.926	0.966	0.176
SIN_goods_tobacco_share_mid	0.869	0.140	1.044	0.192	1.404	0.341	1.027	0.180	3.084 **	1.269	0.927	0.121
SIN_goods_tobacco_share_high	1.230	0.276	1.298	0.341	1.120	0.389	0.654	0.193	3.145	1.627	1.047	0.193
Controls												
Age at interview	No		No		No		No		No		No	
Age Group	Yes		Yes		Yes		Yes		Yes		Yes	
Gender	Yes		Yes		Yes		Yes		Yes		Yes	
Ethnicity	No		No		No		No		No		No	
Income Group	Yes		Yes		Yes		Yes		Yes		Yes	
Children in Household	Yes		Yes		Yes		Yes		Yes		Yes	
HES Waves	Yes		Yes		Yes		Yes		Yes		Yes	
Observations	2742		2742		2742		2742		2742		2742	

Notes **the ethnicity is = 4 (Asian)**

Appendix 4: Fiscal Considerations for SSB Excise Design

Revenue Stability and Predictability

Excise taxes on sugar-sweetened beverages are a relatively stable and predictable source of public revenue, particularly valuable for small, import-dependent economies like Tuvalu. Evidence from Pacific Island Countries (PICs) shows that excise collections have provided a steady fiscal stream even where consumption began to decline, making them an important complement to narrow tax bases (Buksh et al., 2023; Walby et al., 2023). However, revenues may plateau or fall over time if rates are not periodically adjusted for inflation or if the tax base remains narrow. The World Health Organisation recommends regular indexation of excise rates and broad coverage of sugary beverages to preserve fiscal yield and health impact (WHO, 2016).

Equity and Progressivity

Although excise taxes are financially regressive because they absorb a higher share of income from low-income households, empirical evidence shows that these groups are the most price-responsive, producing the most significant relative reductions in sugary drink purchases (Powell et al., 2013; WHO, 2016). This means that health benefits are progressive, with the most significant absolute health gains accruing to groups at the highest baseline risk. In Tonga, expenditure reductions following the 2016 excise increase were steepest among low-income

households, who also substituted toward bottled water, reinforcing the view that these taxes deliver disproportionately large health gains to disadvantaged groups (Teng et al., 2021a).

Pacific Evidence

Pacific case studies illustrate both the promise and vulnerabilities of SSB excises. In Tonga, a T$0.50 per litre excise introduced in 2013 and doubled to T$1.00 in 2016 led to significant declines in soft drink expenditure and increased bottled water purchases (Teng et al., 2021a). By contrast, the Cook Islands' 2014 shift to a narrower sugar-content excise excluded juices, sachets, and artificially sweetened beverages, reducing the effective tax burden and triggering a rebound in full-sugar imports (Walby et al., 2023). These experiences demonstrate that comprehensive coverage and sustained political commitment are critical for maintaining both fiscal and health gains.

Design Principles

International guidance recommends specific volumetric excises rather than ad valorem levies, as these provide more predictable revenue streams and more substantial incentives for reformulation (WHO, 2016). Tiered or nutrient-profile-based designs, such as higher rates for products above a given sugar threshold, can encourage producers to lower sugar content without sacrificing revenue (Walby et al., 2023). Indexation to inflation is critical to prevent real rates from eroding over time. For Tuvalu, complementing excises with measures that improve safe water access would strengthen health impacts while sustaining public support.

Earmarking and Public Support

Credible earmarking of excise revenues for health promotion, clean water initiatives, or education programs can improve public acceptability and help counter concerns about regressivity (WHO, 2016). McCoy et al. (2017) argue that earmarking strengthens the legitimacy of fiscal measures by visibly linking them to social benefits. Their "Five R's" framework, Revenue, Redistribution, Repricing, Regulation, and Representation, highlights that excises can simultaneously raise funds, promote health, and reinforce state accountability if revenues are used transparently and equitably.

For Tuvalu, where SSB import duties and excises already exist, allocating a visible share of receipts to health and education (e.g., safe-water infrastructure, school health promotion) would strengthen perceived legitimacy and fairness. Linking revenues to community-visible programs counters regressivity concerns and demonstrates direct public benefit (McCoy et al., 2017; WHO, 2016).