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Master's Thesis

2010-2015 年國家非傳染性疾病策略對東加共和國學齡青少年健康行為改變的影響

The Impact of 2010-2015 National Noncommunicable Diseases Strategy on Health Behavioral Change in School Aged Adolescents in Tonga

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論文中文題目

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論文英文題目

The Impact of 2010-2015 National Noncommunicable Diseases Strategy on Health Behavioral Change in School Aged Adolescents in Tonga

本論文係 最首映代君 (學號 R10853009) 在國立臺灣大學全球衛生碩士學位學程完成之碩士學位論文，於民國 113 年 1 月 20 日承下列考試委員審查通過及口試及格，特此證明。

This Thesis is written by Akiyo Saishu (R10853009) studying in the graduate program in the Global Health Program. The author of this thesis is qualified for a master's degree through the verification of the committee.

林青青 (指導教授簽名 Advisor Signature)

口試委員 Committee Members:

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中文摘要

在東加共和國，非傳染性疾病（Non-communicable diseases, NCDs）的風險近年來一直在上升，需要採取策略性對策。為此，東加逐步實施了國家非傳染性疾病策略。本研究旨在分析湯加從 2010 年至 2015 年實施的國家非傳染性疾病策略對學齡青少年健康行為的影響。我們利用全球學校學生健康調查（Global-School Health Survey, GSHS），比較了 2010 年實施非傳染性疾病戰略前（n=2211）和 2017 年干預後（n=3333）的數據，重點關注肥胖和超重、飲食習慣、吸煙、飲酒、體育鍛煉和久坐不動的生活方式等方面的行為變化。分析採用了卡方檢驗和邏輯回歸。

研究結果顯示，東加青少年肥胖或超重的總體患病率從 2010 年的 35%略微上升至 2017 年的 37%。此外，女性青少年的肥胖或超重患病率從 2010 年的 37%增至 2017 年的 43%。在飲食習慣方面，低頻食用水果的比例從 58%降至 49%。此外，東加女性青少年的吸煙和飲酒行為明顯減少。女性青少年的吸煙率從 2010 年的 23%大幅降至 2017 年的 9.2%（OR 0.85，95% CI 0.82-0.87，P 值<0.001），飲酒率也從 17%大幅降至 8.8%（OR 0.88，95% CI 0.85-0.91，P 值<0.001）。另一方面，男性青少年吸煙的比例呈現出一定的顯著上升趨勢，但飲酒的比例上升則不明顯。青少年參加低頻率體育活動（每週≤4 天）的比例也從 2010 年的 75%顯著下降到 2017 年的 68%（OR 0.95，95% CI 0.93-0.96，P 值＜0.001）。每天久坐不動時間超過 3 小時的青少年比例從 29%大幅降至 21%（OR 0.94，95% CI 0.92-0.96，P 值<0.001）。女性青少年的體育鍛煉水平有了明顯提高。

這些結果表明，東加青少年的健康行為在 2010 年至 2017 年間發生了一些重大變化。吸煙率的下降和體育鍛煉的增加表明國家非傳染性疾病策略取得了一定程度的成功。然而，肥胖或超重患病率呈上升趨勢，尤其是在女性青少年中，這表明在未來針對東加青少年的健康政策中，有必要進一步關注並採取符合東加獨特文化和社會經濟背景的干預措施。

關鍵詞 非傳染性疾病；青少年健康；湯加；全球人口與健康調查

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Abstract

In Tonga, the risk of Non-communicable Diseases (NCDs) has been on the rise in recent years, demanding strategic countermeasures. In response, the country has progressively implemented a national NCD strategy. This study aimed to analysis the impact of Tonga's national strategy against NCDs, carried out from 2010 to 2015, on the health behaviors of school-aged adolescents. Using the Global School-Based Student Health Survey (GSHS), I compared the data before the implementation of the NCDs strategy in 2010 (n=2,211) and after the intervention in 2017 (n=3,333), focusing on behavioral changes in areas such as obesity and overweight, eating habits, smoking, alcohol consumption, physical activity, and sedentary lifestyle. The analysis employed chi-square tests and logistic regression.

Study results showed that, the overall prevalence of obesity or overweight in Tongan adolescents slightly increased from 35% in 2010 to 37% in 2017. Furthermore, the prevalence of obesity or overweight among female adolescents increased from 37% in 2010 to 43% in 2017. Regarding dietary habits, there was a decrease in low-frequency fruit consumption from 58% to 49%. Additionally, smoking and drinking behaviors significantly decreased among Tongan female adolescents. Smoking rates among female adolescents dramatically decreased from 23% in 2010 to 9.2% in 2017 (OR 0.85, 95% CI 0.82-0.87, p-value <0.001), and alcohol consumption rates also significantly declined from 17% to 8.8% (OR 0.88, 95% CI 0.85-0.91, p-value <0.001). On the other hand, while slightly significant, there was a little increasing trend in smoking and alcohol consumption among male adolescents. The proportion of adolescents engaging in low-frequency physical activity (≤4 days per week) also significantly decreased from 75% in 2010 to 68% in 2017 (OR 0.95, 95% CI 0.93-0.96, p-value < 0.001). The proportion of adolescents spending more than 3 hours a day in sedentary behavior significantly reduced from 29% to 21% (OR 0.94, 95% CI 0.92 to 0.96, p-value < 0.001). A notable improvement in physical activity levels was especially seen among female adolescents.

These results indicate that health behaviors among Tongan adolescents underwent several significant changes between 2010 and 2017. The decrease in smoking rates and the increase

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in physical activity suggest a certain level of success of the national NCD strategy. However, the increasing trend in the prevalence of obesity or overweight, especially among female adolescents, suggests that further attention and interventions compatible with Tonga's unique cultural and socioeconomic context are necessary in future health policies targeting Tongan adolescents.

Keywords: NCDs, Adolescent' health, Tonga, GSHS

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Chapter 1
Introduction

1.1 Non-communicable Diseases (NCDs) Pandemic

Non-communicable Diseases (NCDs) are chronic diseases that are not passed from person to person. They are typically characterized by long duration and generally show progression. Common NCDs include coronary heart disease, hypertension, stroke, cancers, type 2 diabetes, respiratory disease, dyslipidemia and mental disorders, and others. NCDs are not caused by infections, but rather by factors such as lifestyle, genetics, and the environment. Today the global burden of noncommunicable diseases (NCDs) has increased rapidly over the past few decades. In the early 1980s, NCDs accounted for around 30% of the global disease burden, but in 2017, they exceed 60% in the world (Institute for Health Metrics and Evaluation, n.d.). Additionally, 77% of all NCDs deaths have taken place in low-and-middle income countries (WHO, n.d.-a). The impact of NCDs in low- and middle-income countries is severe, with over nine million deaths occurring annually in the productive age group due to NCDs (Engelgau et al., 2011). This not only leads to an increase in medical expenses for individuals, families, and nations, but also poses a significant threat to the economically productive age group, thereby hindering economic activities. Therefore, efforts to address preventable NCDs become increasingly crucial.

Prevention targeting at risk factors of NCDs is critical for reducing burden of NCDs. Among others, obesity is a key risk factor of most NCDs. Specifically, high prevalence of obesity has been seen in Oceania region. The average percentage of overweight or obese adults in 32 OECD (Organization for Economic Co-operation and Development) countries is 54%, of which 18% are obese (*Health at a Glance 2023: OECD Indicators*, 2023). However, in Polynesian countries, a significant proportion of the adult population is affected by obesity : American Samoa at 74.6%, Cook Islands at 61.4%, French Polynesia at 40.4%, Niue at 62.2%, Samoa at 54.7%, Tokelau at 63.4%, and Tonga at 57.0%; (Marie Ng a, 2013) Furthermore, NCDs accounted for 75.4% of all death in the Pacific region (WHO, 2018). In a study on the relationship between obesity and

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cardiovascular diseases involving 63,821 individuals, it was found that in people with a BMI of 20 kg/m² or more, the hazard ratio (HR) for cardiovascular diseases, after adjusting for age, gender, and smoking status, was 1.23 (95% confidence interval: 1.17-1.29) based on BMI, 1.27 (1.20-1.33) for waist circumference, and 1.25 (1.19-1.31) for waist-hip ratio(Emerging Risk Factors et al., 2011). These results indicated a correlation between BMI and an increased risk of cardiovascular diseases. However, the medical systems in these countries are fragile, and resources to adequately respond to prevention of NCDs are limited (Marie Ng a, 2013). One aspect of the fragile healthcare system in these countries is the shortage of doctors and nurses who can actively engage in the treatment or prevention of NCDs at communities. This is due to the outflow of medical staff seeking higher wages in neighboring countries such as New Zealand and Australia (Brown & Connell, 2004). The availability of fewer healthcare professionals to address prevention, early intervention, and treatment of NCDs in their home countries and communities may reduce opportunities to improve health literacy for NCDs prevention and awareness, including among young people. This situation can lead to a worsening of the NCDs epidemic, and exacerbate the already burdened healthcare systems in the Pacific region. Therefore, addressing and combating NCDs in these Oceania countries is an urgent and crucial national issue (Kessaram et al., 2015).

1.2 Adolescents' Obesity in Pacific Region

In the Pacific countries, the region is located in south pacific area divided into two main parts: continental Australia and the islands, which are further divided into Melanesia, Micronesia, and Polynesia (including New Zealand). Population in this area around 44.5 million in 2021 (see Picture 1) (*Tonga*, 2024). Oceania's most competitive economies are Australia, French Polynesia, Hawaii, New Caledonia, and New Zealand. Fiji, Palau, and Tonga are considered to have medium-sized economies and the rest of countries in the region considered as small economies. (*Tonga*, 2024).

According to a 2017 study, the BMI of children and adolescents in Polynesia and Micronesia was the highest, with an age-standardized mean BMI of 20 kg/m². Boys had a

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BMI of 23.1 kg/m² (95% CI 22.4 - 23.8), while girls had a BMI of 22.4 kg/m² (21.6 - 23.1) ((NCD-RisC), 2017). Childhood obesity has some prompt and long-term health outcomes

Picture 1. Map of Oceania.

(Map source: Tintazul (2014). Map of Polynesia, https://en.m.wikipedia.org/wiki/File:Oceania_UN_Geoscheme_-_Map_of_Polynesia.svg)

including an increase in the risk of developing NCDs in the future and potentially lead to earlier onset (Reilly & Kelly, 2011). Obesity in young people can trigger further increases in the cost of treatment of NCDs. For example, in the United States, the projected direct medical expenses for a 10-year-old child with obesity, when compared to a similar child of normal weight and accounting for potential weight gain in adulthood, range between US$12,660 and US$19,630 (Finkelstein et al., 2014). Additionally, in the case of indirect costs related to healthcare expenses and productivity loss among full-time employees in the United States, obesity accounted for 59% of the total (Finkelstein et al., 2010). The increasing prevalence of obesity would have a significant burden on healthcare costs and the workforce.

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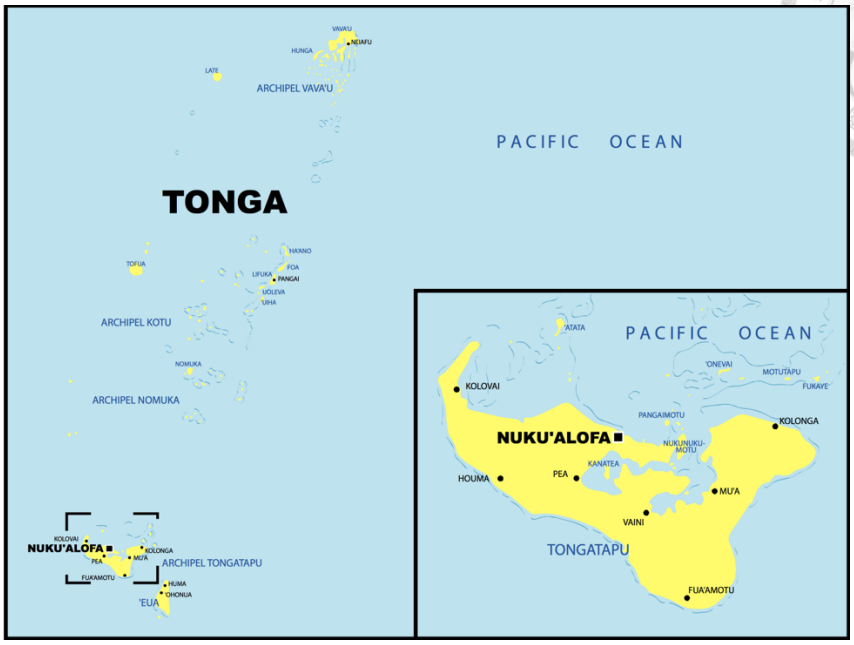
Picture 2. Map of Tonga.



(Map source: WorldAtlas (2023). Divisions of Tonga Map, https://www.worldatlas.com/maps/tonga)

NCDs are preventable by promoting behavior change through environmental approaches (Bonsergent et al., 2013), such as educating children and adolescents about healthy habits in schools. By creating an environment that supports healthy behaviors, individuals can be motivated to make positive changes in their lifestyles. Furthermore, early education on healthy habits can help children and adolescents develop healthy habits that can be maintained throughout their lives, leading to a decreased risk of developing NCDs in adulthood. Therefore, while addressing and combating NCDs among adolescents is an important effort at the national level, environmental approaches that promote behavior change through education and awareness can be an effective strategy in preventing NCDs.

1.3 National Strategy for Prevention and Control of NCDs in the Kingdom of Tonga

The Kingdom of Tonga, located in the Pacific region with almost 106,000 population (The World Bank, 2022) . Tonga is an archipelagic nation consisting of 171 islands. Of these, 45 are inhabited islands and 70% of Tonga's population lives on the main island of Tongatapu. Tonga has five island divisions: 'Eua, Ha'pai, Ongo Niua, Tongatapu,

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and Vava'u (see Picture 2)(*Explore All Countries Tonga*, 2024). The capital is Nuku Alofa in main island of Tongatapu and the ethnic group is Polynesian. The main religion in Tonga in Christianity (*Kingdom of Tonga*, 2023). As for the economic situation, the main industries are agriculture, forestry, fisheries, and automotive, with a GDP per capita of 4,426 USD and an economic growth rate of -2.7% for the same year (*Tonga*, 2021). It should be noted that about half of the GDP, 46.2%, comes from remittances received by individuals abroad (The World Bank, 2022). This imply that many Tongans are migrant workers and their families in Tonga are living on their overseas remittances. While the financial situation is heavily dependent on foreign aid and remittances from migrant workers.

As for the other health indicator in Tonga, the under-five mortality rate is an indicator of the sanitary and medical situation in a region or country. The global under-five mortality rate averaged 37 per 1,000 live births in 2020, and 74 per 1,000 in the sub-Saharan region, which is 14 times higher than in Europe and North America. On the other hand, the average for the same year in the Oceania region suggests a relatively good level of health care at 20 per 1,000 live births, while in Tonga the 2020 level is recorded at 11.1 per 1,000 live births (*UN Inter-agency Group for Child Mortality Estimation*, 2023).

Tonga was one of the first countries in the region to implement measures to address NCDs. This was prompted by a sharp increase in the prevalence rate of NCDs in Tonga, from 7.3% in 1973 to 15.1% in 1999 (Colagiuri et al., 2002) and 16% in 2004 (UNDP, 2013). Furthermore, Tonga was ranked among the top ten globally in the prevalence of diabetes, with a prevalence rate of 16.4% in 2004 (UNDP, 2013). In addition,

Various factors may be behind this rapid increase in the NCDs rate in Tonga, but it is thought that it is largely due to changes in people's dietary habits. One factor is thought to be the fact that, while taro, coconuts, bananas, and other foods have been consumed in the traditional diet, high-calorie processed foods such as corned beef and fatty meats are now sold at low prices and are consumed in many households because they require less time and effort to cook (Food and Agriculture Organization of the United Nations et al., 2017).

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In response, the Tongan government and the Ministry of Health launched a National Strategy for the Prevention and Control of NCDs in 2004 (UNDP, 2013). The first stage of this strategy, which ran from 2004 to 2009, focused primarily on the development of the "Tonga National Non-Communicable Diseases Strategy," which emphasized the prevention and management of NCDs. Moreover, the Tongan government implemented policies to regulate the food industry, including increased tariffs on import of trans fats, fatty meat cuts, processed foods, tobacco and alcohol, and reduced tariffs on fish and other healthy foods, as well as restrictions on smoking in public places (The World Bank, 2019).

While implementing the first phase, Tonga Health was newly established by the Health Promotion Foundation Act 2007. This is an independent body and accountable to the Government of Tonga through MOH. They initiated health promotion activities in 2009 and have covered fully in four Tongan island groups in 2011 (JICA, 2013). In this first phase, the establishment of health promotion implementation organizations and the expansion of activities to the four main islands of Tonga were achieved.

In the second stage, from 2010 to 2015, a more comprehensive approach was taken, with specific numerical targets set for three intervention areas: healthy eating, physical activity, and alcohol and tobacco control in collaboration with local communities (TongaHealth, 2015). In this phase, the NCD Committees were established. They were chaired by the Director of Health and consisted of members not only from the Ministry of Health but also from the Ministry of Finance, Ministry of National Planning, Ministry of Education, Ministry of Agriculture, Tonga Health, and various NGOs. They collaborated across multiple sectors to implement a cross-cutting approach aimed at addressing the three major risk factors. Interventions were implemented in each of the three areas (physical activity, alcohol and tobacco control, and healthy eating) specifically targeting the adolescent population at the school, church, and village levels. The strategy also included the implementation and monitoring of policies to ensure effective program implementation. The Tongan government focused on strengthening efforts to address NCDs in each area at this stage, recognizing the importance of prevention and control measures to curb the rising prevalence of NCDs in the country.

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1.4 The WHO STEPwise Approach to Surveillance (STEPS) and Findings

Tonga's National Strategy for NCDs was aligned with the World Health Organization's (WHO) STEP wise Approach to Surveillance of NCD Risk Factors (STEPS), which is a recommended methodology for epidemiological surveillance of NCDs. The WHO STEPwise approach provides a data collection procedure to assess risk factors for diseases and health, aiming to understand the incidence and impact of NCDs in specific regions or adult populations. The STEP survey conducted by WHO uses standardized methods for data collection, allowing for international comparisons. In Tonga, the STEP surveys were conducted in 2004, 2011, and 2017. The target population for the STEP surveys was as follows: in 2004, it included individuals aged 15 to 64 (n=849); in 2011, it encompassed those aged 25 to 64 (n=2,457); and in 2017, it covered individuals aged 18 to 69 (n=3,858). The results from these three STEP surveys indicated that, from 2004 to 2017, the consumption of alcohol (13.4% in 2004, 9.3% in 2011, 8.7% in 2017) and tobacco (31% in 2004, 29.3% in 2011, 25% in 2017) decreased among both men and women. However, the obesity rates among adult men and women increased from 2004 (90.7% were overweight or above, 67.6% were obese) to 2017 (93.1% were overweight or above, 77.1% were obese). In detail, 2004, the obesity rate was 60.7% for males and 76.3% for females, but in 2017, it increased to 66.8% for males and 82.8% for females. Additionally, the proportion of hypertension has also increased from 2004 to 2017, with the proportion of males with hypertension increasing from 26.5% to 35.7%, and the percentage of females increasing from 19.9% to 37.7%. On the other hand, there has been a significant decrease in smoking and drinking rates among men, with the smoking rate (current smokers) decreasing from 46.2% to 40% and the drinking rate (consumed alcohol in the past 12 months) decreasing from 22.2% to 14.7% among men between 2004 and 2017 (WHO, 2004; WHO, 2012; WHO, 2017).

The results suggest that Tonga's NCDs policies for tobacco and alcohol have had a certain level of success, yet there is a significant increase in obesity and hypertension,

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indicating the need for further efforts to strengthen policies, develop new policies, and invest in projects.

1.5 Research Gaps

Many studies have shown that interventions combining exercise therapy and dietary therapy in early education targeting children aged 6 to 12 years are more effective in preventing NCDs than interventions focused only dietary therapy (Bogataj et al., 2021; Brown et al., 2019; Cerrato-Carretero et al., 2021) . The review study conducted by Brown et al. (2019), a review of research involving interventions targeting children and adolescents, which either employed dietary therapy (interventions in eating habits) or exercise therapy (interventions in physical activity), or both. The children and adolescents targeted in these studies ranged from 0 to 5 years (24%), 6 to 12 years (56%), and 13 to 18 years (20%). In this study, the presence of overweight in children was assessed based on changes in the zBMI, a score that quantifies the degree of obesity relative to the BMI distribution of same-age and same-sex peers in their country of residence. The results showed that children aged 0 to 5 years and 6 to 12 years experienced a reduction in zBMI of 0.07 and 0.04, respectively, compared to those who did not receive an intervention. However, dietary therapy, exercise therapy, or both did not lead to a decrease in zBMI among adolescents aged 13 to 18 years (Brown et al., 2019).

The study pointed out a lack of evidence for interventions such as dietary and exercise therapy targeting adolescents aged 13 to 18 years. Additionally, adolescents of this age group often exhibit resistance to adult authority and school pressure and possess unique physical and psychological traits (Brown et al., 2019). As a result, more specialized strategies such as allow for spontaneous thinking and engagement rather than methods that are managed by adults may be required for this age group.

Another systematic review of health promotion intervention for adolescents aged 10 to 19 in low- and middle-income countries in the Western Pacific Region of the WHO provides several valuable insights. Many adolescents in this Western Pacific Region receive secondary education and this review targeted the studies implemented school-based

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interventions for adolescents. From 1995 to 2019, eight publications of school-based health interventions (with a total of 18,774 participants) were found in this region, primarily in China, the Philippines, Mongolia, Cambodia, and Malaysia. These interventions addressed topics related to HIV/AIDS, sexual and reproductive health, deworming, nutrition, obesity, tobacco use, and suicide. Although some interventions succeeded in improving knowledge, attitudes, and behaviors, their impact and scale were limited (Xu et al., 2020).

Furthermore, this study reported several challenges due to the limited number of included studies. This limitation makes it hard to combine data and make broad conclusions that can be applied to all low- and middle-income countries. Additionally, the review mentions that 25% of the studies under consideration of their study were excluded because they lacked impact data when evaluating their eligibility (Xu et al., 2020). This highlights not only the scarcity of health behavior intervention cases for adolescents in low- and middle-income countries but also underscores the challenges related to the lack of indicators and data for measuring the effectiveness of such interventions.

Regarding to behavioral change strategy conducted in Tonga, the "Ma'alahi Youth Project (MYP)" was implemented from 2005 to 2008 as a youth obesity prevention project, and an evaluation of this project was conducted. The project aimed to reduce obesity rates among adolescents and their families by raising health awareness in schools, churches, adolescents' parents, and the community. The project offered a wide range of programs, including healthy eating demonstrations, regular physical activity programs, and vegetable gardening, implemented in villages, churches, and schools on the main island of Tongatapu. As a result of the project, the interventions were implemented with a wide range of activities, attracting participation not only from the targeted adolescents but also from many other community members. However, these interventions did not show consistent implementation patterns or trends and were characterized by a lack of continuity, resulting in inadequate execution. While the program contributed to raising health awareness in the community, it also revealed issues related to resource shortages and challenges and insufficient capacity in public health research in Tonga, which may have made it difficult to accurately assess the impact of the interventions (Fotu et al., 2011).

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These studies suggest numerous challenges in interventions for health behavioral changes among adolescents in low- and middle-income countries. Firstly, there is a general scarcity of cases involving interventions for adolescent health behaviors. Additionally, long-term interventions often face challenges in maintaining continuity and consistency. Moreover, there is a lack of indicators and impact data for evaluating these interventions.

In Tonga, the "Ma'alahi Youth Project (MYP)" highlighted limitations in the capacity and resources for public health research. Furthermore, during the first phase of the NCDs national strategy in Tonga implemented from 2004 to 2009, a significant issue was the lack of adequate monitoring, evaluation and surveillance systems (UNDP, 2013). The challenges in maintaining long-term interventions in Tonga, along with the lack of adequate systems and resources for assessing these interventions, are viewed as key reasons for the limited research on interventions targeting adolescent health behaviors. Studies on interventions for adolescent health behavior in Tonga are still in the early stages, with a particular lack of evidence for effective dietary and exercise interventions among school aged adolescents. Therefore, analyzing how Tonga's national NCDs strategy has influenced the health behaviors of the Tongan youth holds significant importance.

On the other hand, Tonga was the first among the Pacific nations to implement a comprehensive national-level approach to NCDs. The outcomes of this initiative have the potential to inform the development of more effective interventions to promote behavioral changes among adolescents in future policy-making. Therefore, comparing the changes in adolescent behaviors before and after the implementation of the NCD national strategy from 2010 to 2015 could provide valuable insights into the effectiveness of these policies. Hence, there is a perceived need for research on interventions targeting adolescent health behaviors in Tonga.

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1.6 Research Aim and Objectives

The prevalence of obesity among adolescents in the Pacific region has put them at high risk for future NCDs. It is crucial to develop national policies needed to lead adolescents towards more appropriate health behaviors. To inform policy-developing at national level, understanding the impact of current NCDs strategy is important. Therefore, the study objective is to identify the impact of the national NCDs strategy in 2010 to 2015 on behavioral change in school aged adolescents in Tonga.
to achieve this objective, the following an aims is set:

1. To analyze the survey data and evaluate the impact of the national NCDs strategy implemented in Tonga from 2010 to 2015 on the health behaviors of school-aged adolescents in Tonga.

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Chapter 2

Literature Review

2.1 Trend of Healthy Behaviors in Tonga

2.1.1 Eating Habits

Since 1980, there has been significant transformation in people's dietary habits, particularly in advanced countries, due to the advancements in technology, specifically in mass food preparation. The development of technologies to extend the freshness of food, such as packaging techniques and deep freezing, has enabled the production of larger quantities of food and its distribution to a greater number of consumers than ever before (Cutler, 2003). Globalization has had a significant impact on the dietary habits of countries in Oceania, including Tonga. The availability and affordability of processed foods, which are often high in calories and sodium, have led to a significant shift in the food environment of local communities. As a result, retailers have increasingly focused on selling these types of food products (Food and Agriculture Organization of the United Nations et al., 2017). This change has resulted in a food environment that is characterized by processed foods and inexpensive, high-fat imported proteins (such as chicken tail and mutton flaps), which are associated with weight gain, rather than the traditional diets of the past (Swinburn et al., 2011). In Tonga, sweet potato, taro, yam, cassava, breadfruit, green banana, and plantain were the traditional main starch, with protein being mutton, beef, chicken, fresh fish, and egg. Vegetables were taro leaves and leafy green plants of the hibiscus family called "pele" (Metro South Health, 2015).

As noted by Hughes (2005), the influx of high-calorie, inexpensive foods have made it difficult for citizens to revert to traditional meals. This new food system have greatly developed to supply of cheap energy-dense foods and distribution to the consumers in local communities. As a result, it has led to an increase in obesity and obesity-related conditions such as hypertension and diabetes in Oceania countries.

The dietary habits of Tonga, and the Pacific region as a whole, have experienced significant changes from the 20th to the 21st century.

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Traditionally, Tongans consumed fresh fish, taro, yam, fruits, and vegetables. However, with globalization, unhealthy foods imported from the Western countries, such as Australia, New Zealand, United States (Food and Agriculture Organization of the United Nations et al., 2017) Noodles, snacks, corned beef, fatty meats, and processed foods, began to be sold at retail stores at lower prices than traditional foods, creating an environment that made these items easier to purchase. Additionally, as the production of healthy local foods decreased, the dietary habits of Tongans gradually shifted towards reliance on imported foods.

Furthermore, compared to other Pacific Island countries, Tonga has an exceptionally high proportion of food imports, making up 52% of all imports, and among these, the proportion of processed foods is the highest at 34% (Win Tin et al., 2020). These imported foods tend to be high in sugar, salt, and saturated fats, and generally have lower nutritional value compared to traditional meals. These changes have had a significant impact on the health of the people in Tonga, and are associated with an increase in obesity rates and the prevalence of NCDs (Effects of Food Taxation in Tonga: A Snapshot 2017).

In detail, due to trade developments in the 1990s, Tonga saw a dramatic doubling of the cost of imported meat for its citizens. The total import value in the country was 68 million Tongan dollars (roughly USD155.7) in 1989, but by 1999, it reached 116 million T$, of which one-third was for food products (Food and Agriculture Organization of the United Nations et al., 2017). Along with the increase in import volume, the quantity of imported food also rose. Moreover, the cost of imported meat in food products jumped from 5 million T$ in 1989 to nearly 10 million T$ in 1999. It became evident that the per capita consumption of imported meat increased by more than 60%, from 35 kilograms in 1989 to 56 kilograms in 1999 (Evans et al., 2001). The expansion of food imports has transformed the national food environment from one that traditionally centered around vegetables to one increasingly dependent on imported foods.

Regarding people's food consumption behaviors, based on a 24-hour food recall survey conducted over two weeks in 2005 on 15 male and 19 female participants in Tonga, imported foods accounted for half of the participants' energy intake. One-third of the

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energy was derived from fats. However, a deficiency in micronutrients was observed (Konishi et al., 2011). Furthermore, a STEP survey conducted by the Tonga Ministry of Health targeting individuals aged 15 to 64 to investigate the risk factors of NCDs revealed a decline in the proportion of people consuming fruits and vegetables in the amounts recommended by the WHO. While the percentage stood at 92.2% in 2004, it decreased to 73.1% by 2012. These results imply a potentially growing dependency of the national diet on imported foods and a decreasing intake of fruits and vegetables (WHO & Tonga Ministry of Health, 2012, 2014).

The first-ever survey on the dietary habits of Tongan youth was conducted in 2000. Named "The Health Behavior and Lifestyle of Pacific Youth," this survey aimed at the young generation in Tonga, specifically focusing on 443 Tongan individuals between the ages of 11 and 16 (Kermode et al., 2015). The study encompassed measurements of height and weight, and participants self-reported their physical activity levels and dietary consumption. Key findings from this research indicated that a notable 57% of the students had tinned mutton or beef as a daily dietary staple. In contrast, an alarming half of them reported not consuming taro, vegetables, or fruits even once within a day. Furthermore, a significant one-third of these students consumed soft drinks or items high in sugar on a daily basis (Smith et al., 2007).

Another study that investigated the dietary habits of Tongan youth was conducted in 2005. This research focused on 2,084 Tongan young people aged between 11 and 22, examining their self-reported sources of food and dietary patterns. A significant finding from the study was that over 70% of the young participants sourced their morning tea or lunch from school canteens or nearby shops (Cacavas et al., 2011). The food items typically sold at these Tongan school canteens tend to be high in energy but low in nutritional value. Additionally, the survey revealed gender differences in consumption habits. Young females exhibited a higher propensity towards consuming nutritionally poor foods that might contribute to obesity. Specifically, the daily consumption of packaged snack foods was reported by 38.2% of females compared to 21.3% of males. For chocolate, the consumption

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rate stood at 24.7% for females and 15.0% for males. Regarding soft drinks, 55.3% of females consumed them daily, in comparison to 50.4% of males (Cacavas et al., 2011).

The author of the study emphasized the importance of creating environments at home and in schools where students have access to healthier food options. They suggested that improving the nutritional status of young people could be achieved by regulating the availability of unhealthy foods in local shops, emphasizing the provision and accessibility of more nutritious options for these youths.

However, being surrounded by inexpensive unhealthy foods tends to lead people to choose them, even when they have knowledge about the nutrition and health implications of their choices. In a 2001 survey involving 430 Tongans ranging from 12 to 82 years old, both traditional and imported foods were examined in terms of taste preferences, perceptions of nutritional value, and consumption frequency. The results revealed that despite an understanding that imported foods are often of lower nutritional value, there's a prevalent tendency to consume unhealthy options. Furthermore, even among the highly educated residents of Tonga's capital, who possess enough knowledge about the nutritional differences between traditional foods and imported alternatives, there's a higher likelihood of consuming unhealthy imported foods (Evans et al., 2001). This result imply that health awareness may be inadequate no matter how much nutritional knowledge is available.

The outcomes of this survey suggested that health education programs aimed at preventing diseases related to dietary habits might be insufficient to address the issue. The draw of convenience and the allure of affordable unhealthy options seem to outweigh nutritional knowledge in driving consumption choices. From this, it is considered necessary to examine changes in people's consumption behavior potentially led by policies, such as raising tariffs on unhealthy imported foods or restricting their import.

2.1.2 Food policy and Campaign

Trade liberalization has been championed in the Pacific region with the aim of bolstering economic growth. This shift has led to a surge in the importation of cheap, unhealthy foods, thus impacting both the accessibility to these foods and overall health.

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Tonga is among the countries in Oceania with the highest expenditure on imported foods (54%), with 34% of the food being processed (Estime et al., 2014). A particular challenge is the lack of an established food production industry in Tonga, with 95% of those engaged in agriculture involved in subsistence or small-scale farming. Most of the crops produced are intended for household consumption, and any surplus is sold in markets. Moreover, basic food items such as flour and sugar are primarily reliant on imports. In response to challenges within its food system, Tonga established the National Food and Nutrition Committee in 1982. This body places emphasis on the production of local foods and provides counsel on issues related to nutrition and diseases caused by dietary habits (Food and Agriculture Organization of the United Nations et al., 2017).

Tonga joined the World Trade Organization (WTO) agreement in 2007. This membership ushered in tariff reforms and a simplification of the tariff band structure. Subsequent to this, in 2013, legislation pertaining to food regulation was passed. Termed the "Food Act of 2014", this law's primary objective is to regulate the production, sale, and import/export of foods for commercial purposes, ensure the safety and consumer suitability of food, and foster fair trade practices within Tonga's food sector (The World Bank, 2019). As a measure to address unhealthy dietary habits, the government ratified specific food taxes for the first time. Taxes on fresh fish and tinned fish were reduced from 20% to 5%, while vegetable oil saw a cut from 20% to 10%. Conversely, lard/dripping was taxed at 1T$ (about 2.29USD) per kilogram, up from the previous 15%, and soft drinks were imposed with a tax of 1T$ (about 2.29USD) per liter, from their previous 15% rate(Food and Agriculture Organization of the United Nations et al., 2017).

In 2016, a further refined food tax was enacted and came into effect in July of the same year. At the time, turkey tails and mutton flaps, which were predominantly imported from the United States at low cost, such as 5T$ (about 11.45USD) per kg for Turkey tails, 13T$ (about 29.77USD) per kg for mutton flaps, were circulating widely in Tonga (Tonga Statistics Department, 2014). Compared to other chicken parts, these contained a significantly higher amount of fat. Although such fatty parts of chicken are less valued in other countries' markets, in Tonga, they were cheaper than local chickens and were widely

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available. This made them more likely to be adopted in everyday meals in Tonga (Evans et al., 2002). The items subject to tax were determined based on advice from the Ministry of Health. The scope of taxation on unhealthy foods became broader than that of 2014, including Turkey tails, Chicken leg quarters, Mutton flaps, Mayonnaise, and others. As a result, the market prices of unhealthy foods increased. For instance, the price of Chicken leg quarters, which was an average of 2.9T$(roughly 6.6 USD) per kilogram before July 2016, rose to 3.8T$ (roughly 8.7 USD) after July. As for Mutton flaps, a significant price change was observed from 10.5T$ (roughly 24USD) in 2015 to 15.4T$ (roughly 35USD) in 2017 (The World Bank, 2019).

Regarding the improvement of dietary habits, community-level initiatives carried out under the NCDs strategy included the establishment of fruit and vegetable gardens in homes, villages, and schools, jointly facilitated by TongaHealth and the Ministry of Agriculture and Forests and Fisheries. This activity was implemented in 60% of primary schools on the island of Tongatapu, where the capital is located, and in five schools on the island of Vava'u during 2012-13. Additionally, TongaHealth established a grant system to support such vegetable garden activities. There were a total of 212 grant applications from 2011 to 2015 (TongaHealth, 2015). In 2013, a campaign named "Mai e 5 a-day" was implemented for elementary school teachers to promote the intake of vegetables and fruits. The campaign aimed for the consumption of five varieties of vegetables or fruits of different colors and provided educational tools to teachers to facilitate easy implementation of nutrition and healthy eating habits education for their students. This initiative aimed to enhance the students' knowledge of healthy eating habits and the nutritional value of foods (TongaHealth, 2015). In addition, cooking classes for women were held at the village and church level to prepare healthy meals (TongaHealth, n.d.). However, information and content on this initiative is insufficient in any of the reports, and the specific scale, frequency, and areas where it was implemented are unknown.

Several studies have been conducted on the impact and effectiveness of food policy. There are few cases of countries that have implemented food policies specifically targeting NCDs, and these studies include an investigation titled "Lessons from Tonga" conducted

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by the World Bank, as well as research by the Food and Agriculture Organization of the United Nations on the effects of tax changes due to food policy (Food and Agriculture Organization of the United Nations et al., 2017; The World Bank, 2019).

According to interviews conducted with retailers in focus group discussions by the Food and Agriculture Organization of the United Nations in 2017, sales of mutton flaps and turkey tails decreased after the introduction of the food tax in 2016, but chicken sales were not affected. In Tonga, a Christian nation where Sunday is traditionally a day of rest, mutton flaps and fatty meat are considered essential for the traditional Sunday lunch "lu sipi" - mutton flaps and coconut cream in taro leaves cooked in an earth-oven-. Some expressed concerns that the policy might make it difficult for low-income households to buy their food. Interviews with consumers regarding purchasing behaviors revealed that while the frequency of buying mutton flaps decreased post-policy, there was a shift to chicken as the primary meat consumed at home. Some consumers noted that having meat on the table is a top priority in Tongan home cooking, even at the expense of the household budget. Also, the younger generation's palate, accustomed to the taste of home cooking made with fatty imported foods, showed resistance to healthier eating habits. Healthy alternatives to these unhealthy protein sources include fresh fish, canned fish, lean meats, and beans. However, local chicken, compared to imported meat, requires more effort to prepare, leading to less frequent purchases. Despite the Tongan government reducing taxes on fresh and canned fish in the 2013 Food tax, consumers found these prices high, with canned fish being more expensive than imported chicken (Food and Agriculture Organization of the United Nations et al., 2017).

Furthermore, a World Bank survey on the impact of food taxation on consumer behavior in Tonga was conducted, using 2016 as the baseline and 2017 as the endline for the household survey. The results of the survey conducted in 2016, which was already after the tax increase, indicated that about 49% of respondents reported changes in their consumption of mutton flaps due to previous tax increases. Following additional tax increases in 2016-17, a survey on the consumption trend of mutton flaps revealed that 55% of people reported changes in consumption. In the 2016 survey, 78% answered that they

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had reduced their consumption of mutton flaps, and 16% had shifted to "buying other cheaper food." However, in the 2017 survey, those who reduced their consumption dropped to 53%, with 40% opting for "buying other cheaper food" as an alternative. Salted beef was popular as a substitute being purchased instead of mutton flaps. These findings suggest that consumers are gradually shifting to purchasing other cheaper food items in place of mutton flaps (The World Bank, 2019).

On the other hand, it is interesting to note that despite a 27% increase in excise taxes on chicken leg quarters from 2015-16 to 2016-17, imports of chicken leg quarters decreased only slightly, from 8,965,000 kg to 8,011,620 kg, and excise tax revenues on chicken leg quarters The excise tax revenue on chicken leg quarters increased by a whopping 178% (The World Bank, 2019). This suggests that people's consumption behavior might not be significantly affected in certain food products. Furthermore, 72% of Tongans surveyed after the 2017 tax increase reported that they continued to purchase chicken leg quarters as they did before the tax increase in 2016, and approximately 70% reported consuming chicken leg quarters at least 3-6 times per week (The World Bank, 2019).

Research into the impact of food taxes implemented in various countries on health behaviors, as well as on health outcomes like weight and chronic diseases, is still developing. A research paper systematically reviews the effects of food taxes and subsidies on diet, weight, and chronic diseases. The results indicate that food taxes and subsidies may influence consumption in high-income countries, and imposing higher taxes on obesity-promoting foods could improve health outcomes such as weight and the risk of chronic diseases. The paper also highlights the need for further research into consumer responses to food taxes in developing countries, where the impact of population differences might be significant compare to high-income countries (Thow et al., 2010).

A study was conducted using the 2009 and 2015/16 Household Income and Expenditure Survey (HIES) to research changes in household beverage spending before and after the introduction of the sweetened beverage tax (T$0.50/L) in 2013. The survey indicated a decrease in soft drink expenditure, particularly in lower-income households

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more than higher-income ones. Additionally, expenditure on bottled water significantly increased, especially in higher-income households (Teng et al., 2021). These results suggested that the food tax may have influenced consumers' purchasing behaviors towards healthier choices, possibly affecting the buying habits of the youth as well.

However, in Tonga, there have been no studies conducted specifically comparing behavioral changes in adolescents before and after the implementation of these health policies. This highlights a gap in the research and underscores the need for further studies in this area.

2.2 Physical Activity

In Tonga, participation in physical activity and sports is significantly influenced by gender. The STEP wise survey in 2004 and 2012 reported that females exhibited notably lower levels of physical activity than males. These studies surveyed both males and females using self-reported questionnaires. This investigation utilized the MET (Metabolic Equivalent Task) is a measure of how many times higher your metabolic rate is during physical exercise, such as training, than at rest, it represents, as a measure of physical activity levels. Activities equating to 600 MET or less per week were classified as low-level. The findings showed that in the 2004 survey, approximately half (43.9%) reported low levels of physical activity, with a particularly higher proportion among women (54.8%) compared to men (32.4%) (WHO & Tonga Ministry of Health, 2012). In 2012, approximately 32% of males were categorized under this low-level group, in contrast to over half of the females, at 54.8%. On the other hand, high-intensity physical activities (equivalent to 1500 MET or more per week) were undertaken by 49.0% of males, but only by a mere 21.7% of females. Further narrowing down to females aged 15 to 24, only 17.9% engaged in high-intensity physical activities, the lowest percentage among all female age groups, and 56.8% participated in low-intensity activities, the highest proportion in any female age group (WHO & Tonga Ministry of Health, 2014).

Another highlighting the differences in physical activity levels between men and women is the difference in the amount of time spent on recreation-related physical activity.

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Men (aged 25 to 64) averaged 31.4 METminutes/day, while women (aged 25 to 64) averaged 8.2 METminutes/day. Women showed significantly lower participation in recreational activities involving physical activity than men (WHO & Tonga Ministry of Health, 2014).

This significantly lower participation in physical activity by women compared to men in Tonga possibly has a significant impacted on cultural norms and social expectations for women in Tonga. According to a survey by Keane (2020) on physical activity among Tongan women, women's roles in Tonga are generally expected to be centered around domestic duties and childcare at home, which may deter participation in recreational activities and physical exercise away from the home or their roles. Additionally, the strong sense of community solidarity in Tonga prioritizes participation in community and church activities, often relegating individual recreational activities to a second priority. Perceptions and stigmas in society may also act as barriers to women's motivation for physical activity. Negative views on obesity and body image have been reported to hinder participation in physical activities (Keane et al., 2020).

Additionally, it has become clear that adolescents in the Pacific region are not reaching the recommended amounts of physical activity. Studies focusing on adolescents in the Pacific region have shown that many participants fail to meet the recommended levels of physical activity, with over half of the students surveyed engaging in less than two hours of physical activity per week (Phongsavan et al., 2005). There was also a notable gender difference in the frequency of physical activity, with male students participating more frequently than female students. Younger students showed higher levels of physical activity, and as age increased, there was a tendency for physical activity levels to decrease (Phongsavan et al., 2005).

A survey on physical activity among adolescents in Tonga was conducted in 2005 under the Health Behavior and Lifestyle of Pacific Youth (HBLPY) across 443 schools, including remote islands, targeting youth aged 11 to 16. The survey revealed that only 21% of adolescents regularly participated in physical activities outside of school. Moreover, a quarter of the students were inactive outside school, with a higher proportion of female

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students than male students. Older students, aged 15 to 16, tended to spend more time watching television per day compared to younger students, aged 11 to 12. The survey found a correlation that students who actively participated in physical activities were less likely to be overweight or obese (Smith et al., 2007). This suggests that the level of physical activity among adolescents could influence their health status.

The impact of physical activity patterns during adolescence on long-term health has been clarified by Howie's (2020) research. This study investigated the relationship between physical activity pattern from childhood through adolescence and into adulthood and various health outcomes. It was found that the trajectory of physical activity intensity during adolescence was associated with health outcomes in adulthood. Groups with higher physical activity levels had less body fat, fewer diagnosed ailments, faster cognitive processing speeds, and were associated with better cardiovascular metabolism and mental health compared to those with lower activity levels. Additionally, the link between physical activity trajectories and health outcomes differed by gender, with stronger associations found with BMI in females and mental health in males (Howie et al., 2020). This research highlighted that the trajectory of physical activity from childhood through adolescence is related to a range of health outcomes in adulthood, emphasizing the importance of promoting physical activity from childhood.

Physical education plays a vital role in the school education of such adolescents. It helps children to acquire the disposition necessary for lifelong engagement in exercise and sports, as well as the physical abilities and knowledge for maintaining health and safety throughout life. However, in many low and middle-income countries, physical education is not a compulsory subject, often allocated insufficient class time, and tends to be perceived as having a lower status compared to other subjects. Additionally, there is a lack of qualified and adequately trained teachers for physical education (Hardman, 2008). In Tonga, physical education is not mandatory in primary, middle, and high schools but optional. Teachers in Tonga allocate less time to physical education, resulting in inadequate levels of physical activity for students at school. Furthermore, these teachers are often not sufficiently trained to conduct physical education classes (UNDP, 2013).

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One factor contributing to the acceleration of physical inactivity in Tonga is the transition to a car-centric society as part of economic development. In Tonga, bicycles are not widely used in Tonga, and this is due to several reasons: the fear of cycling near cars, cultural misconceptions about the impact of bicycle riding on the virginity of young girls, and the danger of stray dogs chasing cyclists on the roads (UNDP, 2013).

In response to this situation, from 2010 to 2015, physical activity was identified as one of the key target areas within the NCD policy framework. Aiming to enhance physical activity through this strategy, the national goal was set for the populace to regularly engage in 600 MET-minutes of moderate-intensity physical activity, and various programs were planned and conducted (TongaHealth, 2015).

At the national level, the development of walkway was implemented. In 2012, three walkway projects were planned and implemented on Tongatapu, the main island, to improve walking opportunities for local residents. In the field of physical activity, the execution of sports programs became a core strategy. These programs were jointly developed for school and communities by the Tonga Ministry of Education and the Ministry of Internal Affairs (TongaHealth, 2015).

Regarding community-level interventions, since 2009, the Ministry of Education mandated one hour of daily exercise in primary schools. Various sports organizations including football and touch rugby were allowed to visit primary schools to conduct sports activities and gradually integrating sports programs into school education. Sessions were held to educate teachers on implementing physical activity in schools. Additionally, opportunities for sports and athletic competitions between schools were held to encourage student participation in sports. The workplace sport competition, "Fiefia sports", was organized to promote health through sports among public workers. The competition involved 24 government departments and included activities like touch rugby, volleyball, netball, tennis, aerobics, and walking. Interventions targeting churches implemented physical activities for women, adolescents, and children. Aerobics instructor training was conducted to facilitate physical activity sessions in these churches (TongaHealth, 2015).

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Furthermore, since 2009, a grant program was introduced to support sports activities accessible to schools, churches, workplaces and village communities. This grant could be used for purchasing sports equipment and covering transportation costs associated with sporting events. The use of this grant increased from only 2 applications in the initial phase of 2011-12 to 65 applications annually by the end of the program in 2014-15 (TongaHealth, 2015).

Implemented at the village level was the "Kau Mai Tonga" program, targeting women aged 15 to 45. The program aimed to increase women's participation in and amount of physical activity by promoting community-level netball and organizing inter-village competitions (Ministry of Health, 2010). Netball, a sport derived from basketball, prohibits physical contact and dribbling, with each player having specific roles and designated movement areas, making it a pass-focused sport. This sport has a lower risk of injury from physical contact and ensures a certain level of physical activity, making it accessible for participation of all ages. The netball program was mainly conducted by the Australian aid. The founding included not only support for the netball equipment but also the dispatch of netball coaches from Australia to promote the sport (Justin et al., 2016). The program was also properly evaluated and monitored. Various initiatives were implemented to encourage women's participation in physical activity.

Firstly, workshops were regularly held with local coaches, players, and administrators, to autonomously manage tournaments, accompanying the spread of the sport. These organized operations supported smooth tournament management in large-scale competitions (Schulenkorf et al., 2022). Effective use of media marketing was also executed. Since 2012, extensive media campaigns spanning six weeks annually were conducted to promote the activities. The aim of these media campaigns was not only to provide knowledge about the health risks of physical inactivity but also to improve attitudes towards women's participation in physical activities. Post-program surveys revealed that 90% of women aware of the campaign, and 86% were concerned about the health risks due to physical inactivity. Additionally, 40% of women in the target age group began participating in physical activity more than 3 days a week. Before the program, 27 teams

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with 215 women participated in netball, but through this program, over 560 teams with more than 4,000 women became involved (Netball Australia, n.d.). This program became an activity awarded the WHO Best Practice Award (Netball Australia, n.d.).

2.3 Alcohol and Tobacco Consumption

2.3.1 Tobacco Control

In Tonga, an increase in smoking has become a concern in recent years. According to The World Tobacco Atlas, lung cancer and cancer incidences attributed to smoking in Tonga are reported to be 7% in men and 8% in women (Anna Rodney, 2015). A 2012 STEP survey conducted by WHO found that 29.3% of the 2,457 individuals aged between 25 and 64 surveyed were smokers. The prevalence of smoking among men was approximately half at 46%, and 13% among women. Regarding the age at which smoking begins, men start at 17.5 years and women at 22 years, indicating higher smoking rates and an earlier start age among men. The average number of cigarettes smoked per day by these smokers was 11 (WHO & Tonga Ministry of Health, 2014). Additionally, in 2010, the Tonga Global Youth Tobacco Survey 2010 was conducted among 1,465 adolescents aged 13 to 15. The results showed that 27% of the adolescents smoked, with 37.5% of the boys and 19% of the girls being smokers. The smoking rate of 19% among adolescent girls was higher than the 13% observed in adult women, indicating a challenge with tobacco proliferation among the youth (WHO & Tonga Ministry of Health, 2010) .

Regarding the regulation of tobacco and alcohol, a 2014 health ministers meeting in Oceania explicitly committed to five critical measures for the prevention and control of NCDs. These measures included strengthening the regulation of tobacco and alcohol, raising excise taxes on tobacco up to 70% of the retail price, and considering an increase in taxes on alcohol products (The World Bank, 2019).

The Tongan government gradually introduced measures concerning the increase in tobacco tax. In 2013, an excise tax, indirect taxes levied on a specific product at the time of manufacture (when the product is shipped by the manufacturing company), rather than at the time of sale, which are imposed at the time of sale. was imposed on imported tobacco,

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raising the tax from 210T$ (roughly 109USD) per 1,000 sticks to 250T$ (roughly 109USD). For locally produced tobacco, the tax increased from 200T$ (roughly 87 USD) per 1,000 sticks to 238T$ (roughly 104 USD). Concurrently, the number of cigarettes that travelers could bring into Tonga duty-free was reduced from 500 to 250 sticks (The World Bank, 2019). These tobacco regulations were among the strictest in Oceania at the time, with many tobacco products being subject to excise, consumption, and import taxes. Furthermore, in 2016, further tobacco regulations, taxation on alcohol, and a tax system for unhealthy foods and beverages were introduced. By July of the same year, the tax on imported tobacco had risen from T$250 to T$380 per 1,000 sticks, with the government raising the excise tax on imported tobacco by nearly 50% (The World Bank, 2019).

The introduction of this tobacco tax led to a purchase price increase from USD 2.89 per pack in 2006 to USD 3.27 in 2016, an approximate 13% rise(Ho et al., 2018) (Ho et al., 2018). This increase in tax rates resulted in a significant decrease in tobacco sales volumes. While approximately 70 million sticks were sold during the 2015-2016 fiscal year, sales plummeted to about 40 million sticks in the 2016-2017 fiscal year, implying a significant impact of the tobacco tax on the sales market (The World Bank, 2019). According to a household survey conducted by the World Bank before the tax increase in 2016 and after the increase in 2017, 18% of smokers reported reducing their tobacco consumption (The World Bank, 2019). Furthermore, 70% of the smokers who reported a decrease in tobacco consumption after the tax increase cited "the rise in tobacco prices" as the reason (The World Bank, 2019). These survey results suggest that smokers are highly sensitive to price increases, and the taxation on tobacco has influenced the smoking behavior of smokers.

However, as the import tax on cigarettes increased the purchase price, consumers shifted to relatively cheaper locally manufactured cigarettes and traditional hand-rolled tobacco (Tapaka Tonga) that were not taxed (The World Bank, 2019). Tapaka Tonga, being tax-free and sold in bulk as tobacco leaves, is much cheaper compared to boxed cigarettes and is widely distributed and sold in stores. Boxed cigarettes are subjected to advertisements and images that warn of the dangers of smoking, including pictures of lung and throat cancer, which deter purchasing intentions (Osornprasop, 2018).

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The Tongan Ministry of Health and the Tonga Health Foundation conducted a campaign to strengthen tobacco regulations. They expanded areas where smoking is prohibited, especially in public areas such as schools and churches, as well as on public transportation, enforcing a fine of 200T$ (about 202USD) for violators. In addition, the Ministry of Health provided subsidies for the cost of installing signage to notify the prohibition of tobacco use in these areas (Bank, 2019). Strategically, the ministry carried out anti-smoking publicity campaigns through radio and TV broadcasts about these regulatory enhancements, the increase in tobacco taxes, and the health hazards of tobacco. It has been reported that these efforts have led to a decrease in the practice of selling single cigarettes to the impoverished and young people, which was commonly done in retail stores (TongaHealth, 2015).

Efforts utilizing mass media for tobacco prevention were carried out with the technical and financial assistance of the Australian government. During the commercial creation phase, advertisements containing various messages underwent pretesting among 18-34-year-old male and female smokers. As a result, it was suggested that messages highlighting the risks of secondhand smoke and its impact on family and children, including babies, considering the Tongan context of living in extended families, could be more likely to reduce smoking behavior than complex health messages about pus and arterial effects caused by smoking (Sugden et al., 2017).

Additionally, in 2015, services to support smoking cessation were enhanced. Training was conducted for medical professionals to intervene in smoking cessation, targeting 120 hospitals within Tonga and nursing students aspiring to enter the medical profession. A hotline service for smoking cessation advice and consultation was established by Tongan medical practitioners trained in smoking cessation therapies in Australia. At the launch of this hotline, a commercial encouraging smoking cessation by Tongan actors was broadcasted on TV media, promoting awareness of the service and encouraging quitting smoking (Butt, 2015).

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2.3.2 Alcohol Control

In Tonga, the alcohol consumption among adults was surveyed in the 2012 STEP study, which revealed that 9.3% of the adult population aged 25 to 64 years had consumed alcohol in the past 30 days. A significant gender disparity was observed in these figures, with 16% of males and 2.8% of females reporting alcohol consumption. Furthermore, the prevalence of alcohol consumption was higher among younger age groups, with 19.7% of males and 3.9% of females aged 25-44 years reporting alcohol use. In contrast, the older age group of 45-65 years showed lower rates, with 9.3% of males and only 0.5% of females consuming alcohol (WHO & Tonga Ministry of Health, 2014).

Research on the drinking tendencies among adolescents in Tonga is limited, with most studies focusing on youth and alcohol consumption across the Pacific region (Durand et al., 2016; Nosa et al., 2021; Subica et al., 2020; Subica et al., 2022). A study identified an increasing prevalence of self-reported drunkenness among adolescent males in Tonga, Vanuatu, and the Federated States of Micronesia as they aged (Kessaram et al., 2016). Furthermore, Pacific region adolescents have cultural and social drinking habits that people gather to drink alcohol at kava clubs and celebrations to bond relationship among the participants. Kava, traditionally drink by men, is now being substituted for alcohol (Finau, 1999). Reportedly, these habits have a direct impact on their lives(Phongsavan et al., 2005). In Tonga, it is common to consume alcohol during social gatherings and festivals, and drinking is considered an important element in strengthening social bonds among people. However, excessive alcohol consumption has been identified as a cause of various problems, including health issues, domestic violence, and traffic accidents, and it has been recognized as a significant challenge in Tongan society (Smith et al., 2007). Although, there has been a decreasing trend in adolescent drinking in the region. While approximately 15% of adolescents (both sex) in the Pacific region reported drinking in 2001, this figure dropped to about 7% by 2012. Additionally, as of 2012, the proportion of adolescents drinking and engaging in excessive drinking in the Pacific region was lower compared to their counterparts in New Zealand and Europe (Adolescent Health Research Group, 2016).

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Furthermore, a survey conducted in the 1990s on alcohol consumption in Pacific countries found that Tonga had relatively lower alcohol consumption compared to other Pacific nations (McDonald et al., 1997). Data from 1994 indicated that the per capita alcohol consumption in Tonga was 1.3 liters, with 77% of it being beer, revealing that beer is the most commonly consumed alcoholic beverage in Tonga. While some beer is produced domestically in Tonga, about half of the beer available in the country is imported (McDonald et al., 1997).

As part of its NCD strategy, the Tongan government implemented various measures starting from 2010 under the theme of "restrictive control of the availability of alcohol" (TongaHealth, 2015). Initially, the government significantly increased the license fees for handling alcohol, which had not been revised since 1998. Prior to the 2010 revision, license fees for alcohol sales were set at 200T$ (around 458USD) for wholesale, 200T$ (around 458USD) for bottle stores, 300T$ (around 687USD) for clubs, and 175T$ (around 400USD) for restaurants. The revised fees in 2010 were raised to 5,750T$ (around 13,167USD) for wholesale, 2,300T$ (around 5,267USD) for bottle stores, 3,450T$ (around 7,900USD) for clubs, and 1,437.5T$ (around 3,291USD) for restaurants (Japan International Cooperation Agency, 2013). Additionally, the government reduced the operating hours of nightclubs handling alcohol. Previously, they were open from 8:00 p.m. to 4:00 a.m. from Monday to Friday, which was shortened to 8:00 p.m. to 12:30 a.m., and on Saturdays, the hours were reduced to 8:00 p.m. to 11:30 p.m. (Japan International Cooperation Agency, 2013). Following the implementation of these measures in 2010, the import volume of alcohol dramatically decreased. While the import volume was 162,184 liters per year in 2007, it dropped to 37,594 liters per year in 2010 and further decreased to 18,073 liters per year in 2011 (Japan International Cooperation Agency, 2013). Moreover, a "Don't Drink and Drive" campaign was launched, and subsidies were provided for installing alcohol prohibition signs in public facilities (TongaHealth, 2015). In 2013, with the aim of mitigating the impact of alcohol use among adolescents, the legal drinking age in Tonga was raised. Previously set at 18 years, the legal age for alcohol consumption was increased to 21(Australia network news, 2014).

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Furthermore, gradual revisions were made to the tax rates of excise taxes and customs duties related to alcohol. Tax rates were calculated based on Lal: Liters of alcohol contained in a mixture; a measure used to determine the volume of pure alcohol in alcoholic beverages. Consequently, the excise tax on imported beer rose from 50T$ (about 114USD)/Lal in the fiscal year 2014-15 to 60T$ (about 137USD)/Lal in 2017-18. Additionally, the customs duty on beer imports, previously free, was set at 15% starting from the fiscal year 2015-16. As a result, the total tax amount on imported beer increased from 66.39T$ (about 152USD)/Lal in 2014-15 to 83T$ (about 190USD)/Lal in 2017-18. The excise tax on locally produced beer, which was 10T$ (about 30USD)/Lal in 2014-15, escalated to 15T$ (about 34USD)/Lal in 2015-16 and further to 20T$ (about 46USD)/Lal in 2017-18. Consequently, the total tax amount on locally produced beer rose from 11.5T$ (about 26USD)/Lal in 2014-15 to 23T$ (about 52USD)/Lal (The World Bank, 2019). Moreover, revisions were also made to the tax rates for spirits. In terms of excise taxes, the rate for locally produced spirits was increased from 21T$ (48USD)/Lal in 2014-15 to 25T$ (57USD)/Lal in 2015-16. For imported spirits, the tax rose from 42T$ (96USD)/Lal in 2014-15 to 50T$ (114USD)/Lal. Additionally, customs duties on imported spirits, which were previously free, were set at a 15% tax rate starting from the fiscal year 2015-16 (The World Bank, 2019).

As a result of the increased alcoholic drink prices, a decrease in the frequency of alcohol consumption among people was observed. A household survey conducted by the World Bank through questionnaires to understand consumer behavior before the tax increase in 2016 (baseline) and after the tax increase in 2017 (endline) revealed that, following the tax hike in 2017-18, there was a decrease in drinkers consuming alcohol 3-4 times per week and 5-6 times per week, while the number of individuals drinking once a month increased by 10%. Moreover, among drinkers, the proportion of those who typically consumed 15 or more drinks per week decreased from 34% to 24.9% after the tax increase (The World Bank, 2019). This suggests that the revision of tax rates may have influenced the consumption behavior of the people in Tonga.

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2.4 Adolescents' Obesity

The prevalence of obesity has escalated worldwide, with an alarming trend in recent years being the surge in childhood and adolescent obesity. This trend is concerning as it can increase the risk of developing lifestyle-related diseases and make individuals more susceptible to other illnesses in the future. Marie Ng and colleagues (2013) highlighted that between 1980 and 2015, global trends in childhood and adolescent obesity experienced a substantial increase, resulting in over 124 million children and adolescents being categorized as overweight or obese. This trend is particularly pronounced in developed countries, where the prevalence of overweight and obesity has risen considerably over the 30-year period from 1980. By 2013, the prevalence had reached 23.8% for boys and 22.6% for girls, representing a 6.9% increase for boys and a 6.4% increase for girls since 1980 (Marie Ng a, 2013).

Another global analysis of trends in BMI for children and adolescents from 1975 to 2016 across 200 countries was conducted utilizing a population-based dataset from the Non-communicable Disease Risk Factor Collaboration (NCD-RisC), a worldwide network of health researchers and practitioners. The results of the analysis revealed that the mean BMI and prevalence of obesity among children and adolescents increased by 0.32 kg/m2 per decade for girls and 0.40 kg/m2 per decade for boys globally from 1975 to 2016 (NCD-RisC, 2017). Furthermore, the study identified that over 30% of children and adolescents of both sexes in Nauru, the Cook Islands, and Palau were classified as overweight or obese (NCD-RisC, 2017).

Moreover, UNICEF's (2016) report indicated that Tonga had the highest prevalence of obesity among children under 5 years old in the Pacific region, with a rate of 17%, compared to the regional average of 6%. These findings suggest a global trend of increasing BMI and a high prevalence of obesity among children and adolescents in certain regions, emphasizing the necessity of effective health interventions for this population. A systematic review and meta-analysis study was conducted to investigate the relationship between childhood obesity and future obesity in adolescence and adulthood, utilizing BMI data from large cohort studies involving over 200,000 participants (Simmonds et al., 2016).

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The study found that approximately 55% of obese children developed obesity in adolescence, around 80% of obese adolescents will develop obesity in adulthood, and about 70% of obese adolescents may have obesity over the age of 30 (Simmonds et al., 2016). Moreover, the study concludes that childhood obesity being more than five times more likely to be obese in adulthood than non-obese children (Simmonds et al., 2016).

There are studies suggesting that childhood obesity may be able to predict to the development of cardiovascular diseases, diabetes and some cancers in adulthood (Krul et al., 2009; Umer et al., 2017). A meta-analysis was conducted in subsequent research to identify diseases that may occur in the future due to childhood obesity. In a 2017 systematic review with meta-analysis, a positive association was found between childhood obesity and adult CVD risk factors, particularly in systolic blood pressure (SBP), diastolic blood pressure (DBP), and triglycerides (TG). This study suggests that childhood obesity may be related to adult CVD risk (Umer et al., 2017).

In these studies, BMI is used as a measure of the degree of obesity in children and adolescents to define youth obesity. However, systematic reviews and meta-analyses have revealed that BMI may not be the most accurate method for defining childhood obesity and predicting adult disease risk. A high BMI in childhood was associated with adult diabetes (OR 1.70; 95% CI 1.30-2.22) and coronary heart disease (OR 1.20; 95% CI 1.10-1.31). However, even in diabetes, which has the strongest association with obesity, only about 35% of adult with diabetes were overweight or obese during adolescence. Moreover, many adults with obesity-related diseases had a healthy weight during childhood (Llewellyn et al., 2016). Although the predictive accuracy of BMI might be overestimated, it still remains a useful tool for identifying children at risk of such health problems.

2.5 Body Image among Adolescents

It is known that Tonga has its own perceptions and sensibilities regarding body size. Traditionally in Tonga, a larger body size has been seen as a symbol of status, indicating that individual has enough to eat and does not need to engage in physical labor. Therefore,

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being larger body size is considered a social status symbol of wealth and power, regardless of gender (Young, 2002).

What's more intriguing is the revelation that such attitudes and sensibilities are also present among Tongan adolescents. A 2010 study targeting adolescents and their body image across eight countries (Australia, Fiji, Indo-Fijian, Malaysia, Tonga, Tongans in New Zealand, China, and Greece) included 2,489 participants and investigated body satisfaction and the value attributed to different body sizes. Despite Tongan adolescents recording the second-highest BMI overall, they consistently valued a larger body size and showed the highest rates of satisfaction with their own body size. This trend was particularly strong among females (McCabe, 2010).

Furthermore, such perceptions regarding body size are suggested to be influenced by cultural and religious beliefs. A study conducted in 2013 involving adolescents from Tonga, Australia, Fiji, and Indo-Fiji examined the relationship between cultural values, religious eating habits, and body size. The findings indicated that among the cultural values, Tongan youth tend to value a larger body size, which they consider associating with health, strength, and prosperity. Moreover, in Tongan society, body size is seen as an indicator of one's strong connections with others. For example, a well-built person is often perceived as having a caring family, and this is equated with having strong social ties. Regarding the link between eating habits and religion, the meals served during religious events often encourage eating in abundance. This is influenced by Christianity in Tonga, where the quantity of food represents love and respect. Meals play a significant role in social and religious gatherings in Tonga, with a cultural norm that leaving food uneaten is considered disrespectful to the host. While the influence of media has been increasing the preference for a slimmer Western body among Tongan youth, there is a noticeable tension with the traditional values of a larger body size. These findings suggest that due to the significant influence of religion on the quantity of food consumed, churches could play an essential role as a venue for communicating health promotion messages (McCabe, 2013).

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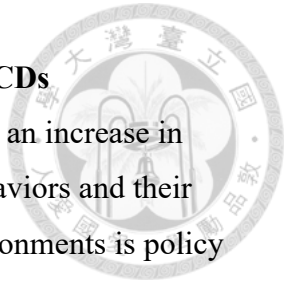

2.6 Association between health behaviors, living environment and NCDs

Recent research on non-communicable diseases (NCDs) has seen an increase in studies examining the interaction between environmental and health behaviors and their impact on the incidence of NCDs. One factor that influences living environments is policy implementation, however, how do these policies affect health behaviors and health outcomes.

A systematic review investigating studies from 2000 to 2020 was conducted to determine whether public policies on unhealthy products in public health have led to a decrease in cardiovascular diseases. The results indicate that fiscal and regulatory policies, as well as educational policies related to sugary drinks, tobacco, and alcohol, contribute to the reduction of cardiovascular diseases (Vellakkal et al., 2021). Specifically, four studies on alcohol-related fiscal interventions in Europe show that increases in alcohol consumption taxes have contributed to the reduction of diabetes and stroke. In the United States, increased taxes in Alaska, Florida, and New York have been associated with a decrease in mortality from alcohol-related diseases. Another four studies on tobacco-related fiscal policies evaluated the direct or indirect effects of increased tobacco taxes. The studies on the regulatory policies of sugary drinks, focusing on restricting access to sugary drinks in schools in the United States and Canada, reported that reducing the availability of sugary drinks decreases their consumption and is associated with a reduction in obesity caused by them (Vellakkal et al., 2021).

Research has also been conducted on the impact of health policies and regulatory enhancements on risky behaviors among adolescents. The effect of stricter tobacco regulations and increased taxes on adolescent smoking behavior was studied in the United States, focusing on the impact of increased tobacco taxes implemented in 2009 on the smoking behaviors of adolescents aged 12 to 17 and young adults aged 18 to 25. The results indicated a significant decrease in the number of young people who started smoking after the implementation of the policy, suggesting that the increase in tobacco taxes is associated with a reduction in smoking behaviors among adolescents and young adults (Hasselt et al., 2015).

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In addition, studies have been conducted on the impact of health policies in low and middle-income countries (LMICs) on adolescents' dietary behaviors and physical activity. One such study used data from the Global School-based Student Health Survey (GSHS) to explore the role of fruit and vegetable policies, social environmental factors, and related factors in the consumption of fruits and vegetables among adolescents in LMICs. The study compared adolescents (89,843 participants) from countries (13 countries) that had policies promoting fruit and vegetable intake announced up to a year before the GSHS and countries (11 countries) that had no such policies. The findings indicated that adolescents in countries with fruit and vegetable intake promotion policies were more likely to have adequate consumption of these foods. Additionally, a sufficient connection and supervision by parents, as well as adequate physical activity, were positively associated with adolescents' fruit and vegetable intake (Darfour et al., 2019). This research highlights the importance of implementing health policies to promote fruit and vegetable intake and underscores the significance of the role of parents and physical activity in adolescents' healthy eating habits.

Also, what specific changes to the living environment can be effected by the policy. Research has also been conducted on the impact of unhealthy living environments on health behaviors, particularly focusing on diet as a major risk factor for NCDs. A systematic review investigated the impact of altering the availability and proximity of unhealthy foods and beverages on individuals' consumption and choice behaviors. This research, primarily conducted in high-income countries, focused mainly on food and sugary drinks. The review found that interventions targeting availability reduced the selection of unhealthy foods and beverages when the absolute number of available options was altered, and the options for unhealthy choices were reduced. Additionally, proximity interventions, which involved changing the distance of unhealthy foods and beverages from participants, showed that increasing the distance moderately decreased the selection and consumption of these targeted items (Hollands et al., 2019).

Additionally, research has been conducted on how social engagement, the aesthetic quality of nearby environments, and participation in community gardens affect fruit and vegetable consumption in personal dietary behaviors. The results indicate that individuals

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involved in community gardening consume more fruits and vegetables compared to those who garden at home or do not engage in gardening at all. Positive correlations were also observed between social involvement, the aesthetic appeal of the immediate environment, and the intake of fruits and vegetables (Litt et al., 2011).

These researches indicates that environmental elements, like the accessibility and location of unhealthy food, significantly impact people's food choices. Limiting the availability of unhealthy foods or placing them further away can lead to healthier eating habits. Additionally, community gardens promote social engagement, which can connect individuals more closely with their food sources, fostering better dietary practices. This approach represents an effective method of social intervention for improving nutrition. This has implications for public health strategies aimed at reducing the consumption of unhealthy foods and beverages, which are key contributors to obesity and other diet-related non-communicable diseases. However, further research is needed in a broader range of settings, not limited to food and beverages but also including tobacco and alcohol, especially in low- and middle-income countries setting.

Research has also been conducted on the environmental behaviors surrounding adolescents, particularly in terms of physical activity. A systematic review in 2009 focused on the relationship between active school transport (AST), such as walking or cycling to school, and the amount of physical activity in adolescents. This review included 13 studies, of which nine indicated that children who actively commute to school through AST significantly engage in more physical activity. Furthermore, two of these studies reported that children who use AST consume significantly more calories per day. However, out of ten studies that investigated the relationship between AST and body weight, only one study reported that children who engage in active school transport tend to have lower body weight (Faulkner et al., 2009). In a systematic review conducted in 2013 focusing on the relationship between AST, physical activity, sedentary behavior, and weight, 52 studies were included. Most of these studies centered on the association between AST and physical activity, demonstrating a significant positive correlation. However, the relationship between AST and weight status lacked consistency across studies. Furthermore, there were very few

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studies examining the correlation between AST and screen time or sedentary behavior, leaving the relationship unclear (Schoeppe et al., 2013).

Number of studies investigating the relationship between environmental behaviors and health behaviors have been reported recently, but there is a demand for more research in diverse environmental settings and long-term comparative analyses. A scoping review focusing on observational studies examining this relationship included 136 studies, with the majority being cross-sectional studies conducted in the United States using self-reported measures. Most of these studies related to active travel behaviors, such as walking and cycling (92 studies), and sedentary behaviors (19 studies). Many studies particularly focused on the association between using walking or cycling and physical activity levels, indicating the impact of environmental behaviors on health behaviors. However, most were cross-sectional, and there were few long-term or before-and-after comparative analyses (Hutchinson, 2015). The research predominantly focuses on certain high-income countries, highlighting the need for discussions about its relevance and application in other high-income as well as low- and middle-income countries.

These findings highlight unhealthy diets as a key risk factor for NCDs. In Tonga, efforts such as changing food prices have been implemented to curb such behaviors. Altering the availability of unhealthy foods may be an effective way to improve dietary behaviors among adolescents. Additionally, initiatives both within and outside schools in Tonga to ensure adequate exercise time could significantly increase physical activity levels among young people. Therefore, it is expected that investigating adolescents' health behaviors and living environments during adolescence, in addition to BMI, may be helpful in predicting future illnesses.

2.7 Hypothesis

Since Tonga initiated the second phase of its national strategy for Non-Communicable Diseases (NCDs) from 2010 to 2015, it is believed that school-aged adolescents have started making healthier choices. This strategic effort, aimed at fostering healthier lifestyles and reducing the prevalence of NCDs, is posited to have significantly

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influenced adolescents' daily behaviors in three key areas: dietary habits, tobacco and alcohol use, and physical activity. As a result of this strategy, it is anticipated that by 2017, adolescents will have begun to engage in healthier behaviors compared to those in 2010, leading to a decrease in the number of obese or overweight young individuals. This study seeks to verify this hypothesis by comparing the health behaviors of Tongan adolescents before the implementation of the NCD strategy's second phase in 2010 with those after the policy implementation in 2017.

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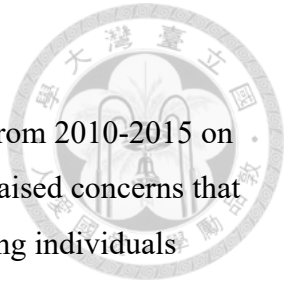

2.8 Conceptual Framework

This thesis analyzes the impact of Tonga's National NCDs Strategy from 2010-2015 on the health behaviors of school-aged adolescents. Previous research has raised concerns that obesity during adolescence increases the risk of developing NCDs, making individuals more susceptible to illnesses in the future (Marie Ng, 2013). BMI is used as an indicator to demonstrate the extent of obesity among adolescents. By international standards, BMI classifications are defined as underweight for below 18.5, normal weight for 18.5-24.9, overweight for 25.0-29.9, and obese for 30 and above, identifying the presence or absence of health risks. Additionally, the WHO defines risk behaviors that increase the risk of developing NCDs as unhealthy diets, smoking habits, harmful use of alcohol, and low levels of physical activity (WHO, n.d.-a). These risk behaviors in adolescents will be evaluated based on changes in diet, smoking habits, alcohol use, and physical activity reported in the School-Based Global Survey (GSHS) conducted in Tonga in 2010 and 2017.

The dietary habits targeted the intake of fruits and vegetables, and the consumption of soft drinks. The WHO defines the recommended intake of fruits and vegetables to maintain a healthy lifestyle as 400 grams per day. Furthermore, dietary guidelines provided by the Centers for Disease Control and Prevention (CDC) in the United States recommend consuming 2-3 cups of vegetables and 1.5-2.5 cups of fruits daily (McGure, 2013). In addition, a study investigating the changes in risk behaviors among Filipino adolescents using the GSHS data defined vegetable intake as inadequate if less than three times per day, and fruit intake as inadequate if less than two times per day, and analyses were conducted accordingly (Peltzer, 2015). Therefore, in this study, risk behaviors related to the intake of vegetables and fruits are defined as less than three times per day for vegetables, and less than two times per day for fruits.

Regarding the consumption of soft drinks, an article published by the WHO in 2016 on the consumption of sugary drinks and their effects on health states that the free sugars contained in soft drinks are a major source of unnecessary extra caloric intake, and are considered a primary cause for the increase in obesity and diabetes (WHO, 2016). Healthy

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dietary habits recommend that the intake of these free sugars be less than 5% of total energy, and this amount has been reported to be less than one serving of a typical sugary drink (250ml) (WHO, 2016). Therefore, in this study, the consumption of soft drinks more than once per day is defined as a risk behavior.

In this study, the consumption of tobacco and alcohol was defined as a risk behavior if an individual smoked or drank alcohol for one or more days within the past 30 days. Additionally, the question for smoking other tobacco products in the GSHS, include other type of tobacco products such as Tapaka Tonga, which is a local tobacco in Tonga.

Regarding physical activity, the WHO recommends the following for children and adolescents aged 5 to 17: 1) Engage in an average of at least 60 minutes per day of moderate to vigorous intensity, predominantly aerobic, physical activity throughout the week. 2) Incorporate vigorous intensity aerobic activities and those that strengthen muscles and bones, at least three times per week. 3) Limit the amount of time spent sitting, especially recreational screen time (WHO, 2022). On the other hand, as an indicator of low levels of physical activity, the WHO framework for assessing risk factors for NCDs defines insufficient physical activity among adolescents as less than 60 minutes per day of moderate to vigorous intensity (WHO, 2012). Additionally, the recommended level of physical activity in the final report of Tonga's GSHS is defined as at least 60 minutes of activity on five or more days out of seven (WHO, 2010). Therefore, this study defines a lack of physical activity as less than 60 minutes of activity per day on four or fewer days over the past seven days.

Sedentary behavior is assessed through GSHS questions regarding the time spent sitting watching television, playing games, or talking with friends, excluding time sitting at school or doing homework. In a study comparing the physical activity and sedentary behavior of adolescents in 34 countries using the 2010 GSHS, children who spent more than three hours per day in sedentary activities were defined as "sedentary" (Guthold, 2010). Thus, in this study, sedentary behavior is also defined as spending more than three hours per day sitting.

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The analysis will investigate whether the measures against NCDs that were implemented in Tonga from 2010 to 2015 have impacted the reduction of risk behaviors among adolescents. The national NCD strategy carried out in Tonga targeted four areas in line with the WHO-defined NCD risk behaviors: diet, smoking and alcohol use, and physical activity, with various initiatives being undertaken in each field. These included policy-level approaches such as food policy, changes in the pricing and availability of tobacco and alcohol, and community-level efforts to promote physical activity and healthier diets in schools, workplaces, villages, and churches. Interventions at the individual level also took place, such as strengthening obesity outpatient clinics and services to support smoking cessation (Tonga Health Promotion Foundation, n.d.).

This thesis will analyze the changes observed in the NCD risk behavior items in Tonga's GSHS for adolescents by comparing data from 2010 and 2017 as a result of the Tongan NCD strategy efforts (see table.1).

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Figure 1. Conceptual framework

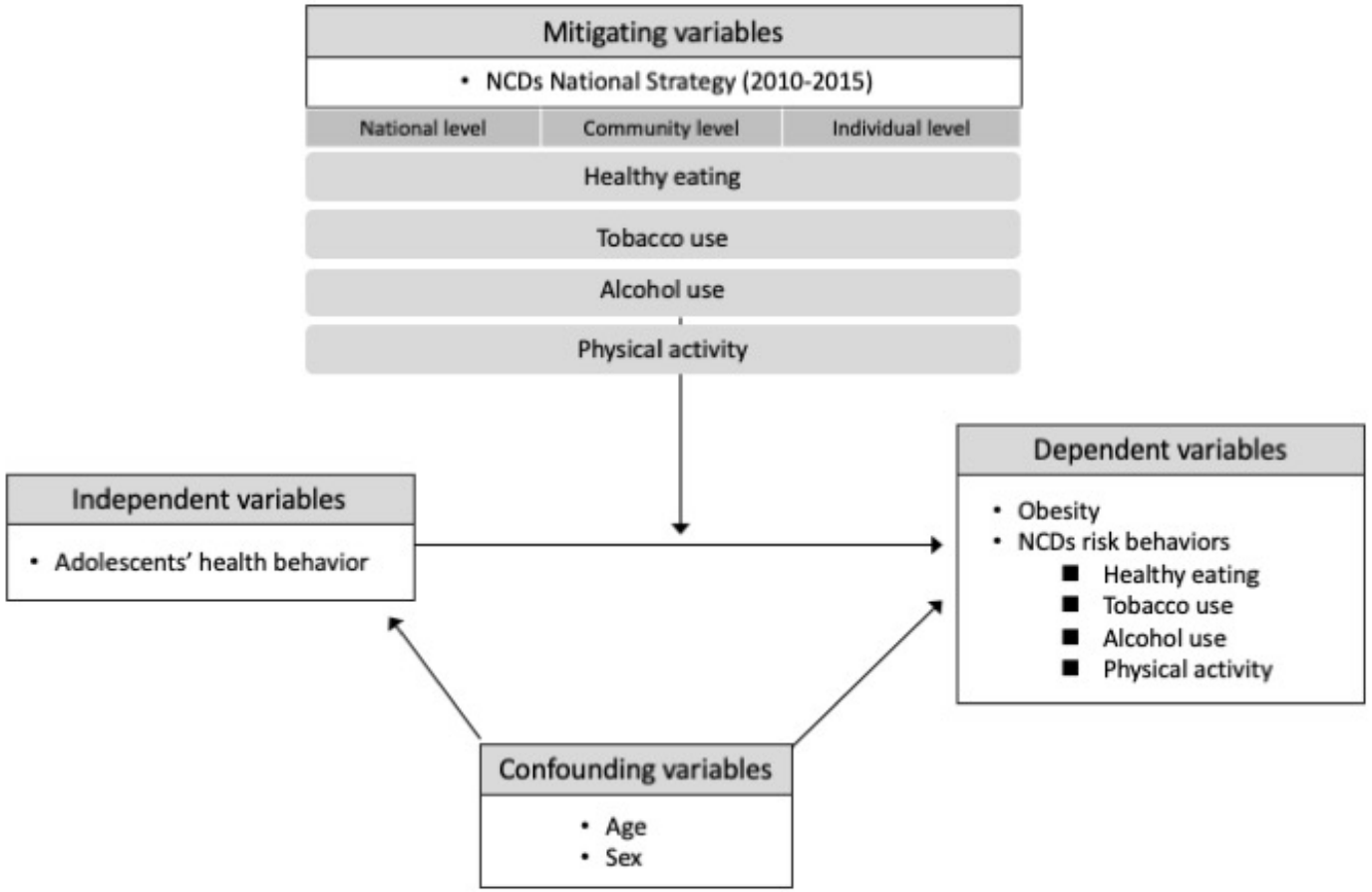

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Table 1. Lists the interventions implemented in the NCDs strategy from 2010-2015

Categories	Interventions	Start year	level	Description
Eating habits	Vegetable and fruits gardens	2011	Community	Grant seedling for gardening on home, village and schools in Tongatapu (main island) and Vava'u island.
Eating habits	Fruits eating promotion (Mai e Nima)	2013	School	Provide educational tools for healthy and nutritious meal ideas with primary school teachers in order to promote healthy eating to students and their families.
Eating habits	Food act	2014	Policy	Reduced the food tax on healthy foods (fresh and canned fish, imported vegetables) and increased the tax on unhealthy foods (fatty meat, carbonated drinks).
Eating habits	Healthy cooking demonstration	n.d.*	Village	Implemented healthy cooking demonstrations and developed a recipe book aimed at women's groups.
Tobacco	Tax and duty amendments	2013	Policy	19% excise tax increase. Additional import duty rate of 15% imposing on imported cigarettes and tobacco products.
Tobacco	Smoke free regulations	2013	Community	Smoke free in public place and public transport. A smoker was fined TOP200 (USD458) for non-compliance. Also, grant for no smoking signature.
Tobacco	Smoking cessation services	2015	Individual	Increased the capacity for supporting smoking cessation service and established hotline to provide smoking cessation advise.

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Table 1. Cont.

Categories	Interventions	Start year	level	Description
Alcohol	Raising alcohol license fees	2011	Policy	Raising liquor license fees for liquor shops, bars and restaurants.
Alcohol	Changed to opening hours for licensed premises	2011	Policy	Shortened the opening hours in night clubs from 8:00 p.m.-4:00 a.m. to 8:00 p.m.-12:30 a.m.
Alcohol	Raising drinking age	2014	Policy	Raising the alcoholic drinking age from 18 to 21 years old.
Alcohol	Tax and duty amendments	2015	Policy	Increased excise taxes or import duties for local beer and spirits, imported beer and spirits.
Physical activities	Sports equipment grants	2011	Community, School, Workplace	Grant for sport equipment in communities, schools, churches and workplaces in order to facilitate sports and recreational physical activities.
Physical activities	Work place sports competition (Fiefia Sports)	2011	Workplace	Held workplace sport competitions September to November each year. Almost 20 workplaces participated the competition.
Physical activities	Promoting netball (Kau Mai Tonga)	2012	Community	Increased the level of physical activity among women and girls through promoting netball in communities.

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Table 1. Cont.

Categories	Interventions	Start year	level	Description
Physical activities	Extension of the walkway	n.d.	Community	Extended walkway along the waterfront in Tongatapu island (main island) in order to promote walking activity.
Physical activities	Promoting the Movement and Fitness curriculum	n.d.	School	Promoting the Movement and Fitness curriculum at primary schools through providing physical activity's training session to teachers and collaborating with national sport federations.
All area	Social marketing campaign	n.d.	All levels	Advertising strategies using television and radio were implemented in the areas of healthy eating, tobacco and alcohol use, and physical activity.

*List the interventions mentioned in the program's post-report, Hala fononga (TongaHealth, 2015)

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Chapter 3
Method

3.1 Data--The Global School-Based Student Health Survey (GSHS)

The STEP surveys targeted adults aged 15 to 64 in 2004 and 18 to 69 years old in 2017 in more than 100 low- and middle-income countries (WHO, n.d.-b). The STEP surveys conducted in Tonga also targeted adults aged 15 to 64 in 2004 and 18 to 69 years in 2017, but they did not include a comprehensive coverage of the school-aged adolescent population aged 13 to 17 years. To evaluate the effectiveness of the national strategy for adolescent health behavior, it is desirable to use a health survey targeting adolescents, such as the Global School-Based Student Health Survey (GSHS), as various interventions for adolescents have been implemented in schools, churches, and communities at the village level. Therefore, the effectiveness of interventions in this age group cannot be fully assessed using the STEP surveys alone.

This study was a secondary analysis of existing data form the Global School-Based Student Health Survey (GSHS) conducted in Tonga. The GSHS is open-source data on WHO's website. Comprehensive information on GSHS data and methodologies is available through the website, NCDs Microdata Repository (https://www.who.int/teams/noncommunicable-diseases/surveillance/systems-tools/global-school-based-student-health-survey). The GSHS survey is a collaborative surveillance project designed and conducted by WHO to allow countries to measure and assess behavioral risk and protective factors in 10 key areas such as Alcohol Use, Dietary Behaviors, Drug Use, Hygiene, Mental Health, Physical Activity, Protective Factors, HIV infection, Tobacco Use, and Violence and Unintentional Injury (in 2017, adding Media access and Physical difficulties). The GSHS is administered to students aged 13 to 17 years using a self-administered questionnaire. Surveyed schools and individuals are randomly selected and the privacy of participating individuals and schools are protected. Thus, the GSHS did not include the information of individual's geographic and social economic status (WHO, 2010a, 2017).

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3.2 Survey Implementation and Sampling Method

The survey conducted two rounds were implemented in Tonga in 2010 and 2017. The survey consists of a questionnaire and physical measurements (height, weight and BMI.) The questionnaire part includes almost 84 to 89 items (84 items in 2010 and 89 items in 2017) and the language was used in English or Tongan (NCD Microdata Repository, n.d.). The 2010 Tonga GSHS employed a two-stage cluster sample design to produce a representative sample of students in forms. The first-stage sampling frame consisted of all schools containing any of forms. Schools were selected with probability proportional to school enrolment size. 24 schools were selected to participate in the Tonga GSHS. The second stage of sampling consisted of randomly selecting intact classrooms (using a random start) from each school to participate. All classrooms in each selected school were included in the sampling frame. All students in the sampled classrooms were eligible to participate in the GSHS. The Tonga GSHS was a school-based survey of students in Forms 2, 3, and 4. A two-stage cluster sample design was used to produce data representative of all students in Forms 2, 3, and 4 in Tonga.

In 2017, a two-stage cluster sample design was used to produce data representative of all students in grade Forms 1-7 in Tonga. At the first stage, schools were selected with probability proportional to enrollment size. At the second stage, classes were randomly selected and all students in selected classes were eligible to participate. A weighting factor was assigned to each student record to account for non-response and the differing selection probabilities. The weighting calculation used was: W=W1 * W2 * f1 * f2 * f3; W1 - The inverse of the probability of selecting each school, W2 - The inverse of the probability of selecting each classroom, f1 - A school-level non response adjustment factor, f2 - A student-level non response adjustment factor calculated by classroom, f3 - A post stratification adjustment factor calculated by sex within grade (WHO, 2010; WHO, 2017).

3.3 Response Rates

For the 2010 Tonga GSHS, 2,211 questionnaires were completed in 24 schools. The school response rate was 100%, the student response rate was 80%, and the overall

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response rate was 80%. In 2017, the school response rate was 100%, the student response rate was 90%, and the overall response rate was 90% (WHO, 2010b; WHO, 2017b).

3.4 Sample Characteristics

The Tonga GSHS in 2010 was completed by 2211 students in 24 schools and the gender distribution was 51.6% male and 48.4% female. As for grade levels, in the 2010 survey, students in Form 1 (where "Form" is synonymous with "Grade") were not included in the study population, Form 2 (13-14 years-old) accounted for 26.8%, Form 3 (14-15 years-old) for 33.9%, Form 4 (15-16 years-old) for 38.5%, and other grades made up 0.8%. The schools have randomly selected the sampling of 24 schools in Tonga where 14 in Tongatapu, 5 in Vava'u, 3 in Ha'pai and 2 in 'Eua (WHO, 2010b). Tonga GSHS 2017 was completed by 3,333 students from 35 secondary schools and the gender distribution was 50.7% male and 49.3% female. The grade levels, Form 1 (12-13 years-old) accounted for 17.1%, Form 2 (13-14 years-old) for 19.1%, Form 3 (14-15 years-old) for 18.7%, Form 4 (15-16 years-old) for 19.2%, Form 5 (16-17 years-old) for 18.5%, Form 6 (17-18 years-old) for 7.3% and other grades made up 0.1%. The schools have randomly selected of 35 secondary schools in Tonga (WHO, 2017). However, detailed description of areas was not mentioned in 2017 report. The number of people surveyed increased by more than 1,000 from 2010 to 2017. In terms of age structure, the 2010 survey had six scales ranging from 11 and under to 16 and over, while the 2017 survey had seven scales ranging from 11 and under to 17 years old (Table 2).

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Table 2. Characteristics of participating students in 2010 and 2017

Characteristic	2010, N = 2,211[1]	2017, N = 3,333[1]
Age		
≤11 years	10 (0.5%)	313 (9.4%)
12 years	111 (5.0%)	468 (14.0%)
13 years	487 (22.0%)	491 (14.7%)
14 years	684 (30.9%)	545 (16.4%)
15 years	664 (30.0%)	563 (16.9%)
≥16 years	243 (11.0%)	-
16 years	-	486 (14.6%)
17 years	-	323 (9.7%)
≥18 years	-	139 (4.2%)
Unknown	12 (0.5%)	5(0.2%)
Gender		
Male	1,006 (45.5%)	1,520 (45.6%)
Female	1,186 (53.6%)	1,792 (53.8%)
Unknown	19 (0.9%)	21 (0.6%)
Grade		
Form 1	11 (0.5%)	620 (18.6%)
Form 2	668 (30.2%)	536 (16.1%)
Form 3	805 (36.4%)	614 (18.4%)
Form 4	689 (31.2%)	599 (18.0%)
Form 5	3 (0.1%)	664 (19.9%)
Form 6	4 (0.2%)	282 (8.5%)
Unknown	31 (1.4%)	18 (0.5%)

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3.5 Study Design and Variables

The research was designed to assess the impact of Tonga's NCD policy on the health behaviors of adolescents. The dependent variable is set as the health behaviors of adolescents in categories targeted by Tonga's NCD policy. These categories include dietary habits, alcohol and tobacco consumption, and physical activity patterns. The years 2010 (prior to the implementation) and 2017 (post-implementation) of Tonga's second phase of NCD policy are treated as independent variables. Confounding factors, such as age and gender, are incorporated as additional explanatory variables in the Table 3.

3.6 Measures

For this study, I use variables from the Global School-based Student Health Survey (GSHS). The height and weight data in GSHS are based on students' self-report. Using the reported height and weight, I computed the Body Mass Index (BMI) and subsequently categorized students based on their obesity levels. For BMI classifications, I adhered to internationally recognized standards, specifically: under 18.5 (underweight), 18.5-24.9 (normal weight), 25.0-29.9 (overweight), and 30.0 or higher (obese). For fruit consumption, intakes of less than two or more servings a day were deemed inadequate. Similarly, vegetable intakes of less than three or more servings a day were considered inadequate (WHO, 2021) (McGuire, 2013). Sugary beverages were categorized as having an inappropriate consumption level if consumed once or more per day (WHO, 2016). As for physical activity, insufficiency was defined as engaging in less than 60 minutes of physical activity on fewer than 5 days a week (Prochaska et al., 2001). Sedentary behavior was defined as spending 3 or more hours per day sitting (Guthold et al., 2010) (see Table 3). Finally, year dummies were created to indicate year 2010 (yes/no) and 2017 (yes/no).

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Table 3. Variables definitions of inappropriate health behavior

Variables	Definition
Overweight and dietary behavior	
Overweight or obesity	BMI 25.0-29.9 were overweight, 30.0 or higher were obese
Fruit eating	<2 servings a day were defined inadequate
Vegetables eating	<3 servings a day were defined inadequate
Soft drink intake	1≤ intake a day were defined inappropriate consumption
Tobacco and alcohol use	
Smoking cigarette	Smoked cigarettes on at least 1 day during the 30 days before the survey
Other tobacco products	Used any tobacco products on at least 1 day during the 30 days before the survey
Alcohol use in past month	At least 1 drank of alcohol for at least 1 day during the 30 days before the survey
Alcohol consumption	At least 2 drank of alcohol per day for at least 1 day during the 30 days before the survey
Physical activity and sedentary behavior	
Physical activity	Physically active for at least 60 min / day on 5/7 days during the 7 days before the survey
Sedentary behavior	Time sitting ≥3 hours a day

3.7 Data Analysis

As a data analysis strategy, I first conducted chi-square tests to analyze differences in adolescent health behaviors (obesity and dietary behavior, smoking and alcohol use, physical activity and sedentary time) between 2010 and 2017. A p-value of less than 0.05 was considered statistically significant for these differences.

Furthermore, using logistic regression models, I analyzed the potential impact of NCD policies on adolescent health behaviors after their implementation in 2017 compared to before their implementation in 2010. The regression models were stratified by sex, running two separate logistic regression models for male and female students (Tables 6.1, 6.2, 7.1, 7.2). Regarding age, Table 5.1 (total for both sexes), 6.1 (males), and 7.1 (females) present an analysis divided into six categories based on 2011 age data: under 11 years old, 12 years, 13 years, 14 years, 15 years, and over 16 years: under 11 years old, 12 years, 13 years, 14 years, 15 years, 16 years, 17 years, and over 18 years. The age data in these tables are ordered categorical data integrating data from 2010 and 2017. Table 5.2 (total for both sexes) represents the analysis treating age as continuous data and adjusting for age and

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additionally for sex. Tables 6.2 (males) and 7.2 (females) are the tables where the age was treated as an adjusting factor in the data stratified by sex.

I examined whether the changes in proportions for each health behavior category (obesity and dietary actions, smoking and alcohol intake, physical activity and sedentary time) from 2010 to 2017 were statistically significant. The Odds Ratio (OR) indicates how the odds of NCD risk behaviors have changed between 2010 and 2017. The calculation of the odds Ratio is performed using a logistic regression model, calculated by comparing the odds from 2017 to the odds of baseline year of 2010. The calculated odds ratios are interpreted as follows:

- OR = 1: Indicates no change in the odds of the behavior between 2010 and 2017.
- OR > 1: Suggests that the odds of the behavior increased from 2010 to 2017.
- OR < 1: Implies that the odds of the behavior decreased from 2010 to 2017

A p-value of less than 0.05 was considered indicative of a significant difference.

In this analysis, I adjust for age and sex as confounding factors in the logistic regression model. The risk factor, such as consuming fruits less than 2 days per week, is treated as the dependent variable, while the year serves as an independent variable, with both age and sex being controlled for in the model to account for their potential influence on the outcome.

$$log = \beta 0 + \beta 1 \times year + \beta 2 \times age + \beta 3 \times sex$$

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Chapter 4
Results

4.1 Chi-square test

The Chi-square test used to examine the changes between 2010 and 2017 revealed significant shifts in several key demographic and health-related behaviors. While the male-to-female ratio remained stable throughout the years, a marked increase in the younger age groups was evident ($\chi^2 = 1553.61$, $\varphi c = 0.530$, $p < 0.001$). In terms of BMI classification, there was a notable rise in the proportion of individuals classified under the underweight (4.3% to 9.8%) and Obesity II (2.2% to 3.7%) categories. Also, there was decrease trend in the proportion of Normal (58% to 50%) and Overweight (26% to 24%) categories but Obesity III was unchanged (1.1%), ($\chi^2 = 86.03$, $\varphi c = 0.129$, $p < 0.001$). Dietary patterns also showed significant changes, particularly a decrease in percentage of individuals in fruit intake and an increase in percentage of individuals in soft drink consumption (for fruit intake $\chi^2 = 47.59$, $\varphi c = 0.093$, $p < 0.001$; for soft drink consumption $\chi^2 = 5.40$, $\varphi c = 0.031$, $p = 0.019$).

Moreover, the prevalence of smoking behavior and other tobacco product use significantly decreased (for cigarette smoking $\chi^2 = 20.90$, $\varphi c = 0.063$, $p < 0.001$ for other tobacco products $\chi^2 = 39.96$, $\varphi c = 0.085$, $p < 0.001$). There was also a slight but significant decline in alcohol consumption patterns (for general alcohol use $\chi^2 = 12.26$, $\varphi c = 0.048$, $p < 0.001$; for drinking alcohol two or more per day $\chi^2 = 7.04$, $\varphi c = 0.036$, $p = 0.008$). In physical activity levels, there was a notable trend toward increased frequency of exercise ($\chi^2 = 35.92$, $\varphi c = 0.081$, $p < 0.001$). Conversely, there was a significant rise in sedentary behavior, as indicated by increased sitting time ($\chi^2 = 42.82$, $\varphi c = 0.088$, $p < 0.001$).

4.2 Overweight and Obesity

This study compared the health behaviors of adolescents in Tonga between 2010 and 2017. The overall prevalence of overweight or obesity showed a slight increase from 35% in 2010 to 37% in 2017, yet the odds of being overweight or obese between the two

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years did not significantly differ from 1 (OR, 1.00, 95% CI: 0.98-1.02, p-value >0.9). Among male adolescents, a decrease in the prevalence of overweight or obesity from 33% in 2010 to 30% in 2017 was observed, with the odds indicating no significant difference from one (OR, 0.97, 95% CI: 0.94-0.99, p-value 0.008). Conversely, the odds of female adolescents being overweight or obese significantly increased from 2010 to 2017, with a rise from 37% to 43% (OR 1.03, 95% CI: 1.00-1.05, p-value 0.018).

4.3 Eating Habits

Regarding to fruit consumption, the odds of eating fruit less than twice a day significantly decreased from 58% to 49% overall, showing a favorable dietary shift (OR 0.95, 95% CI: 0.93-0.96, p-value <0.001). A similar significant reduction in the odds was observed in male adolescents, decreasing from 60% to 50% (OR 0.95, 95% CI: 0.92-0.97, p-value <0.001), and in female adolescents from 57% to 48% (OR 0.94, 95% CI: 0.92-0.96).

While vegetable intake showed a slight overall increase from 63% to 65% (OR 1.01, 95%Cl 0.99-1.02, p-value 0.4), the odds did not reveal a statistically significant. For male students, there was no change in the vegetable consumption with 66% in 2010 and 2017 (OR 1.00, 95%Cl 0.97-1.02, p-value 0.7). For female students, there was a slight increase trend from 61% to 64% (OR 1.02, 95%Cl 1.00-1.04, p-value 0.7) with no significant change.

The odds of soft drink consumption increased from 57% to 60% (OR 1.02, 95% CI: 1.00-1.04, p-value 0.018) overall, and this change was marginally significant. Among male adolescents, there was no change in the soft drink intake from 55% to 56% was observed, with no significant difference from one (OR 1.00, 95% CI: 0.98-1.03, p-value 0.70). For female students, an increase trend from 58% to 63% (OR 1.03, 95%Cl 1.01, 1.05, p-value 0.005) with a certain level of significance.

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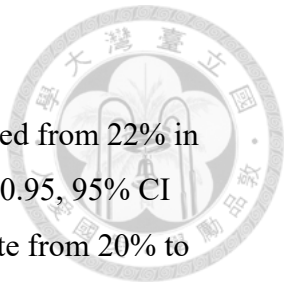

4.4 Cigarette and Alcohol Use

In this study, while the adolescent smoking rate in Tonga decreased from 22% in 2010 to 17% in 2017, the odds of smoking did significantly decline (OR 0.95, 95% CI 0.93-0.97, p-value <0.001). For male students, an increase in smoking rate from 20% to 26% was noted; however, the odds show a slight significant change (OR 1.04, 95% CI 1.02-1.07, p-value 0.002). Female students experienced a significant decrease smoking rate from 23% to 9.2% (OR 0.85, 95% CI 0.82-0.87, p-value <0.001). The smoking of other tobacco products saw an overall decline from 20% to 13%, with the odds reflecting a significant decrease (OR 0.93, 95% CI 0.91-0.95, p-value <0.001). The slight increase among male students from 20% to 22% was not significant (OR 1.02, 95% CI 0.99-1.05, p-value 0.2), while female students had a marked decrease from 19% to 5.9% (OR 0.82, 95% CI 0.79-0.85, p-value <0.001).

For drinking alcohol in the past 30 days, there was a significant reduction from 18% in 2010 to 14% in 2017 (OR 0.96, 95% CI 0.94-0.98, p-value <0.001)). Males showed an increase from 18% to 20%, but this was not significant (OR 1.02, 95% CI 0.99-1.05, p-value 0.2), whereas females saw a significant decrease from 17% to 8.8% (OR 0.88, 95% CI 0.81-0.91, p-value <0.001).

Regarding two or more alcohol consumption per day, there was a decrease from 6.6% in 2010 to 4.9% in 2017 (OR 0.95, 95% CI 0.91-0.98, p-value <0.001). The rate among male student slight decreased from 8% to 7%, and this change was not statistically significant (OR 0.98, 95% CI 0.93-1.02, p-value 0.3). Conversely, there was a decrease in alcohol consumption among female students from 6% to 3% (OR 0.90, 95% CI 0.85-0.95, p-value <0.001).

4.5 Physical Activity and Sedentary Behavior

Overall, there was a significant reduction in the proportion of adolescents engaging in a low frequency of physical activity (≤4 days per week), decreasing from 75% in 2010 to 68% in 2017 (OR 0.95, 95%Cl 0.93-0.96, p-value <0.001). This change was statistically significant. Among male students, the frequency of physical activity also decreased

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significantly from 75% in 2010 to 65% in 2017 (OR 0.93, 95%Cl 0.91-0.96, p-value <0.001). For females, a decrease from 75% to 69% (OR 0.96, 95%Cl 0.94-0.98, p-value <0.001) was observed over the same period, which was statistically significant.

Additionally, the amount of time spent in sedentary behavior, defined as sitting for more than 3 hours a day, showed a significant decrease overall, from 29% in 2010 to 21% in 2017 (OR 0.94, 95% CI 0.92 to 0.96, $p < 0.001$). This trend was also evident among male students, with a reduction from 28% to 22% (OR 0.96, 95% CI 0.93 to 0.98, $p = 0.002$). In female students, there was a decrease from 29% to 19%, which was statistically significant (OR 0.93, 95% CI 0.90 to 0.95, $p < 0.001$).

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Table 4. Chi-square test result

Variable	2010 Total N=2,211 N (%)	2017 Total N=3,333 N (%)	X-squared	φc	P_value	
Sex						
Male	1,006 (46.5%)	1,520 (45.6%)				
Female	1,186 (53.6%)	1,792 (53.8%)	0.000[1]	0.000[1]	>0.9	
Unknown	19 (0.9%)	21 (0.6%)				
Age						
11<= years	10 (0.5%)	313 (9.4%)				
12 years	111 (5.0%)	468 (14.0%)				
13 years	487 (22.0%)	491 (14.7%)				
14 years	684 (30.9%)	545 (16.4%)				
15 years	664 (30.0%)	563 (16.9%)	1553.61	0.530	<0.001	***
16>= years	243 (11.0%)	0 (0%)				
16 years	0 (0%)	486 (14.6%)				
17 years	0 (0%)	323 (9.7%)				
18>= years	0 (0%)	139 (4.2%)				
Unknown	12 (0.5%)	5 (0.2%)				
BMI						
Under weight (<18.5)	89 (4.0%)	304 (9.1%)				
Normal (≥18.5 - <25)	1,214 (54.9%)	1,558 (46.7%)				
Overweight (≥25 - <30)	546 (24.7%)	753 (22.6%)	84.03	0.127	<0.001	***
Obesity II (≥35 - <40)	46 (2.1%)	115 (3.5%)				
Obesity III (≥40)	23 (1.0%)	35 (1.1%)				
Unknown	132 (6.0%)	244 (7.3%)				
Fruits intake						
<2 day	1,278 (57.8%)	1,605 (48.2%)				
>2 day	920 (41.6%)	1,696 (50.9%)	47.59	0.093	<0.001	***
Unknown	13 (0.6%)	32 (1.0%)				
Vegetable intake						
<3 day	795 (36.0%)	1,177 (35.3%)				
>3 day	1,380 (62.4%)	2,140 (64.2%)	0.61	0.010	0.437	
Unknown	36 (1.6%)	16 (0.5%)				

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Table 4. Cont.

Variable	2010 N (%) N=2,211	2017 N (%) N=3,333	X-squared	φc	P_value	
Soft drink intake						
Not drink or ≤1 day	950 (43.0%)	1,331 (39.9%)				
>1 day	1,242 (56.2%)	1,984 (59.5%)	5.40	0.031	0.019	*
Unknown	19 (0.9%)	18 (0.5%)				
Smoking cigarette						
Not smoking	1,658 (75.0%)	2,680 (80.4%)				
Smoking	466 (21.1%)	545 (16.4%)	20.90	0.063	<0.001	***
Unknown	87 (3.9%)	108 (3.2%)				
Other tobacco products						
Not smoking	1,766 (79.9%)	2,874 (86.2%)				
Smoking	433 (19.6%)	441 (13.2%)	39.96	0.085	<0.001	***
Unknown	12 (0.5%)	18 (3.7%)				
Drinking alcohol						
Not drink	1,737 (78.6%)	2,759 (82.8%)				
Drinking alcohol	372 (16.8%)	451 (13.5%)	12.26	0.048	<0.001	***
Unknown	102 (4.6%)	123 (3.7%)				
Drinking alcohol ≥2 per day						
Not drink or ≤1 day	1,991 (90.0%)	3,117 (93.5%)				
Drinking alcohol ≥2 day	141 (6.4%)	160 (4.8%)	7.04	0.036	0.008	*
Unknown	79 (3.6%)	56 (1.7%)				
Physical activity						
≥5 days / week of 60 min	545 (24.6%)	1,068 (32.0%)				
≤4 days / week of 60 min	1,646 (74.4%)	2,224 (66.7%)	35.92	0.081	<0.001	***
Unknown	20 (0.9%)	41 (1.2%)				
Sedentary behavior						
Time sitting ≤2 hrs / day	1,565 (70.8%)	2,597 (77.9%)				
Time sitting ≥3 hrs / day	625 (28.3%)	682 (20.5%)	42.82	0.088	<0.001	***
Unknown	21 (0.9%)	54 (1.6%)				

Note. ∗p < 0.05, ∗∗p < 0.01, ∗∗∗p < 0.001

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Table 5.1 Logistic regression on health behaviors in 2010 and 2017 among adolescents in Tonga

Variables (Total)	2010 Total N=2,211 N (%)	2017 Total N=3,333 N (%)	Changes from 2010 to 2017 OR	95% CI	p-value	
Obesity and dietary behavior						
Overweight or obesity	776 (35%)	1,227 (37%)	1.00	0.98, 1.02	0.80	
Fruits <2 day	1,278 (58%)	1,605 (49%)	0.94	0.92, 0.95	<0.001	***
Vegetable <3 day	1,380 (63%)	2,140 (65%)	1.00	0.98, 1.02	>0.9	
Drink soft drink ≥1 day	1,242 (57%)	1,984 (60%)	1.02	1.00, 1.04	0.028	*
Tobacco and alcohol use						
Smoking cigarette	466 (22%)	545 (17%)	0.93	0.91, 0.96	<0.001	***
Smoking other tobacco products	433 (20%)	441 (13%)	0.92	0.89, 0.94	<0.001	***
Drinking alcohol in past month	372 (18%)	451 (14%)	0.93	0.91, 0.96	<0.001	***
Drinking alcohol ≥2 per day	141 (6.6%)	160 (4.9%)	0.91	0.87, 0.96	<0.001	***
Physical activity and time sitting						
≤4 days / week of 60 min	1,646 (75%)	2,224 (68%)	0.95	0.93, 0.97	<0.001	***
Time sitting 3 hrs or more /day	625 (29%)	682 (21%)	0.94	0.92, 0.96	<0.001	***

Note. ∗p < 0.05, ∗∗p < 0.01, ∗∗∗p < 0.001.

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Table 5.2 Logistic regression on health behaviors in 2010 and 2017 among adolescents in Tonga (age and gender controlled)

Variables (Total)	2010 Total N=2,212 N (%)	2017 Total N=3,333 N (%)	Changes from 2010 to 2017 OR	95% CI	p-value	
Obesity and dietary behavior						
Overweight or obesity	776 (35%)	1,227 (37%)	1.00	0.98, 1.02	>0.9	
Fruits <2 day	1,278 (58%)	1,605 (49%)	0.95	0.93, 0.96	<0.001	***
Vegetable <3 day	1,380 (63%)	2,140 (65%)	1.01	0.99, 1.02	0.400	
Drink soft drink ≥1 day	1,242 (57%)	1,984 (60%)	1.02	1.00, 1.04	0.018	*
Tobacco and alcohol use						
Smoking cigarette	466 (22%)	545 (17%)	0.95	0.93, 0.97	<0.001	***
Smoking other tobacco products	433 (20%)	441 (13%)	0.93	0.91, 0.95	<0.001	***
Drinking alcohol in past month	372 (18%)	451 (14%)	0.96	0.94, 0.98	<0.001	***
Drinking alcohol ≥2 per day	141 (6.6%)	160 (4.9%)	0.95	0.91, 0.98	<0.001	***
Physical activity and time sitting						
≤4 days / week of 60 min	1,646 (75%)	2,224 (68%)	0.95	0.93, 0.96	<0.001	***
Time sitting 3 hrs or more /day	625 (29%)	682 (21%)	0.94	0.92, 0.96	<0.001	***

Note. ∗p < 0.05, ∗∗p < 0.01, ∗∗∗p < 0.001. . All estimation controlled for age and gender.

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Table 6.1 Logistic Regression on Health behaviors in 2010 and 2017 among male students in Tonga

Variables (Male)	2010 Total N=1,006 N (%)	2017 Total N=1,520 N (%)	Changes from 2010 to 2017 OR	95% CI	p-value	
Obesity and dietary behavior						
Overweight or obesity	335 (33%)	463 (30%)	0.98	0.95, 1.01	0.10	
Fruits <2 day	600 (60%)	751 (50%)	0.93	0.91, 0.96	<0.001	***
Vegetable <3 day	650 (66%)	993 (66%)	0.98	0.95, 1.01	0.14	
Drink soft drink ≥1 day	548 (55%)	849 (56%)	1.01	0.99, 1.04	0.30	
Tobacco and alcohol use						
Smoking cigarette	197 (20%)	379 (26%)	1.03	0.99, 1.06	0.13	
Smoking other tobacco products	196 (20%)	330 (22%)	1.00	0.97, 1.04	>0.9	
Drinking alcohol in past month	173 (18%)	294 (20%)	1.00	0.96, 1.03	0.80	
Drinking alcohol ≥2 per day	75 (8%)	101 (7%)	0.95	0.90, 1.01	0.13	
Physical activity and time sitting						
≤4 days / week of 60 min	750 (75%)	980 (65%)	0.95	0.92, 0.97	<0.001	***
Time sitting 3 hrs or more /day	280 (28%)	335 (22%)	0.96	0.93, 0.99	0.012	*

Note. $*p < 0.05$, $**p < 0.01$, $***p < 0.001$.

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Table 6.2 Logistic Regression on Health behaviors in 2010 and 2017 among male students in Tonga (age controlled)

Variables (Male)	2010 Total N=1,006 N (%)	2017 Total N=1,520 N (%)	Changes from 2010 to 2017 OR	95% CI	p-value	
Obesity and dietary behavior						
Overweight or obesity	335 (33%)	463 (30%)	0.97	0.94, 0.99	0.008	**
Fruits <2 day	600 (60%)	751 (50%)	0.95	0.92, 0.97	<0.001	***
Vegetable <3 day	650 (66%)	993 (66%)	1.00	0.97, 1.02	0.70	
Drink soft drink ≥1 day	548 (55%)	849 (56%)	1.00	0.98, 1.03	0.70	
Tobacco and alcohol use						
Smoking cigarette	197 (20%)	379 (26%)	1.04	1.02, 1.07	0.002	**
Smoking other tobacco products	196 (20%)	330 (22%)	1.02	0.99, 1.05	0.20	
Drinking alcohol in past month	173 (18%)	294 (20%)	1.02	0.99, 1.05	0.20	
Drinking alcohol ≥2 per day	75 (8%)	101 (7%)	0.98	0.93, 1.02	0.30	
Physical activity and time sitting						
≤4 days / week of 60 min	750 (75%)	980 (65%)	0.93	0.91, 0.96	<0.001	***
Time sitting 3 hrs or more /day	280 (28%)	335 (22%)	0.96	0.93, 0.98	0.002	**

Note. $*p < 0.05$, $**p < 0.01$, $***p < 0.001$. All estimation controlled for age.

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Table 7.1 Logistic Regression on Health behaviors in 2010 and 2017 among female students in Tonga

Variables (Female)	2010 Total N=1,186 N (%)	2017 Total N=1,792 N (%)	Changes from 2010 to 2017 OR	95% CI	p-value	
Obesity and dietary behavior						
Overweight or obesity	441 (37%)	764 (43%)	1.03	1.00, 1.05	0.041	
Fruits <2 day	667 (57%)	845 (48%)	0.94	0.92, 0.96	<0.001	***
Vegetable <3 day	716 (61%)	1,133 (64%)	1.02	0.99, 1.04	0.20	
Drink soft drink ≥1 day	682 (58%)	1,123 (63%)	1.03	1.00, 1.06	0.023	*
Tobacco and alcohol use						
Smoking cigarette	262 (23%)	161 (9.2%)	0.82	0.79, 0.86	<0.001	***
Smoking other tobacco products	230 (19%)	106 (5.9%)	0.79	0.75, 0.83	<0.001	***
Drinking alcohol in past month	196 (17%)	153 (8.8%)	0.85	0.81, 0.89	<0.001	***
Drinking alcohol ≥2 per day	66 (6%)	58 (3%)	0.85	0.78, 0.91	<0.001	***
Physical activity and time sitting						
≤4 days / week of 60 min	883 (75%)	1,229 (69%)	0.95	0.92, 0.98	<0.001	***
Time sitting 3 hrs or more /day	340 (29%)	344 (19%)	0.92	0.89, 0.95	<0.001	***

Note. *p < 0.05, **p < 0.01, ***p < 0.001.

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Table 7.2 Logistic Regression on Health behaviors in 2010 and 2017 among female students in Tonga (age controlled)

Variables (Female)	2010 Total N=1,186 N (%)	2017 Total N=1,792 N (%)	Changes from 2010 to 2017 OR	95% CI	p-value	
Obesity and dietary behavior						
Overweight or obesity	441 (37%)	764 (43%)	1.03	1.00, 1.05	0.018	*
Fruits <2 day	667 (57%)	845 (48%)	0.95	0.93, 0.97	<0.001	***
Vegetable <3 day	716 (61%)	1,133 (64%)	1.02	1.00, 1.04	0.70	
Drink soft drink ≥1 day	682 (58%)	1,123 (63%)	1.03	1.01, 1.05	0.005	**
Tobacco and alcohol use						
Smoking cigarette	262 (23%)	161 (9.2%)	0.85	0.82, 0.87	<0.001	***
Smoking other tobacco products	230 (19%)	106 (5.9%)	0.82	0.79, 0.85	<0.001	***
Drinking alcohol in past month	196 (17%)	153 (8.8%)	0.88	0.85, 0.91	<0.001	***
Drinking alcohol ≥2 per day	66 (6%)	58 (3%)	0.90	0.85, 0.95	<0.001	***
Physical activity and time sitting						
≤4 days / week of 60 min	883 (75%)	1,229 (69%)	0.96	0.94, 0.98	<0.001	***
Time sitting 3 hrs or more /day	340 (29%)	344 (19%)	0.93	0.90, 0.95	<0.001	***

Note. $*p < 0.05$, $**p < 0.01$, $***p < 0.001$. All estimation controlled for age.

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Chapter 5
Discussion

5.1 Discussion

According to this study, the overall prevalence of obesity or overweight among Tongan adolescents increased slightly from 35% in 2010 to 37% in 2017, but the difference was not significant. By gender, the prevalence of obesity or overweight among male adolescents decreased from 33% in 2010 to 30% in 2017, this was a significant difference. In contrast, the prevalence of obesity or overweight among female adolescents increased significantly from 37% in 2010 to 43% in 2017. Regarding dietary habits, a significant increase in fruit intake was suggested by the decrease in the consumption of fruit two times a day or less. However, there was an increasing trend in vegetable intake less than three times a day and soft drink consumption once a day or more, although it was not significant.

Additionally, the smoking rate among Tongan adolescents significantly decreased from 22% in 2010 to 17% in 2017. Alcohol consumption also significantly decreased from 18% in 2010 to 14% in 2017. These decreasing trends in smoking and alcohol consumption were particularly strong among females. Furthermore, the proportion of adolescents engaging in low-frequency physical activity (four days a week or less) significantly decreased from 75% in 2010 to 68% in 2017. The proportion of adolescents sitting for more than three hours a day also significantly decreased from 29% to 21%.

These results indicated that health behaviors among Tongan adolescents experienced several significant changes between 2010 and 2017. In particular, the decrease in smoking rates and increase in physical activity may suggest the success of the national NCD strategy. However, the increase in the prevalence of obesity or overweight, especially among female adolescents, suggests the need for further attention and intervention in future health policies.

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5.1.1 Eating habits

Previous research has suggested an improvement in health behaviors among adolescents in low- and middle-income countries where health policies have been implemented. Studies utilizing the GSHS have investigated the impact of dietary habits and health policies, examining how the presence of fruit and vegetable policies and socio-environmental factors play a role in adolescent intake. Research across 24 low- and middle-income countries showed a positive correlation between the presence of fruit and vegetable policies and appropriate consumption (Darfour et al., 2019). Additionally, it has been suggested that in high-income countries, increasing the prices of unhealthy and obesity-prone foods can improve health outcomes such as national weight averages and chronic disease risks (Thow et al., 2010).

In Tonga, the Food Act of 2014, which was implemented in August 2013, primarily aimed at promoting healthy foods by reducing taxes on fresh fish, vegetable oil, and canned fish, while increasing taxes on lard and soft drinks. In 2016, additional tax increases on fatty meats and tax reductions on vegetables (onions and potatoes) were implemented. This study found a slight but significant improvement in fruit intake among adolescents, no substantial improvement in vegetable intake, and a slight increase in soft drink consumption. The findings suggest that Tonga's policy might have focused more on taxing unhealthy imported foods rather than adjusting prices to promote the consumption of fruits and vegetables, resulting in a minimal impact on healthy behaviors among adolescents. Additionally, a report investigating the impact of Tonga's Food policy indicated that when the price of mutton flaps, a meat product commonly consumed in homes, increased due to taxation, people tended to shift consumption towards cheaper alternatives like salted beef (The World Bank, 2019). This suggests that even raising the price of specific unhealthy foods may not lead to healthier dietary improvements at home due to a consumption shift to other readily available unhealthy food options.

Furthermore, the implementation of this policy, which began in 2014 as part of the latter half of the NCD strategy, and the initiation of tax reductions on vegetables and tax

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increases on fatty meats not starting until 2016, suggests that the GSHS survey may have been conducted before the policy's effects could be fully realized.

As part of the NCD strategy's efforts to improve dietary habits, community-level vegetable garden initiatives and educational activities to promote vegetable and fruit intake were conducted in primary schools (TongaHealth, 2015). While these initiatives could have improved adolescents' knowledge of nutrition and healthy eating habits, there were no findings on the evaluation of the effectiveness or details of these activities. Additionally, as parents typically manage household finances and choose food purchases, adolescents might have limited opportunities to choose and consume vegetables and fruits, even if they recognize their importance. Thus, even if adolescents receive education on healthy eating habits, the impact on their vegetable and fruit consumption behavior may be limited if parents lack knowledge and health beliefs about healthy eating and nutrition. A study in 2021 indicated that parents' and family's eating habits greatly influence children's dietary patterns, with breakfast habits and snacking also shaped by parents' behaviors and attitudes (Lubna et al., 2021). Therefore, interventions in educating parents on healthy eating and adjusting prices for healthy foods and ingredients may become increasingly important for the healthy improvement of adolescents' dietary habits.

5.1.2 Tobacco consumption

The trend in smoking among Tongan youth overall shows a significant decrease, with smoking rates dropping from 22% in 2010 to 17% in 2017, and for other tobacco products (including local tobacco), a decline from 20% to 13%. However, there is a stark difference in the trends between males and females. For cigarette smoking, the rate for boys increased from 20% in 2010 to 26% in 2017. In contrast, for girls, the smoking rate for cigarettes dramatically decreased from 23% in 2010 to 9.2% in 2017, and for other tobacco products from 19% to 5.9%. These results indicate that despite a slight increase in smoking rates among boys, the overall smoking rate has decreased significantly due to the substantial reduction among girls.

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In terms of smoking prevention efforts at the policy level, a price increase was implemented by raising tobacco taxes. As a result of this policy, the price of a pack of cigarettes went up from USD 2.9 to USD 3.27 by 2016 (The World Bank, 2019). However, according to a study by the World Bank on the effect of Tonga's tax increase on tobacco purchasing, while some smokers quit due to the increased prices of imported cigarettes, many continued smoking by switching to cheaper alternatives, such as local tobacco. Additionally, community-level initiatives have been put in place to restrict smoking areas, and at the individual level, services to support quitting smoking, led by specially trained nurses, have been implemented in hospitals.

In the smoking prevention efforts implemented in Tonga, there were no records of gender-specific approaches being carried out, as per the reports. However, in the advertising strategies using mass media for tobacco prevention, the commercials adopted contained messages emphasizing the impact of secondhand smoke on families and children. With a national television penetration rate of about 77% in 2011 (Tonga Statistics Department, 2014), it is likely that these anti-smoking advertisements had ample opportunity to be seen by the public. Moreover, it is conceivable that commercials highlighting the effects of smoking on families and children could have been particularly effective for women of childbearing age and adolescent girls who may experience pregnancy in the future.

Additionally, Tonga's unique religious and cultural background can be cited. In a paper that reviewed data on the smoking behavior and cultural background of men and women in groups from Western regions, Asia, Africa, the Pacific Islands, and Latin America, it was reported that in Western regions, men are more likely to quit smoking than women, but in non-Western regions, women are more inclined to quit. Furthermore, in Tonga, not only is the quit rate higher among women than men, but it is also noted that, unlike other regions, religious reasons contribute to the decision to quit smoking (Waldron et al., 1988). In a smoking survey conducted in Tonga in 1982, 43% of the men and women with smoking experience who participated in the survey cited religious reasons for quitting. Additionally, quitting due to pregnancy was the second most frequently mentioned reason

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(Finau et al., 1982). Therefore, it is possible that women are more likely to quit smoking due to involvement in religious activities.

5.1.3 Alcohol consumption

The overall rate of alcohol consumption has shown a significant decrease, from 18% in 2010 to 14%. However, when looking at the data by gender, the rate for males slightly increased from 18% in 2010 to 20% in 2017, and the proportion of those consuming more than two drinks per day decreased marginally from 8% to 7%, with neither result representing a significant decline. On the other hand, for females, the drinking rate significantly decreased from 17% in 2010 to 8.8%, and the proportion of those consuming more than two drinks per day also significantly halved from 6% to 3%. Despite no significant decrease in the drinking rate among males, the substantial decrease among females has contributed to the overall reduction in alcohol consumption, similar to the trend observed in smoking rates.

As part of the NCDs strategy related to drinking, the Tongan government has implemented measures such as increasing the price of alcoholic beverages and restricting the opening hours of stores that sell alcohol. Additionally, as a policy targeting youth, the legal drinking age was raised from 18 to 21 years in 2013. Following these measures, the selling price of beer, the most consumed alcohol in Tonga, increased by 16% for imported beers and 12% for locally produced beers. There have been reports that this price increase led to a reduction in the proportion of people who drink more than 15 glasses per week from 34% to about 25%, although this result is from a survey targeting adults (The World Bank, 2019). No surveys other than the GSHS were found regarding the trends in youth drinking after the implementation of the NCDs strategy.

In this survey, a clear gender difference was observed in the health behaviors of adolescents, with smoking and drinking behaviors standing out. Females showed a significant decreasing trend in both behaviors, whereas males exhibited an increasing trend, although none of the changes were statistically significant

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5.1.4 Physical Activity

Physical inactivity has shown a decreasing trend among both male and female adolescents. Overall, the proportion of individuals engaging in 60 minutes of physical activity less than four days per week decreased significantly from 75% in 2010 to 68% in 2017. Sedentary behavior of sitting for more than three hours per day also significantly decreased from 29% to 21%. By gender, the proportion of males engaging in 60 minutes of physical activity less than four days per week significantly reduced from 75% to 65%, and sedentary behavior decreased from 28% to 22%. For females, the proportion decreased significantly from 75% to 69% for physical activity, and from 29% to 19% for sedentary behavior. After the implementation of measures in 2017, physical activity increased for both genders.

As for the measures related to physical activity, it is believed that a significant impact was made by changes to the physical education curriculum in schools. Traditionally, physical education and sports were not established as subjects within the school education system. The NCDs strategy brought about an increase in adolescent physical activity through the implementation of physical education and sports in schools (TongaHealth, 2015). In the 2010s, without trained physical education teachers in Tonga, the Ministry of Education's Movement & Fitness department collaborated with sports associations to train instructors who then provided physical education classes in primary schools. Concurrently, current teachers received about a week of training in sports instruction. Furthermore, at institutions that train teachers in Tonga, learning physical education methodology became a requirement for obtaining a teaching license. Additionally, with the revision of the School Education Act in 2013, a 'Social Science & Health' curriculum was introduced for fourth-grade students in Tonga, which included health education promoting healthy eating (Reiri Takeuchi et al., 2016).

Within the long-term framework for achieving Tonga's educational objectives from 2004 to 2019, sports are considered important for improving student health. However, the focus for current teachers has been more on identifying youths with high athletic ability and channeling students with talent into the national elite athlete development process rather

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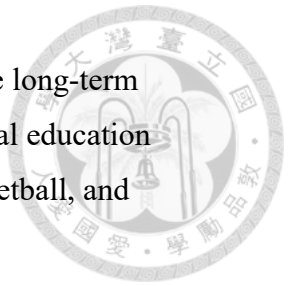

than enhancing their ability to teach physical education. Furthermore, the long-term framework recommends the inclusion of sports in primary school physical education curricula that are internationally competitive for Tonga, such as rugby, netball, and throwing events like javelin (Ministry of Education, 2004).

In particular, rugby is considered the national sport of Tonga, and despite being a small nation, Tonga's international competitiveness in rugby is on par with developed countries, making it a sport of intense national interest. From 2017 to 2019, in the lead-up to the Rugby World Cup, Tonga utilized the growing excitement for the event. With financial aid from the Australian and New Zealand governments, rugby league was introduced as an educational tool during physical education classes in primary schools nationwide, alongside lessons on rugby to promote a healthy lifestyle, dietary habits, and physical activity (Joanna Leste, 2017). This indicates that the implementation of physical education in schools tends to be concentrated on specific sports disciplines.

Further research studies considering the formation of optimal exercise programs in Tonga indicate that due to the tropical climate, outdoor exercise during the day is not preferred by Tongan. Such climatic conditions make it challenging to maintain motivation and continuity in individual activities such as walking. As a result, team sports that are played indoors or under shelter with specific equipment and multiple participants are preferred (Mori, 2019). Thus, team sports and group physical activities are considered important for the long-term continuation of physical activity among the people of Tonga.

Furthermore, in promoting physical activity, there was a particular demand for programs targeting women. The 2004 STEP survey indicated that 92% of women aged between 15 to 64 years engaged in no vigorous physical activity at all (WHO & Tonga Ministry of Health, 2012). Moreover, the situation was such that women had more limited opportunities for participation in sports and physical activities compared to men (Turk et al., 2013).

Therefore, the Kau Mai Tonga (KMT) program, implemented from 2012 to 2015, which promoted physical activity among women through netball, was successful in achieving behavioral change regarding women's participation in sports, and many studies

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have been conducted on it. According to research by Turk and colleagues, in the first year of the KMT program, 58% of the women participants aged between 15 to 45 years reported engaging in some physical activity during the week, and 33% reported exercising for more than 30 minutes at least three times a week, which is the recommended level of activity. Furthermore, 90% of the women who participated in the program expressed a desire to continue exercising regularly (Turk et al., 2014). The participation of women in sports has expanded dramatically through the KMT program. Thus, it is believed that this program has influenced the improvement of physical activity among adolescent girls observed in this study.

In the formation phase of this KMT program, interviews were conducted with the target group to identify barriers to women's physical activity. The results pointed to cultural factors limiting participation in sports activities, entrenched gender roles, and reduced opportunities to earn income (Tahir et al., 2014). To promote the added value of exercise, campaigns utilizing two models were implemented. One was a campaign that highlighted women's sports role models using the social learning theory (Bandura, 1969), and the other utilized elements of the health belief model (Janz, 1984) to highlight the risk of NCDs arising from insufficient exercise. These mass media campaigns, conducted over a period of six weeks each year, placed emphasis on messages calling for women and female adolescents to actively participate in physical activity and highlighting the health risks associated with a lack of exercise (Schulenkorf et al., 2022).

Reports related to KMT suggest that its activities and the messages conveyed through mass media may have contributed to an increase in vegetable consumption among women and a decrease in the consumption of soft drinks, tobacco, and alcohol (Australian Government et al., n.d.). Thus, by allocating leisure time to sports participation, it may be possible to expect a reduction in the risk of tobacco, alcohol, and drug use among adolescents. Various studies have been conducted on the relationship between participation in sports and substance use. A review of 34 studies conducted at the high school and college sports level indicated that participation in sports was especially related to an increase in alcohol consumption, but was associated with a decrease in smoking and illegal

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drug use. Researchers have suggested that this relationship may vary depending on the competitive nature of the sport and gender (Lisha & Sussman, 2010). A Canadian study in 2019 reported that participation in team sports among female adolescents could increase the risk of substance use, especially alcohol and drug use (Lau et al., 2019). Thus, participation in sports does not necessarily contribute to a reduction in the risk behaviors of smoking and drinking, and it has been reported that it may actually increase the risk of drinking. However, as previously mentioned in KMT, interventions focused on the employment of active role models to promote participation in sports based on the Social learning theory and the Health belief model, and messages that raise awareness of health risks, were implemented. By strategically incorporating behavior change models into sports programs, it may have contributed to the participants' awareness of health risks, increased consciousness of a healthy lifestyle, and a reduction in risk behaviors. Moreover, KMT reports indicated that participants who were aware of and knowledgeable about health risks were more likely to engage in physical activities. This suggests that participation in sports may have been promoted not by reducing risk behaviors but by raising awareness of the dangers of health-risk behaviors. Learning about the risks of physical inactivity has been shown to be an important step in increasing long-term physical activity.

What is particularly interesting about the outcomes of the KMT program is the shift in mindset among women who traditionally valued the role of women as homemakers and caregivers. Post-participation in KMT, 80% of women recognized the importance of engaging in sports, indicating a significant change in attitude(Tahir et al., 2014). This shift was not only observed in the women themselves but also in the attitudes of their husbands, family members, and church members who share similar traditional views. It was reported that during tournament periods, support was provided not only from the family but also from the church and community members to allow the women to concentrate on the games. This support included assisting with team practices, taking care of the women's children during practice, transportation to game venues, and providing food and drinks (Australian Government et al., n.d.).

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In KMT, community tournaments lasting between six to ten weeks were held two to three times a year (Justin et al., 2016). The structure of these community tournaments may have further encouraged support from families and community members for women's participation in sports. In Tonga, values are shared through weekly church meetings, religious events, and kava clubs, which are attended only by men several times a week, fostering strong bonds among members. The Tongan value of "Ofa fai he feohi," which represents a Bonding Love — an expression denoting a bond beyond that of brothers or sisters and symbolizing a lifelong unbreakable bond, is prevalent (Malakai et al., 2020). There is a strong sense of unity among community members, with deep affection and pride for their region. Hence, the community tournaments likely stimulated a sense of belonging and pride within their own community among the members, increasing the excitement of the matches and potentially overriding the traditional values that discouraged women's participation in sports. By involving the community in the program, understanding and support for women's participation in sports advanced, leading to a significant increase in the number of registered teams. From only 27 teams prior to KMT, the number of registered teams grew to 370, with over 3,000 women signing up to participate in netball tournaments through KMT (Australian Government et al., n.d.).

On the other hand, there still exists a prevailing attitude in Tonga that frowns upon women participating in intense sports. In 2018, Tonga's Minister of Education expressed the opinion that the practice of rugby and boxing by schoolgirls should be banned as it goes against Tongan culture and traditions. The Prime Minister opposed this view, stating that sports should be accessible to all genders, but on March 15, 2018, the Ministry of Education officially issued a letter to Tongan high schools enforcing a ban on girls practicing rugby and boxing in public schools (Don, 2018), (Pacific Waves, 2018). The presence of such entrenched traditional values that discourage women's participation in sports and a governance system where policies are determined based on these values rather than evidence-based measures acts as a barrier to women's involvement in sports. The opportunity for physical activity in schools, where adolescents spend much of their time, is

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of paramount importance, and there is a need for the establishment of appropriate policies based on evidence.

5.1.5 Cultural difference lifestyle between men and women

Cultural differences between men and women in Tonga may contribute to the gender disparities in smoking and drinking behaviors. A concept known as "traditional brother-sister avoidance" exists within Tongan families, which views any sexual contact between siblings as a cultural taboo. The aim is to maintain propriety within the family by enforcing this separation. This results in the recommended separation of adolescent boys and girls in all aspects of daily life, including sleeping arrangements, and even prohibits them from discussing sexual topics or watching television together. As such, once boys surpass the age of 10, they are expected to sleep separately from their unmarried sisters. Girls typically reside in modern homes with their parents or grandparents, while boys live in separate, traditional Tongan huts and are required to sleep there. Men are allowed to live with their parents in the maternal home once they are married (Futa, 1995), (Hiromi Otani, 1975).

Due to the "traditional brother-sister avoidance" practice, while female adolescents live constantly with their guardians, male adolescents live away from their guardians' watchful eyes. As a result, it may be easier for male adolescents, who are less supervised, to start and continue smoking and drinking behaviors. Additionally, since men return to live with their families in the maternal home upon marriage, particularly boys from the age of 10 until marriage are less influenced by other family members, which might make it easier for male adolescents to engage in smoking and drinking compared to their female counterparts.

Furthermore, there is a male-specific cultural tradition in Tonga known as the kava club. Kava is a Pacific traditional drink made by dissolving the powdered root of a non-toxic variety of pepper plant in water. The culture of drinking kava is widespread across Oceania (Malakai et al., 2020). Tonga has one of the highest consumptions of kava in the region, with two-thirds of men having experienced drinking kava at some point in their

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lives, while less than 1% of women have done so. The consumption of kava averages about two to three times a week (Pacific Research & Development Services, 2004). Kava is typically consumed at community gatherings such as kava clubs, as well as at religious meetings in churches and community events like weddings. Participation in kava sessions is not only culturally significant for men but also essential for building their social status and political involvement within the community, as community leaders and elders discuss regional politics and decision-making at these kava gatherings.

Additionally, since kava clubs often operate from late at night until morning, men spend less time with their families (Malakai et al., 2020). Therefore, the participation of adolescent boys in these kava clubs may lead to reduced family time. It is assumed that the boys may be susceptible to the influence of the adult men in the community who participate in the kava clubs. Research suggests that especially during adolescence, boys are susceptible to peer influence (Sumter et al., 2009). Thus, it is possible that the health behaviors of adults in the community have a significant impact on the health behaviors of boys and young men. If adults frequently drink and smoke in kava clubs, boys and young men can be influenced by these negative health behaviors, however, there is also a great potential for them to be influenced by better lifestyle influences and preaching from the adults through kava clubs.

Given Tonga's unique cultural background, the lifestyles of adolescent boys and girls differ significantly. Particularly during the period when NCDs strategies were implemented, girls may have had reduced proximity to drinking and smoking by spending their leisure time participating in the KMT program. Further research is required to explore the differences in cultural lifestyles and their impact on health behaviors. Moreover, the creation of health intervention programs for Tongan adolescents that consider such cultural characteristics is desirable.

5.1.6 Obesity and overweight

In this study, there were no significant changes in the rates of overweight and obesity among adolescents, with a slight increase from 35% in 2010 to 37% in 2017. When

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analyzed by gender, the rate for boys slightly decreased from 33% to 30%, and for girls, it increased from 37% to 43%, but neither change was significant. However, girls tended to have a higher prevalence of overweight and obesity than boys.

As risk factors for obesity and overweight, a sedentary lifestyle, the intake of multiple servings of high-energy and nutrient-poor foods, excessive marketing of unhealthy foods, consumption of sugary drinks and juices, and socio-economic disadvantages were identified (Swinburn et al., 2004). To combat obesity and weight gain, various interventions aimed at promoting healthy eating behaviors and increasing physical activity were implemented as part of the NCDs strategy. Between 2010 and 2017, there was a significant increase in fruit consumption, while the intake of vegetables and sugary drinks showed little significant change. It was also shown that physical activity frequency increased significantly for both genders during this period. Despite these positive changes towards a healthier lifestyle, including increased intake of fruits and frequency of physical activity, there was little change in obesity and overweight rates. This result suggests that the intervention implemented may not have been sufficient or that other contributing factors, such as the intake of high-energy, nutrient-poor foods and socio-economic conditions, had a more substantial impact than the positive changes.

In the GSHS conducted in Tonga, this study focused on the comparison and analysis of common variables between 2010 and 2017, such as the intake of vegetables and fruits and the consumption of sugary drinks. However, the 2017 GSHS included more detailed questions on risk and protective behaviors than in 2010. Specifically, these included the frequency of purchasing breakfast at school canteens, bringing lunch from home, frequency of consuming high-salt and high-fat meals, exposure to sugary drinks and fast-food advertising, how often they watched health programs on TV or listened to the radio provided by the Ministry of Health, and the extent of diet restriction and exercise for weight loss.

Among the key findings, 66% of adolescents reported purchasing lunch at school canteens, 54% consumed high-salt meals at least two days within a 30-day period, 27%

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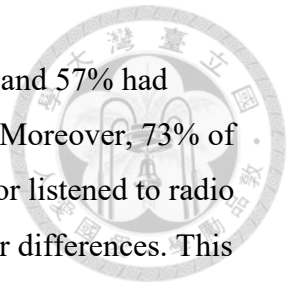

were exposed to sugary drinks and fast-food advertising on TV or radio, and 57% had engaged in diet restriction or exercise to lose weight in the past 30 days. Moreover, 73% of adolescents reported having watched health-related television programs or listened to radio broadcasts provided by the Ministry of Health, with no significant gender differences. This suggests that despite differences in lifestyles by gender in Tonga, many adolescents have access to health and health risk messages provided by the Ministry of Health.

Tongan culture traditionally values larger body sizes. A 2013 survey reported that Tongan adolescents, both male and female, are more likely to respect and value larger-bodied men and women compared to those in Australia and other Pacific nations like Fiji (McCabe et al., 2013). However, the 2017 GSHS results also indicated that more than half of the adolescents, 57%, were taking action towards weight loss through diet restriction and exercise, suggesting a high level of interest in weight loss among the youth. Therefore, considering the use of television and radio to disseminate effective health communication strategies about the health risks of obesity and overweight, healthy eating habits, and prevention of excessive dieting may be one effective method to increase health interest and improve health behavior awareness among adolescents.

Interventions for weight loss in Tonga included the "Tonga Healthy Weight Loss Competition" held from 1995 to 1997 for adults aged 18 and over, competing for weight loss based on BMI. This competition was held over a period of six months, with a total of three competitions held over two years and a total of 3,429 participants. Exercises to aid weight loss and healthy cooking were also conducted. More than 50% of participants achieved some weight loss through the competition, indicating certain successes. However, many challenges remained, such as the loss of motivation for weight loss among many participants, leading to dropout. Surveys indicated that participants lost motivation and dropped out of the competition due to slow weight loss progress, no change, or even weight gain. A follow-up survey of 140 participants after the competition revealed that 38% had returned to their original weight and 30% had gained more weight (Englberger et al., 1999).

As evidenced by the cases described, focusing solely on the numerical increase or decrease in weight as a measure of success in intervention programs aimed at weight loss

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among adolescents may lead to fluctuations in motivation and not necessarily encourage a transition to a long-term healthy lifestyle. The issues of obesity and overweight are influenced not only by eating and exercise habits but also by a broader set of factors, necessitating a comprehensive approach that includes the adolescent's living environment, social elements, and policy measures.

The school environment, where adolescents spend a considerable amount of their time, is particularly crucial. Interventions in schools, such as regular health checks (measuring height, weight, and blood pressure) recorded as part of school events, can effectively encourage students to take an interest in their health status. This, in turn, provides them with opportunities to learn about their bodies and understand the importance of health education. Moreover, implementing policies that limit the sale of high-calorie, nutrient-poor foods and sugary beverages in school canteens is another essential measure.

At the community level, implementing programs that promote physical activity through sports and group activities appropriate to Tongan culture, along with providing nutrition education, could be considered. As demonstrated by the success of the Kau Mai Tonga program, promoting initiatives that involve the entire community, including parents, community leaders, and religious figures, and that are based on behavior change models, can contribute to maintaining a healthy lifestyle among adolescents.

The impact of these policies and programs must be carefully evaluated to understand how they influence adolescent health awareness and behavior change. Consequently, it is crucial to assess whether these efforts lead to sustainable health promotion methods and to make necessary improvements if the effects are insufficient.

5.1.7 Effect of Health Interventions and Policies

As mentioned earlier, a number of health policies have been implemented in Tonga between 2010 and 2015. Such health policies and interventions have been implemented in many countries such as OECD (Organization for Economic Co-operation and Development) countries in recent years and their effectiveness has been debated. According to the OECD framework for health policy and intervention, there are classified into three

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areas. The first involves policies that influence lifestyle changes through information and education, such as food labeling. The second includes incorporating health programs into school curricula and workplaces. The third comprises policies that increase healthy choices in daily life, along with efforts to restrain unhealthy behaviors through restrictions and regulations on food advertising (OECD, 2019).

As mentioned in the previous section, obesity and unhealthy lifestyles have multifaceted causes. Therefore, addressing them through multiple approaches is crucial, as suggested by the OECD report. What is interesting is the high synergy observed by combining interventions and policies, allowing simultaneous approaches to different population groups, such as youth and workers. For instance, initiatives that simultaneously implement information dissemination and education about food through mass media and institutionalize food labeling have been highlighted for their potential effectiveness (Surkan et al., 2016).

Particularly effective combinations are those incorporating efforts to raise public awareness of health, such as packages that include food labeling, advertising regulations, and media campaigns. These packages are estimated to prevent 3 million cases of cardiovascular disease and 84, 400 cases of diabetes in the OECD (OECD, 2019). Thus, intentionally combining intervention strategies is suggested to yield greater health benefits for the population.

On the other hand, in Tonga's health policies, various interventions, including those related to diet, physical activity, and the control of tobacco and alcohol, were implemented simultaneously. However, as indicated in this study, a decrease in overweight and obesity among adolescents was not satisfactory achieved, and further, in adults, the mean BMI in both sex increased from 33.1% to 35.1% between 2012 and 2017 (WHO & Tonga Ministry of Health, 2012, 2017).

One possible cause could be the limited human resources and budget in Tonga, leading to the necessity of prioritizing interventions based on their importance. In fact, during my stay in Tonga from 2012 to 2014, there were active efforts to increase physical activity through aerobics, unlike the KMT initiative. One such initiative involved

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promoting aerobics across various regions of Tonga through instructor-led sessions and providing training program to young villagers to become instructors in their villages. Despite allocating budget and human resources, almost villages experienced a decline in participant attendance over time, leading to the eventual suspension of the initiative. It is speculated that the need for prioritization based on limited resources and budget constraints may have contributed to the challenges faced in achieving the desired outcomes.

Furthermore, to achieve synergistic effects through the combination of various interventions, appropriate coordination and collaboration across sectors are deemed necessary. However, in Tonga, the NCDs strategy faced challenges in aligning efforts because different interventions were initiated by various entities, including the Tongan government agencies, UN agencies, and donor countries. The major donors in Tonga include AusAID, WHO, Japan International Cooperation Agency (JICA), and New Zealand Agency for International Development (NZAID). For example, AusAID mainly supported the dissemination of KMT and media campaigns, WHO conducted monitoring of NCDs through GSHS and STEP surveys, and formulating the Tongan NCDs strategy fundamentally, JICA implemented the construction of a large hospital in the capital and the training of nurses and teachers at primary schools with an understanding of NCDs.

The need for multiple donors is influenced by Tonga's healthcare financial situation. The Tongan government's healthcare budget faces significant constraints. For instance, in 2005/06, health expenditure for NCDs prevention in Tonga accounted for only 1.6% of the overall health budget, making it challenging to achieve NCDs strategies without support from international agencies and donor countries. In 2005/06, assistance from these donors constituted 30% of the total healthcare financing (UNDP, 2013). Therefore, receiving support from these major donors is crucial given Tonga's financial constraints. However, the structure makes it difficult for Tonga, as the recipient of funding in various areas where each donor takes the initiative, to have leadership and coordinate the overall effort effectively.

Thus, to implement a more effective health strategy, it is crucial to understand the limitations in Tonga's human resources and financial capabilities. Focusing on

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interventions that contribute to raising public health awareness while taking into account these constraints and concentrating efforts on selected areas becomes essential. Additionally, fostering collaboration among donors, leveraging their respective strengths while coordinating efforts, is deemed crucial for achieving higher goals in supporting Tonga.

5.2 Limitations

This study suggests a potential correlation with the implementation effects of Tonga's national strategy on non-communicable diseases (NCDs) but does not directly prove causality. The reliance on self-reported data may introduce biases due to subjective reporting. Inadequate consideration of Tonga's unique cultural and societal context might lead to an oversight of factors influencing adolescent health behaviors.

There's insufficient data on the geographical distribution of surveyed schools, with no specifics for 2017, unlike in 2010 when 24 schools, including 10 from remote islands, were reported. This discrepancy raises the possibility of bias due to regional differences. Furthermore, there is a lack of detailed records on the initiatives at the community, school, and church levels related to the national strategy, constraining the evaluation of their impact on adolescents' health behaviors.

Key policies like the Food Act and taxation on tobacco and alcohol, significant for assessing the NCDs strategy's effectiveness, were enacted late in the strategy period (2014-2015), potentially limiting the full assessment of their impact on adolescent behaviors by the 2017 GSHS survey. These limitations suggest a need for a cautious approach in interpreting the results presented by this study regarding the impact of national strategies on Tongan youth. Further research is needed to generalize the findings to other regions or contexts. Future research calls for broader data collection, consideration of diverse cultural backgrounds, and transparent reporting to clarify regional differences.

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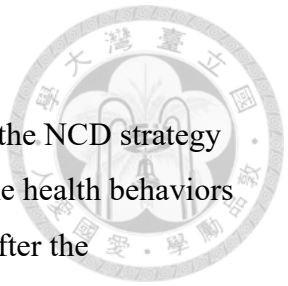

5.3 Conclusion

In Tonga, the risk of NCDs is increasing, and interventions from the NCD strategy implemented from 2010 to 2015 were examined. This study compared the health behaviors of school-aged adolescents in 2010 before the intervention and in 2017 after the intervention to analyze the impact of the policy. The results showed certain positive changes in adolescents' health behaviors. Specifically, the frequency of fruit consumption and physical activity levels increased, and alcohol and tobacco use among female adolescents significantly decreased.

The main outcome was the change in physical activity levels, with both male and female adolescents showing a decrease in sedentary behavior and a notable increase in physical activity frequency. These changes are partly attributed to regional initiatives like the integration of sports into the school curriculum through the NCD strategy and the "Kau Mai Tonga" program, which significantly improved women's participation in sports. These efforts contributed to a cultural shift in attitudes towards sports, especially among women, and fostered a supportive environment for sustained physical activity among the youth.

While positive changes in health behaviors were observed, there was no change in obesity and overweight issues, highlighting ongoing challenges in addressing adolescent obesity. The study suggests that a comprehensive approach considering sociocultural factors, policy formulation, and continuity of health promotion strategies is essential for more impactful results.

The study's limitations include reliance on self-reported data that could introduce bias and a lack of insight into the cultural and social dynamics affecting health behaviors. Future research should delve deeper into these aspects and focus on evaluating the long-term sustainability of current interventions. Additionally, policies and programs adaptable to Tonga's unique cultural and socioeconomic context are needed, ensuring health promotion strategies are comprehensive and effective for all population segments, including adolescents.

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