The power to choose: proximal determinants of access to nutritious food in the Pacific region

Penny Farrell

A thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

School of Public Health
Faculty of Medicine

The University of Sydney

2019
Statement of originality

This is to certify that to the best of my knowledge, the content of this thesis is my own work. This thesis has not been submitted for any degree or other purposes.

I certify that the intellectual content of this thesis is the product of my own work and that all the assistance received in preparing this thesis and sources have been acknowledged.

Penny Farrell
Abstract

Background
Pacific Island Countries and Territories are experiencing a crisis of high and rising diet-related health conditions, whose impact is exacerbated by a lack of health system capacity to treat them. However there is a severe paucity of data in the Pacific region on what is influencing, and thus how to improve, access to a healthy and nutritious diet (otherwise defined as food and nutrition security). This research gap is a roadblock to efforts to develop effective policies and regulatory frameworks to improve national and regional food systems. Without progress in the Pacific, it is also not possible to solve the challenge at a global level – in particular in relation to achieving Sustainable Development Goal 2, which is to end hunger, achieve food security and improved nutrition and promote sustainable agriculture.

The primary aim of this thesis is to identify factors within people’s immediate food environment which affect access to healthy and nutritious food, with the intention of providing practical insight for policy makers to tailor policies and programs to improve food and nutrition security, and in turn diets.

Methods

Three main methodological approaches were used. First, a realist systematic review was performed to identify the key mechanisms in the relationship between food insecurity and obesity. This study explored the concept of food access using both the food security measurement paradigm and Freedman et al.’s multicomponent model of nutritious food access.

The second and third approaches involved empirical research in Samoa and Solomon Islands. The second approach was multivariate analysis of large national datasets to study the dietary consumption patterns of different socio-demographic groups. The datasets were from the most recent available large nationally representative databases: the Demographic and Health Survey (DHS) dataset from Samoa and the Household Income and Expenditure Survey dataset from Solomon Islands. The analytical methodology was based on established methods for
performing and interpreting multivariate analysis. Analysis was performed using SPSS version 23 (IBM Analytics - Australia) and STATA SE versions 14.1 and 14.2 (Stata Corporation, College Station, Texas, USA).

The third approach was qualitative assessment of drivers of nutritious food access in Solomon Islands and Samoa, which aimed to collect policy-relevant information to inform action. Data were collected using a novel tool which measured food security using an adapted Radimer/Cornell food security measurement tool, diet patterns using a food frequency questionnaire, and questions about the drivers of nutritious food access using a series of semi-open ended questions.

**Main findings**
This thesis documented the link between food insecurity and the consumption of inexpensive, high-calorie, often processed foods in the development of obesity in low- and middle-income settings. It also provided essential information on food security and the drivers of access to nutritious food for two Pacific Island Countries.

The research showed that: *i.* diets were poor overall amongst study participants; *ii.* of the many drivers of diets in the case study countries, economic access is the main driver; *iii.* the food environment focus of the research in this thesis was an effective way to gain insights into drivers of nutritious food access; and *iv.* the novel qualitative tool was valuable in identifying key themes around food access.

**Conclusion**
Together, this body of research adds to the evidence that the food environment in low- and middle-income countries and in particular the Pacific region is urgently in need of change. The research contributes contextual insight from Samoa and Solomon Islands which identifies groups who are particularly vulnerable to unhealthy eating behaviour. Economic access to nutritious food was the key driver of its consumption.

**Keywords:** Food security, food access, Pacific region, nutrition transition
Acknowledgements

I would first like to thank the participants in the research studies included in this thesis, whose shared life experiences tell a story that I hope will help improve health for all.

I would like to thank my supervisors Joel Negin and Anne Marie Thow. Their academic guidance, expertise, mentorship, and patient encouragement has helped me immensely throughout this project.

I also express my sincere thanks to those who assisted with the research and those who generously shared their skills and insights, in particular to Mamaru Awoke, Michael Sharp, Malaefono Taua, Taiaopo Faumuina, Suzie Schuster, Pavle Vizintin, Cynthia Hunter, Mia Rimon, Douglas Kimie, Nicola Hawley, Samson Kanamoli, Simon Tomasusu, Andy Roosen, Jill Losi, Jenny Vao, Seye Abimbola, Neha Faruqui, Justin Richards, and Seema Mihrshahi. Thank you to Jane Lake as well for the very warm introduction to Solomon Islands some years ago now.

Thank you to my food policy PhD colleagues for your friendship and collegiality, especially Sarah Mounsey, Tara Boelsen-Robinson, Alexandra Jones, Erica Reeve, Helen Trevena, and Simone Sherriff.

Completing this complex intellectual exercise during the first 18 months of my son’s life was challenging and I thank my family and dear friends for being there for me during this time, and throughout my candidature. My husband Grant has provided me with incredible emotional support; and in the last year took extended leave from work, travelled interstate and internationally so that I could attend meetings and conferences, and helped produce the figures in this thesis. Deep and heartfelt thanks also go to my mother Jan who has unwaveringly believed in me, and has been a significant source of daily encouragement. My father Geoff has also been an ongoing source of strong support. A very special thank you to my beautiful boy Jude, who is my inspiration.
Thank you to Paige Callaghan, Deirdre Roche, Terri Mc Menamin, Jane Zarfati, Mariel Gotlieb and all at Jane’s Place South Coogee for the exceptional care, love, and nutrition provided to Jude this year while I have been completing this thesis.

This PhD was enabled by an University of Sydney Postgraduate Award Scholarship, a James Kentley Memorial Scholarship, support from the Postgraduate Research Support Scheme and Sydney School of Public Health Student Grant Scheme, and support for conference attendance from both my supervisors.
List of publications

**Chapter 3** of this thesis is published as:

**Chapter 4** of this thesis is published as:

**Chapter 5** of this thesis is published as:

**Chapter 6** of this thesis is an unpublished manuscript under journal review as:

**Chapter 7** of this thesis is an unpublished manuscript under journal review as:
Farrell P, Thow AM, Rimon M, Roosen A, Vizintin P, Negin J. “Today, we live on money and depend on processed food from the shop”: analysis of healthy food access amongst women in peri-urban Honiara. *Under review*
Authorship attribution statement

For each paper contained in this thesis, I designed the study in discussion with my supervisors, performed the majority of, and was responsible for, the data analysis, and wrote the drafts and final versions of the manuscript.

Penny Farrell

12 September 2019

As supervisor for the candidature upon which this thesis is based, I can confirm that the authorship attribution statement above is correct.

Joel Negin

12 September 2019

As auxiliary supervisor for the candidature upon which this thesis is based, I can confirm that the authorship attribution statement above is correct.

Anne Marie Thow

12 September 2019
Table of contents

1. Thesis overview........................................................................................................... 1

2. Introduction................................................................................................................ 9
   2.1 Food security and nutrition: the global picture.................................................... 9
   2.2 Food security and nutrition in the Pacific region............................................... 20
   2.3 Methodological approach.................................................................................... 23


8. Discussion.................................................................................................................... 143
   8.1 Summary of findings ............................................................................................ 143
   8.2 What has changed in the food and nutrition security field since thesis commenced .................................................. 150
   8.3 Methodological considerations and reflections on the research approach .......................................................... 153
   8.4 Policy priorities .................................................................................................. 163
8.5 Conclusions: How the thesis findings inform future research .......... 170

Appendix

A) Oral presentations ................................................................. 183
B) Samoa Observer article .......................................................... 184
C) Qualitative survey tool ............................................................. 187
D) Chapter 4 supplementary analysis ............................................ 195
Abbreviations

AME – Adult Male Equivalent
BMI – Body Mass Index
BMJ – British Medical Journal
CASP – Critical Appraisal Skills Programme
DHS – Demographic and Health Survey
FAO – Food and Agriculture Organization of the United Nations
FFQ – Food Frequency Questionnaire
FIES – Food Insecurity Experience Scale
FNSV – Fruit and Non-Starchy Vegetables
GDP – Gross Domestic Product
HIES – Household Income and Expenditure Survey
ICN – International Conference on Nutrition
IMMANA – Innovative Methods and Metrics for Agriculture and Nutrition Actions
LMIC – Low- and Middle-Income Country
MANA – Pacific Monitoring Alliance for NCD Action
NCD – Non-Communicable Disease
NICE – National Institute for Health and Care Excellence
PIC – Pacific Island Countries
PICT – Pacific Island Countries and Territories
SDG – Sustainable Development Goal
SOFI – State of Food Security and Nutrition in the World
SPC – The Pacific Community
STEPS – STEPwise approach to surveillance
UNICEF – United Nations Children’s Fund
WHO – World Health Organization
Chapter 1: Thesis overview

Pacific Island Countries and Territories (PICTs) are experiencing a crisis of high and rising diet related health conditions, whose impact is exacerbated by a lack of health system capacity to treat them.(1) Over the past half century, diets have become increasingly reliant on imported foods and are now dominated by highly processed, energy dense, high-fat foods which are often lacking in micronutrients.(2, 3) Fresh fruit and vegetable consumption has been described as “disturbingly low”.(4) Largely owing to this dietary transition, the rates of overweight and obesity, non-communicable diseases (NCDs) including diabetes, and in some countries micronutrient deficiencies and stunting, are alarming and on the increase.(5-8) At the same time, while there is some evidence that the prevalence of food insecurity is high in at least some countries,(9, 10) the Pacific is the only region worldwide that does not collect sufficient food security data to track progress on Sustainable Development Goal (SDG) Indicator 2.1.2 (Prevalence of moderate or severe food insecurity in the population).(11, 12)

In many ways, the double burden of malnutrition in the Pacific represents an extreme case of the situation globally. In particular, the coexistence in some countries of rising rates of NDCs alongside pervasive undernutrition;(10, 11) as well as the co-occurrence of food insecurity(9, 10) and obesity.(13)

This thesis takes as its starting point that there is an emerging global consensus on the need for action – but also recognition that action needs to be informed by context.(8, 14-16) This means that appropriate programs and policies must broadly address food supply and the consumer food environment, but in order to be effective, the ever-changing and complex nature of human society, cultural, socio-demographic and economic factors need to be measured and taken into account.(16) However, the mechanisms underlying the link between the food environment, food access, and people’s interaction with food remain poorly understood, especially in low- and middle-income countries (LMICs).(15, 17, 18)
With respect to developing contextually appropriate and effective interventions, the Pacific region again represents an extreme example of the challenges. In PICs there is a severe paucity of data on what is influencing, and thus how to improve, access to a healthy and nutritious diet, otherwise defined as food security.\(^6, 11, 19\) This research gap is a roadblock to efforts to develop effective policies and regulatory frameworks to improve food systems in the Pacific region,\(^2\) and without progress there, it is also not possible to solve the challenge at a global level – in particular in relation to achieving SDG 2. There have also been calls in the recent literature from the Pacific for the need to understand the behavioural perspective that feeds into food consumption choices.\(^8, 14\) The research presented in this thesis was designed to address the gaps in understanding what affects food and nutrition security in the Pacific region, and provide methodological insights for food environment research in low- and middle-income settings globally.

This thesis focusses on proximal food environment factors affecting food and nutrition security in the Pacific region. The thesis had two overarching aims. The first was to provide information and insights about factors which affect people’s access to healthy and nutritious food which are directly applicable to policy and program design in the case study countries and the region. This was first addressed by examining current evidence for the link between food insecurity and obesity in LMICs more broadly, and identifying the mechanisms involved in this relationship. It was further explored through quantitative analysis of large national datasets which examined socio-demographic patterns of food consumption and acquisition; and analysis of primary data collected from community members. These studies are detailed below.

The second aim was to respond to the global need for the development of metrics and measures of food access for use in LMICs. This aim was first achieved by using realist review methodology in the review of the literature, and by situating the analysis within theoretical frameworks for food access. This was a new way to study these issues and brought important insights to understanding the problem in LMICs.
Also, a new tool was developed and used to collect data in Samoa and Solomon Islands. The tool performs a rapid, resource light measurement of food security and drivers of nutritious food access at the community level. The tool was used to collect primary data from Samoa and Solomon Islands – neither of which had previously had a food security measurement tool validated in that country.

Samoa and Solomon Islands were strategically chosen as case studies to address these research aims as each is an example of a country experiencing high rates of diet related disease; but each has a lack of data on, and validated metrics to measure, access to healthy food. The methodologically novel research presented through these case studies responds to a global call for the need for methodological innovation in food access measurement through initiatives including the Global Initiative, Innovative Methods and Metrics for Agriculture and Nutrition Actions (IMMANA).(18, 20)

In Chapter 2 I provide an explanation about the nutrition situation globally, in the Pacific region, and in Samoa and Solomon Islands, and explain why there is a critical need for more research. I first review the nutrition situation globally, and how this informs our understanding of food access issues and diet-related disease in both Samoa and Solomon Islands; countries which are heavily burdened by these challenges. I also review the metrics currently available for measuring food and nutrition security. In Samoa and Solomon Islands, multiple factors have contributed to rapid changes in diets. As such, I identify the importance of context-specific generation of different methodologies as critical in gathering both baseline and policy and program monitoring and effectiveness data.

This thesis contains five substantive pieces of new analysis which correspond with Chapter 3 to 7. Chapters 3, 4, and 5 have been published, and Chapters 6 and 7 are under journal review and are expected to be published in 2020.

Chapter 3 (Paper 1) presents results from a literature review which used realist systematic review methodology(21) to identify the key mechanisms at play in the
relationship between food insecurity and obesity. The chapter offers a new analytical framework to study how food access can be related to a health outcome (in this case obesity) by exploring the concept of food access through a) the food security measurement paradigm and b) Freedman et al.’s multicomponent model of nutritious food access. The study revealed that the most important mechanism in the food insecurity-obesity relationship in LMICs is likely to be access to energy dense, highly processed food. The review also showed that overall there was insufficient research in the area and, notably, a gap in the literature was observed in the Pacific.

The subsequent four studies provide new information about factors affecting food access in Samoa and Solomon Islands. Each of these studies inspects household, community, and population-level factors which influence access to a diet that supports good health.

**Chapter 4** (Paper 2) presents multivariate analysis of data from 4,805 participants in the Samoa 2014 DHS dataset. The study question was which socio-demographic groups were associated with consumption of a healthy diet. The study revealed a high rate of unhealthy diet patterns across the population and some patterns of unhealthy behaviour in specific groups including those in the younger age group. Results for both those in the high-income group and those in urban areas were mixed – both these groups reported consuming more high-sugar food and beverages, but also more fruit and vegetables, than those with lower incomes and in rural areas.

**Chapter 5** (Paper 3) presents primary data collected using the novel data collection tool from women in urban Samoa. The study found that amongst study participants food insecurity was high, diets had largely transitioned away from traditional foods and were focussed on unhealthy foods high in refined sugar and fat, and that affordability was the most important determinant of food choice in particular in relation to fruit and vegetables.
For **Chapter 6** (Paper 4), detailed pricing and food item acquisition information from the 2012/13 Solomon Islands Household Income and Expenditure Survey dataset (a nationally representative dataset containing data from 4,478 households) was analysed to examine affordability and sociodemographic determinants of access to fruit and non-starchy vegetables in Solomon Islands. This study showed that relative affordability of fruit and non-starchy vegetables was low, and key associations between inhibited access to fruit and non-starchy vegetables and specific sociodemographic groups are identified for those in low income and urban areas.

**Chapter 7** (Paper 5) presents data from the urban capital of Solomon Islands collected from community members using the novel survey tool. Analysis of participant responses showed food insecurity was experienced by all participants. Participants reported a pattern of predominantly unhealthy diets which is likely to be linked with the ongoing shift from subsistence agriculture to a cash based economy, combined with a lack of affordable and convenient fresh healthy food options.

**Chapter 8** brings together the research as a whole and identifies the key themes that emerge from the different methods used to measure food and nutrition security, thus triangulating the findings. The dominant finding was that economic access to nutritious food relative to energy dense, nutrient poor food was the most important driver of diet. The chapter also provides my reflections of the research process, and on policy solutions and future research directions.

Together, this body of research adds to the evidence that the food environment in LMICs and the Pacific region is urgently in need of change. The triangulation of methods(22) achieved from the use of both quantitative and qualititative research methodologies increases the validity of the thesis findings as a whole. The review used realist review methodology(21) to create a new interpretation of the data on food security in low- and middle-income countries. The empirical case study research contributes contextual insight through four pieces of new data analysis from Samoa and Solomon Islands which identifies particularly vulnerable groups to unhealthy eating such as those with low incomes.
Ethical clearance

Chapter 3: Ethical approval was not required as it was a review of already published literature.

Chapter 4: The authorship team was given official permission in February 2016 to access the 2014 Samoa DHS 2014 dataset via a Data Access Agreement between the Samoa Bureau of Statistics and The University of Sydney School of Public Health. The DHS was conducted by the Samoa Bureau of Statistics – the official data collection agency of the Samoan Government and was officially exempt from ethical approval by the Samoan Government. Participants signed informed consent forms prior to participating in the survey.(4) The research presented in this chapter was formally exempted from review by the University of Sydney Human Research Ethics Committee in February 2016 as it involved secondary analysis on anonymised data from the 2014 Samoa DHS.

Chapter 5: The National University of Samoa University Research Ethics Committee issued approval in July 2016 to conduct this research under the research project title ‘Understanding the socio-demographic determinants of access to healthy food in urban Samoa’. The Government of Samoa Ministry of Education, Sports and Culture also granted permission to conduct the research in August 2016.

Chapter 6: The Solomon Islands National Statistics Office granted formal permission to access the anonymised dataset in October 2017. The authors’ secondary analysis on the anonymised data was officially exempted from review by the University of Sydney Human Research Ethics Committee.

Chapter 7: The study was approved by the Solomon Islands National Health Research and Ethics Committee in April 2016.
References

Chapter 2: Introduction

In this introduction I explain the global context surrounding the aims of the research presented in this thesis – which were to: i. to provide much needed information and insights about factors which affect people’s access to healthy and nutritious food and which are directly applicable to policy and program design in the case study countries and the region; and ii. to respond to the global need to understand the way people interact with their food environment, in particular in the development of metrics and measures of food access which can be used in low- and middle-income countries (LMICs). I first review the global nutrition situation that informs understanding of the stark co-existence of food insecurity and diet-related non-communicable diseases (NCDs) in both Samoa and Solomon Islands; countries in which these challenges play out in remarkable ways. I also review the current status of metrics for measuring the ‘nutrition problem’, and the need for more nuanced understanding of the drivers (and not just the nature) of this problem. In both countries, multiple factors have contributed to rapid changes in food environments and diets. As such, I identify the importance of context-specific methodological development, which is critical for gathering both baseline data, and for monitoring the effectiveness of policy and program changes.

2.1 Food security and nutrition: the global picture

2.1.1 Poor diets are now a highly prominent global health issue

In understanding the current food and nutrition security situation in Samoa and Solomon Islands, it is essential to comprehend the situation on a global scale. The consumption of suboptimal diets is a worldwide problem. Every country faces significant challenges in meeting global nutrition Sustainable Development Goal (SDG) targets,(1) but LMICs are especially vulnerable due to challenges because low incomes impact access to nutritionally adequate diets, there are infrastructure challenges in transporting fresh food,(2) and, importantly, some countries’ health
systems have limited capacity to treat health conditions that result from suboptimal nutrition.(3)

Unhealthy diets are now the leading cause of poor health(4) and death worldwide.(5, 6) Globally, it is estimated that at least 2 billion people experience a lack of regular access to nutritious, safe, and sufficient food.(7) In contrast to the preceding decades, in very recent years the worldwide hunger rate has stopped declining.(8) Suboptimal diets are contributing significantly to the global burden of obesity, diet related NCDs including type II diabetes, cardiovascular disease, and some types of cancer,(9) as well as nutrient deficiencies.(2) Poor diets currently pose “a greater risk to morbidity and mortality than does unsafe sex, and alcohol, drug, and tobacco use combined.”(2) More than 85% of deaths from NCDs occur in LMICs.(10) This high burden, and the increased vulnerabilities of LMICs to the health consequences of unhealthy diets described above, means focussed attention on improving diets in LMICs will be critical to address the epidemic of malnutrition globally.

Key issues in the contemporary global food system are inequitable distribution of nutritious foods, and in their place a trend towards the consumption of unhealthy foods which are often cheaper, highly processed, energy-dense, and low in nutrients.(7, 11) High intake of refined sugar significantly increases weight gain.(12) Diets low in fruits and vegetables are leading features of the global burden of health consequences related to unhealthy diets.(12) Replacing saturated fat with unsaturated vegetable oil markedly reduces cardiovascular disease and mortality risk.(13, 14) The nutrition transition is a global phenomenon whereby diets are shifting away from foods high in complex carbohydrates, whole grains, fresh fruit and vegetables, and lean meats, towards diets characterised by increased consumption of processed foods, and which are high in refined sugar, saturated fats, and low in fibre.(15) This transition has been progressively occurring over at least four decades in LMICs in all regions of the world, with dramatic epidemiologic consequences in particular in the development of overweight, obesity, and NCDs.(16-18)
The type of food available to those with limited choice matters. Chapter 3 of this thesis presents detailed background information from the existing literature on the link between food insecurity (lack of access to nutritious food) and the development of obesity (a form of malnutrition) in low- and middle-income settings. In brief, this paper found that access to energy dense, highly processed food was the most important mechanism in the link between food insecurity and obesity in LMICs in the literature reviewed. (19) Popkin and colleagues (16) summarise the problem well: “A challenge for programs and policies is the need to address food insecurity and hunger without adding to the burden of overweight and obesity. This is particularly challenging given the relatively low cost and high availability of foods that are energy dense but low in micronutrient content.”

2.1.2 The need for more data on food access from low- and middle-income countries

Despite the knowledge we have about the nutrition transition globally and the epidemiological evidence for diet related disease, (7, 11) and the existence of the definitions and frameworks around household food access discussed below, the mechanisms underlying the link between the food environment, food access, and people’s interaction with food remain poorly understood, especially for LMICs. (20-22) Although the related existence of food insecurity and all forms of malnutrition in LMICs is now documented, it continues to increase, (7) including in Pacific Island Countries and Territories (PICTs), (23) highlighting the urgent need for change at the local, national, and global levels. There is a need for nuanced and contextually appropriate policy responses – but these require data. Empirical food environment research to date has been focussed on high-income countries, and although such research has potential use for policy making in LMICs, a validated approach to performing research to effectively inform action to increase acquisition and consumption of healthy food in LMICs is “in its infancy” and lacks a cohesive research agenda. (21)

Although the original Food and Agriculture Organization of the United Nations (FAO) definition of food security (discussed in section 2.1.4 below) does encompass the
concept of nutrition, there has recently been a ramping-up in the use of the term “food and nutrition security” instead of “food security” in the global discourse.(24) For example, the State of Food Security and Nutrition in the World (SOFI) report changed its name in 2019 from *The State of Food Security in the World* to *The State of Food Security and Nutrition in the World*. This more overt focus on nutrition has been motivated by a need to shift the focus of programs and policies away from hunger prevention, towards preventing malnutrition in all its forms.(24) The work in this thesis seeks to operationalise this shift by collecting data on patterns of consumption of foods of varying level of nutritious value, and also measuring food security using a traditional food security measurement tool.

There is variation between and within LMICs in the way food consumption leads to malnutrition (both undernutrition and obesity).(1, 21, 25, 26) Due to this, research based on current, context-specific data on the patterns of diet-related disease risk factors is required in order to design prevention programs and policies.(27, 28) The research presented in this thesis adds valuable methodological insight to measuring access to nutritious food globally, particularly for LMICs, as well as helping to fill a critical research gap for Samoa and Solomon Islands, countries that are heavily burdened by food insecurity and diet related disease.

2.1.3 *The rise of public health nutrition to global political prominence*

There has been a rapid acceleration in attention to nutrition globally over the past decade. Nutrition has gone from being a neglected issue a decade ago(29) to being a prominent issue on the public health agenda globally.(21) Milestones in this acceleration in global attention include The Lancet’s 2008 Nutrition Series, the Scaling Up Nutrition network launch in 2010, and the first Global Nutrition Report in 2014.(30, 31) The United Nations General Assembly has declared the current decade of 2016–25 to be the Decade of Action on Nutrition.(32) Goal 2 of the Sustainable Development Goals (SDGs) is Zero Hunger, with Target 1 “By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round” and Target 2 “By 2030, end all forms of malnutrition ...”.(33)
There is an opportunity for LMICs to leverage from this global momentum to improve understandings of the complex factors which cause malnutrition in all its forms.

2.1.4 Framing food access

Despite the recent increased attention to nutrition globally, there is insufficient evidence on how to increase consumption of nutritious food, especially in most affected countries. Access to nutritious food is crucial to increasing its consumption. Before examining what affects food access and how to measure it, it is important to understand the different uses of the term “food access” in the global food policy discourse. Turner et al. in their recent publication(21) discuss the definitional diversity of this term, and the tension between defining the term as a: a) a “multifaceted determinant of food acquisition (i.e. physical, social, economic access)” which has origins in Penchansky and Thomas’ work,(34) and the United Nations Children’s Fund (UNICEF) Framework on the causes of child malnutrition(35) (Figure 2.2 below); or b) a more literal definition which exclusively refers to physical distance and transport and time-based aspects relative to individuals. In this definition, access is literally situated between availability and acquisition (Figure 2.1).(21) This definition is similar to the concept of spatio-temporal access discussed in Chapter 3.

The definition of access used in this thesis draws on the former, broader framing of the term, with implied links between the socio-demographic determinants of acquisition and consumption. It also aligns with SDG 2, Target 1 which provides “internationally-comparable estimates of the proportion of the population facing moderate or severe difficulties in accessing food.”(36)
The FAO define food security as a state in which “all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.” (37) This widely accepted FAO definition includes the dimensions of food security (38) tabulated below. The research presented in this thesis sought to resonate with the food access dimension.

### Table 2.1. Dimensions of food security

<table>
<thead>
<tr>
<th><strong>Food availability</strong></th>
<th>The availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports (including foreign aid).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Food access</strong></td>
<td>Access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet. Entitlements are defined as the set of all commodity bundles over which a person can establish demand given the legal, political, economic and social arrangements of the community in which they live (including traditional rights such as access to common resources).</td>
</tr>
<tr>
<td><strong>Utilization</strong></td>
<td>Utilization of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met. This brings out the importance of non-food inputs in food security.</td>
</tr>
<tr>
<td><strong>Stability</strong></td>
<td>To be food secure, a population, household or individual must have access to adequate food at all times. They should not risk losing access to food as a</td>
</tr>
</tbody>
</table>
The focus of the research in this thesis on food security and food acquisition and consumption situated within the broader context of socio-demographic levers of food access means the UNICEF Framework on the causes of child malnutrition (35) is also helpful in framing the way food access is explored (although the focus of the program of research on this thesis is on adult populations and not children). This framework encompasses the complexity of the drivers of access to nutritious food and articulates the food environment in terms of the immediate (personal), household, and societal level. It shows how socio-demographic levers of access to food including economic and social systems can intersect with people’s physical acquisition and consumption patterns.
2.1.5 Current status of methods to measure access to a healthy diet in low- and middle-income countries

Turner and colleagues stated in their 2018 publication that for LMICs “a new research paradigm is required in order to better account for the socio-ecological interactions that determine food acquisition patterns, diets, nutrition and health outcomes”. The authors identify the concept of the food environment as one such paradigm, but emphasise the current lack of measurable dimensions to use in empirical research in LMICs. (21) The paper then presents the following measurable metrics and food environment definitions offered by key recent publications: “availability, affordability, convenience, and desirability of various foods”; (21, 39) and “Food environments comprise the foods available to people in their surroundings as
they go about their everyday lives and the nutritional quality, safety, price, convenience, labelling and promotion of these foods”. (21, 40) The program of research presented in this thesis aligns closely with these food environment definitions and metrics, and thus constitutes a building block in validating these methodological approaches for the development of food environment research for LMICs worldwide.

The concept for this thesis was originally derived from the literature on the associations between socio-demographic and dietary risk factors for health conditions including obesity and NCDs. These are well described and have proven important for health policy making in high-income countries, but evidence is sparse in LMICs. (20, 41, 42) Analysing the socio-demographic patterns of diet using country-specific data is one dimension via which we can identify those most at risk of diet-related diseases with the potential to develop and evaluate targeted policies for their prevention. (42) There is increasing discussion of the social determinants of malnutrition (both undernutrition and obesity) amongst the global food policy community; in other words factors including wealth and income, education, and gender empowerment are important in the relationship between poor diet and the development of malnutrition, and these are especially complex in LMICs. (1, 2, 20)

There is a key opportunity for harmonisation of food environment research with food security measurement to bring deeper understandings to the field of food environment research in LMICs. (21) The use of food security as a metric to study access to nutritious food is gaining momentum: food security is increasingly being recognised as a social determinant of health; (43, 44) and in 2017 SDG Indicator 2.1.2 started to include prevalence of severe food insecurity measured using the Food Insecurity Experience Scale (FIES) (45), with the 2019 SOFI report presenting figures of both severe and moderate food insecurity for the first time. (7) This very recent progress in the use of the FIES is significant to this thesis for two key reasons. Firstly, it is the closest the world has come to global consensus on a food security measurement tool; and secondly, the measurement of moderate food insecurity for the first time in 2019 signifies a global recognition of the importance of
not only hunger and severe food insecurity (typically linked with undernutrition), but also moderately impaired access to sufficient, safe and nutritious food to health outcomes such as overweight and obesity.

In examining access to a healthy diet, it is quickly apparent that there are diverse definitions of what a healthy diet itself entails. The World Health Organization (WHO) classifies a healthy diet as one: a) that includes at least five serves of fruit and non-starchy vegetables per day; b) in which free sugars make up less than 10% of total energy intake; c) in which less than 30% of total energy intake comes from fats; d) in which less than 10% total energy from saturated fats; and e) which contains less than 5g of salt per day. The nutrient based component of these guidelines are arguably difficult to follow in practice by the general population as they are not straightforward to apply in terms of serves of specific food items.

Over the decades following the 1992 International Conference on Nutrition (ICN), FAO and WHO have promoted the development of food based dietary guidelines. Following this guidance, many individual countries and regions including the Pacific have shifted in their focus from nutrient and food group based advice (based on exact minimum or maximum levels of saturated fat or iron for example, to food based diet guidelines, for example quantity of red meat) for ease of application by individual members of the general public. The 1992 ICN called for nutrition messaging to use “food-based approaches that encourage dietary diversification through the production and consumption of micronutrient-rich foods, including appropriate traditional foods”.

Individual country guidelines greatly vary between countries and regions. This in part reflects the need for guidelines to honour differing food cultures, traditions, and local food availability, however this does not appear to be the only reason for the variation. One example of this is that advice to limit highly processed foods appears in all regions except North America. A 2019 global review of food-based dietary guidelines reported considerable variation between guidelines, for example in whether legumes are included as a vegetable. A comparison of national
Introduction

guidelines of two high income countries with relatively similar Western food cultures – the Australian and Canadian guidelines – with the current Pacific regional guidelines also helps to illustrate this variation. All three of these sets of guidelines were released in the past two years, which also reflects the diversity in recommendations over time. The Australian Guidelines to Healthy Eating (50) and Canada’s Food Guide (51) are based around pie chart style infographics which recommend the largest proportion of the diet consists of fresh fruits and vegetables (but do not distinguish between starchy and non-starchy vegetables), and the remaining proportions consist of protein foods, wholegrain based foods, and dairy (for Australia only – there is no discrete dairy section in Canada’s guide). The proportion recommendations differ between countries in other ways, for example, the Canadian guide recommends a combination of fruit and vegetables make up exactly half the plate,(51) whereas the Australian guidelines differentiate between vegetables (around one-third of the plate, including legumes), and fruit roughly one-eighth of the plate.(50) In the Canadian guide, legumes are included as a protein food, whereas in the Australian guide they are categorised as both a vegetable and as a protein food.

The Pacific Guidelines for Healthy Living are the regionally endorsed diet guidelines for the Pacific region. They were used as the backbone of the analysis in this thesis for ease of direct application by policy makers in the region, and because they echo the WHO guidelines for at least five serves a day of fruit and non-starchy vegetables. These are more prescriptive and differ in language and recommended proportions from Australia and Canada’s guidelines. For example, meat and meat substitutes are referred to as ‘body building foods’ and these are recommended to make up 15% of all food eaten each day. In contrast to the Australian and Canadian guidelines, the Pacific guidelines do distinguish between starchy and non-starchy vegetables and recommend that non-starchy vegetables and fruit make up 35% of the diet. Starchy staples are classified as ‘energy foods’ (meaning carbohydrate based foods) and the guidelines recommend that 50% of the diet is based on energy foods – which is a larger portion than is recommended in the Australian and Canadian guides.
The inconsistency between guidelines makes global application of any in-country research on healthy diet challenging. While types of foods and cultural perspectives on foods do vary between countries and regions, and there are challenges in providing recommendations accounting for human variation in factors such as age and level of physical activity, more specific and globally cohesive dietary guidelines would make it easier to perform research with regional and global significance. A recent comprehensive analysis of healthy dietary patterns is EAT-Lancet’s reference diet, published in 2019, which presents a guide to eating for both human (encompassing cultural diversity and differences in regional food availability) and planetary health. However the strong plant based food focus received backlash from the meat industry – and as a consequence of pressure from an Italian official who highlighted concerns about the impact of the diet on health and livelihoods, lost the endorsement of the WHO at one launch. The debate over what constitutes the best approach to socio-culturally sensitive diet guidelines for optimal health continues, and complicates efforts on the part of researchers, policy makers, and populations, to understand and improve nutrition.

2.2 Food security and nutrition in the Pacific region

2.2.1 Current challenges

Pacific Island Countries and Territories are currently experiencing a crisis of diet related disease. In fact, the issues described above at the global scale are playing out in an exaggerated way in the Pacific region, as demonstrated by the high and rising rates of malnutrition, and there is an especially large knowledge gap in the way people interact with food. Progress on SDG 2 to date has shown that the Pacific region is the only region globally where the proportion of stunted children has not fallen. The region thus offers an opportunity to study an extreme case of how the global nutrition problem is manifesting at the local and national level. This can provide lessons for other regions and jurisdictions in terms of both the mechanisms through which the food environment impacts on food consumption and acquisition, and the methodologies through which these issues can be studied.
A key issue is the nutrition transition which is well underway in the Pacific region. For more than half a century, diets in PICTs have been transitioning from those high in locally produced foods with a focus on fresh fruit, green vegetables, root crops, nuts and seeds, and seafood and wild-caught meat – towards diets dominated by energy dense, processed, and often imported foods such as white bread and white rice, and fatty meats. (26, 57-59) Modern Pacific diets are often high in refined sugar, fat, and salt, and because of this are contributing significantly to the very high and increasing burden of obesity and NCDs such as diabetes and cardiovascular disease in the region. (10, 41, 55, 60-62). Several studies from the Pacific have reported increased rates of NCDs and NCD risk factors occurring in parallel with increases in consumption of imported processed food. (41, 61, 63-65) NCDs currently account for around three-quarters of deaths in PICTs. (66) Further complicating the problem, diets are often low in micronutrients and sometimes in protein and consequently in some countries stunting and micronutrient deficiencies also remain prominent. (7, 54)

The food environment in the Pacific region is undergoing rapid and multifaceted change as a result of several complex and often interlinked proximal and distal drivers of food access. These include Western colonisation; globalisation of trade and fluctuations in the global economy; changes in agricultural systems; urbanisation; and climate change. (67, 68) McLennan and Ulijaszek (69) attribute contemporary obesogenic diet practices in the Pacific to the Western colonial social values related to capitalist economics which place value on low-cost, high volume foods, and convenience foods to save time. Economies are transitioning from subsistence-based economies to cash-based economies, (70) which is affecting the types of food available as access to cash facilitates access to imported, processed foods. (55)

2.2.2 The need for more food environment research in Pacific region

Thow and Snowdon (71) describe the Pacific region as an ideal environment to study the mechanisms affecting diets because there is a marked difference between traditional and modern diets, and the relatively small population sizes and island
geography “provides a discrete situation” to study diet related pathways. However, there has been little research to date on food access and food security in the Pacific region.(55, 66) and previous research has called for more work in this area. As examples, Seiden et al.(41) note “future research should include … local dietary intake data … and qualitative data on cultural practices and values and the role of food in society”, and that “[there is a] need for a behavioural perspective about food purchasing and consumption patterns.” Ezeamama et al.(56) recommended that designers of interventions targeted at cardiovascular disease and obesity prevention consider “the socio-economic context of risk factor exposures, and individual characteristics such as age, sex and education level”. Given the extreme double burden of malnutrition seen in the region,(33) and the high diversity in socio-ecological factors affecting food access in the region(72) the Pacific also offers opportunity for insights regarding the impact of more proximal food environment factors on access to nutritious food.

Food insecurity is believed to be increasing in the Pacific region,(23) however a major barrier to effective regional action in the form of programs and policies is the lack of data in the area of food and nutrition security (physical and economic access to sufficient, safe and nutritious food).(19, 55, 66, 73) This is exacerbated by definitional complexities in the current food access data available from the Pacific. For example the Solomon Islands poverty profile based on the 2012/13 Household Income and Expenditure Survey report (74) frames “food poverty” as a lack of access to sufficient calories, and thus links different socio-demographic vulnerabilities to those that might be listed if access to other nutritious foods such as fresh fruit and vegetables. In a country experiencing all forms of malnutrition,(54) and given the finding in Chapter 3 that food insecurity appears to be most strongly linked with obesity when relatively low cost energy dense foods are available, a more detailed framework for measuring access to nutritious food and which takes into account moderate food insecurity is needed. The very recent global application of the FIES discussed above offers a useful measure to implement measurement of food security regionally and start to address this research gap. However mid-2019 global reporting on SDG Indicator 2.1.2 (which measures moderate or severe food
insecurity in the population) reveals a gaping data gap in the Pacific region, rendering full understanding of the situation guesswork.

2.3 Methodological approach
This thesis examines proximal level access to healthy diets in LMICs, then in two low- and middle-income countries in the Pacific region with high burdens of malnutrition: Samoa (obesity) and Solomon Islands (undernutrition and obesity). The program of research had two main aims: i. to provide much needed information and insights about factors which affect people’s access to healthy and nutritious food and which are directly applicable to policy and program design in the case study countries and the region; and ii. to respond to the global need to understand the way people interact with their food environment, in particular in the development of metrics and measures of food access which can be used in low- and middle-income countries. These aims were achieved through five key objectives as outlined in Table 2.2 below.
### Table 2.2. Thesis aims and objectives

<table>
<thead>
<tr>
<th>Aims</th>
<th>Objectives</th>
<th>Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Provide much needed information and insights about factors which affect people’s access to healthy and nutritious food and which are directly applicable to policy and program design in the case study countries and the region</td>
<td>1. Examine current evidence for the link between food insecurity and obesity in low- and middle-income countries and identify the mechanisms involved in this relationship</td>
<td>Chapter 3</td>
</tr>
<tr>
<td>2. Respond to the global need to understand the way people interact with their food environment, in particular in the development of metrics and measures of food access which can be used in low- and middle-income countries</td>
<td>2. Study how patterns of apparent food consumption are affected by socio-demographic circumstances</td>
<td>Chapters 4 &amp; 6</td>
</tr>
<tr>
<td>3. Identify pertinent inter- and intra-household food access issues for vulnerable community members (women responsible for children in urban environments)</td>
<td>3. Identify pertinent inter- and intra-household food access issues for vulnerable community members (women responsible for children in urban environments)</td>
<td>Chapters 5 &amp; 7</td>
</tr>
<tr>
<td>4. Address research gap of measuring food security in Pacific</td>
<td>4. Address research gap of measuring food security in Pacific</td>
<td></td>
</tr>
<tr>
<td>5. Add to global methodological tool pool by developing a novel tool for measuring nutritious food access in local environments</td>
<td>5. Add to global methodological tool pool by developing a novel tool for measuring nutritious food access in local environments</td>
<td></td>
</tr>
</tbody>
</table>
2.3.1 Overall approach

This thesis focusses on proximal food environment factors affecting food and nutrition security in the Pacific region.

Figure 2.3. Proximal and distal drivers of access

Multiple ways of measuring food access were used in order to achieve triangulation of methods, producing different constructions of the phenomenon of how proximal food environment and socio-demographic factors can lead to unhealthy food consumption, and thus providing a deeper understanding of the findings. (21, 76, 77)

The findings were analysed separately in Chapters 4-7, and then analysed in concert in Chapter 8. As illustrated in Figure 2.4, three main streams of food access measurement were used:

- **Food security** – both theoretical exploration (Chapter 3) and empirical measurement (Chapters 5 and 7)
- Individual insights about what affects food access and food acquisition from community members (Chapters 5 and 7)
- Quantitative assessment of patterns of consumption, acquisition and affordability in large national datasets (Chapters 4 and 6).

This mixed methods approach also has the advantage of adding to the methodological diversity in the literature on studying food environments in the Pacific region, and in low- and middle-income countries more generally.

**Figure 2.4. Mixed methods approach to measuring food access**

The program of research in this thesis is closely aligned with the practical opportunities for food environment research in LMICs discussed in the recent paper *Concepts and critical perspectives for food environment research: A global framework with implications for action in low-and middle-income countries*. (21)

These are tabulated below.

<table>
<thead>
<tr>
<th>Methodologic approach</th>
<th>Quote from <em>Concepts and critical perspectives for food environment research: A global framework with implications for action in low-and middle-income countries</em> (21)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Food security measurement</strong></td>
<td>“A key opportunity is to incorporate food environment research within wider food security and livelihood research taking place in LMICs. There is also considerable scope to harmonize research agendas, concepts, methods and</td>
</tr>
</tbody>
</table>
metrics between these fields that share the common goal of promoting healthy diets and optimal nutrition.“

| Qualitative research | “Qualitative food environment research remains underutilized yet has great potential, particularly in understudied settings such as LMICs. Qualitative approaches provide the opportunity to learn from lived experiences of food environments, and may reveal greater insights into issues such as which dimensions people perceive to be important in shaping their food acquisition and consumption. Such knowledge is vital to the successful design, implementation and uptake of appropriate interventions and policies.” |
| Mixed methods research | “Integrating qualitative and quantitative approaches in mixed-method studies offers the potential to triangulate multiple data sources, further improving knowledge and understanding of people’s interactions with their food environment.” |

The thesis focusses on women as the literature review in Chapter 3 presents worldwide evidence which shows that that in comparison with men, women are more vulnerable to malnutrition: both biologically, and due to socio-cultural contributors leading to uneven distribution of resources within households. Obesity prevalence worldwide is higher in women than in men,(78) and women of reproductive age are especially vulnerable to deficiencies in some nutrients such as vitamin A and iron.(79) When the food security status of women improves, so does that of their families. There is worldwide evidence that autonomy in women within a household is positively linked with their household’s nutritional status.(80) The 2019 SOFI report found that women experience significantly more food insecurity than men in every region of the world, although a data gap was again noted for the Pacific region.(7) The report states that: “After controlling for area of residence (rural or small town versus large city or suburbs), poverty status and education level of the respondents, the chances of being food insecure are still approximately 10 percent higher for women than for men. This finding reveals that other – possibly subtler – forms of discrimination make access to food more difficult for women, even when they have the same income and education levels as men and live in similar areas.”(7)

Gender disparities in nutritious food access, and in diet-related health outcomes, are very important in the Pacific region, including in Samoa and Solomon Islands. Between 1975 and 2014 in PICTs, increases in Body Mass Index for women were amongst the largest globally.(81) In Samoa, female-headed households are less likely than male-headed households to have adequate nutrient intakes;(82) the
prevalence of obesity is almost 25% higher in women than in men; (83) and women are more vulnerable to poverty than men. (70) In Solomon Islands, the prevalence of overweight and obesity is higher in women than in men; (54) and there are strong inequalities in women’s access to resources and control of household decision making within households. (84)

2.3.2 Realist review

Overall approach
To address Aim 1 Objective 1, the first piece of analysis performed for this thesis was a realist systematic review of the literature on the association between food insecurity and obesity in LMICs. Realist review methodology was chosen for the review as the methodology allows for the complexities of the ‘real world’ to be studied. The approach aims to provide policy makers with an understanding of the mechanisms by which (how) changed conditions (in this case differing levels of food insecurity) lead to outcomes (obesity), and how that relationship may vary in different contexts. (85)

Data collection
An iterative approach to refining the research question was taken, as outlined by realist review guidelines. (85) The original research question aimed to examine the association between food insecurity and obesity from Asia and the Pacific region, but as a gap was identified in research from the Pacific region, the question was expanded to include LMICs worldwide. Peer-reviewed journal articles with research from LMICs that measured food insecurity and included overweight and/or obesity as outcome measures were deemed relevant.

Analytical approach
Eleven cross-sectional studies and two review articles were included. Rigour was assessed using The Critical Appraisal Skills Programme appraisal tool (86) for the review papers and an adaptation of the UK National Institute for Health and Care Excellence appraisal checklist (87) was used for the cross sectional papers.
Data were entered into a data extraction template in Excel and then were analysed through an iterative process until the most pertinent context-mechanism-outcome relationships emerged in the relationship between food insecurity and obesity. Freedman et al.’s multicomponent model of nutritious food access(88) was used as a framework for the analysis.

2.3.3 Quantitative research

Overall approach
The quantitative studies (Chapters 4 and 6) were designed to study the dietary consumption behaviour of different socio-demographic groups in order to bring new understanding about patterns of behaviour, and potential vulnerabilities, of certain socio-demographic groups to unhealthy eating patterns within the complexities of the food environment, addressing Aim 1, Objective 2 in Table 2.2.

Data analysis
The analytical methodology was based on established methods for performing and interpreting multivariate analysis,(89, 90) and approaches in the peer reviewed literature – the socio-demographic pattern analysis was influenced by Sengupta et al.(25) and Subramanian et al.;(28) the Adult Male Equivalent (AME) analysis in Chapter 6 was informed by other studies using AME in their analysis;(91, 92) and the model for the minimum value of 400g fruit and non-starchy vegetables used in Chapter 6 was informed by a similar study in Vanuatu.(93)

Analyses were performed using SPSS version 23 (IBM Analytics - Australia) and STATA SE versions 14.1 and 14.2 (Stata Corporation, College Station, Texas, USA).

2.3.4 Qualitative research

Theoretical basis and methodological foundation
The qualitative component (presented in Chapters 5 and 7) was designed to collect policy relevant information and produce data in a form that was accessible for policy makers in order to inform action (Aim 1, Objectives 2-4 in Table 2.2). Turner et al.(21) state that “Improving knowledge and understanding about food environments,
including the who, what, when, where, why and how of food acquisition and consumption, will be key to addressing malnutrition in all its forms." The core purpose of these studies was to explore the most pertinent reasons for and modifiers of consumption of unhealthy diets – is it education, culture, taste preference, price, intra-household decision-making power? Or if it is a combination of these factors which are the most important ones at particular times and for certain groups of people?

The approach for the qualitative survey design and analysis was informed by Green and Thorogood’s description of surveys and individual-in-depth interviews (77, 94) and drew from interpretive theory, in which the research aim is to derive “an understanding of the world from the point of view of participants in it".(77)

**Development of data collection tool**

The data collection tool was methodologically novel and was designed in response to knowledge gaps identified in the area of food security and nutritious food access in the Pacific region.(41) Designing and using this tool addressed Aim 2, Objectives 4 and 5. There has been a small amount of food environment research performed in PICTs, for example research from Tonga has shown that cost and convenience are key drivers of consumption of imported over local foods.(95, 96) However, there have not been any studies which measure food security, food consumption patterns, and examine the drivers of diet together.

The tool included: a) a shortened food frequency questionnaire (FFQ) based on that validated by DiBello and colleagues,(60) b) food security measurement, and c) a series of open-ended questions about factors affecting participants’ access to healthy food and how they interact with their food environment. The idea to combine a food security measurement tool with a diet survey was derived from a 2007 study by Shoae and colleagues.(97)

There was no readily available food security measurement tool which had been validated for use in the Pacific region when I was designing the qualitative tool. It is
important to have regionally validated methodologies in order to collect such data, both to collect baseline data (as discussed above, there is currently not much country data available on food security in PICTs) and to monitor the progress of programs and policies. The Radimer/Cornell food security measurement tool was chosen because of: i) its widespread use globally,(97) ii) validation of a very similar version, the Core Food Security Module, in Pacific populations living in Hawai‘i,(98) and iii) the findings of Shoae and colleagues’ study (97) which tested and comprehensively validated the Radimer/Cornell tool for use in urban Iran, and found that despite the fact that the tool was initially designed for Western cultures, it was interpreted effectively in the Iranian context and relatively minor changes were needed.

**Analytical approach**

Interview answers were entered into a template in Microsoft Excel. FFQ answers were classified using the Pacific Guidelines for Healthy Living.(59) Food security questionnaire responses were analysed to classify each participant as household, individual, and/or child food insecure. The answers to the questions about drivers of nutritious food access were analysed using thematic analysis and coding for common themes.(77, 94)

**Fieldwork**

I visited Samoa and Solomon Islands twice each, each visit for 1-2 weeks. For each country I conducted an initial shorter visit where I built the connections required to do the primary data collection in each country, and on the second visit 3-6 months later I conducted the study. This approach worked well as it allowed for time to discuss and refine the study plans with my in-country collaborators between the first and second visit, and time for the research to be receive ethics approval.

The initial visits were also instrumental in accessing the national datasets for the quantitative studies. During my first visit to Samoa I met and provided statistical training to the Bureau of Statistics with a team from The University of Sydney, and
on the initial visit to Solomon Islands I met with the National Statistician to discuss my research plans.

### 2.3.4 Case study countries: Samoa and Solomon Islands

Table 2.4. Demographic characteristics

<table>
<thead>
<tr>
<th></th>
<th>Samoa(^{(99)})</th>
<th>Solomon Islands(^{(100)})</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Human Development Index</strong></td>
<td>0.713 (High)</td>
<td>0.546 (Low)</td>
</tr>
<tr>
<td><strong>Life expectancy at birth (years)</strong></td>
<td>75</td>
<td>71</td>
</tr>
<tr>
<td><strong>Mean years of schooling</strong></td>
<td>10.3</td>
<td>5.5</td>
</tr>
</tbody>
</table>

The program of research was designed to encompass four separate pieces of empirical research in Samoa and Solomon Islands: a quantitative (national level) and a qualitative study (individual level) study in each country. Samoa and Solomon Islands were chosen as case study countries through which to explore patterns of food consumption behaviour as these countries are excellent examples of countries under the strain of the challenges described above: the nutrition transition and high rates of malnutrition; and a research gap in both countries,\(^{(41, 56, 73)}\) as well as in the region,\(^{(7, 75)}\) and in LMICs across the world,\(^{(21)}\) in terms of how to measure what in the food environment affects acquisition and consumption.

Samoa is more “advanced” in the nutrition transition and is the third most obese country in the world,\(^{(6)}\) whereas in the Solomon Islands population there is both a combined burden of overweight, obesity and NCDs, and undernourishment.\(^{(7)}\) As with other low- and middle-income settings, the health burden – both societally, economically, and personally, of diet-related disease (malnourishment in the form of obesity and associated non-communicable diseases such as diabetes, and undernourishment and micronutrient deficiencies) in both these countries are exacerbated by limited health system capacity to treat these diseases.\(^{(3, 54)}\)
The obesity prevalence in Samoa almost doubled from 1978 to 2013, and the WHO reports around 75% of the population is obese. Non-communicable disease prevalence in Samoa is high, causing the majority of deaths, and a recent WHO survey found a diabetes prevalence of 50% amongst the population screened. Prior to commencing the program of research presented in this thesis, previous research in Samoa had emphasised a need for effective policy action on both food insecurity and obesity – and had identified a knowledge gap in the literature in the area of food purchasing and consumption patterns which could to inform such policy development.

Solomon Islands is a strong example of a country with a “double burden of malnutrition” – a concept referring to a dual burden of undernutrition along with overweight and obesity that was relatively recently coined globally. The country has a “triple burden” of malnutrition if anaemia is included. As such, Solomon Islands is a country with good potential to provide insights to the global nutrition discourse on designing coordinated approaches to measuring and solving all forms of malnutrition. Currently 69% of deaths in Solomon Islands are caused by NCDs, and the rate is rising. The impact is exacerbated by limited health system capacity to treat these diseases, and the country is further burdened with the highest reported undernourishment rate in the Pacific region. Three years before the program of research in this thesis commenced, the FAO highlighted the fact that a lack of data on food and nutrition security was posing a serious challenge to policy and planning in the country.

**Engagement in-country**

For all pieces of empirical research I engaged with local organisations in the case study countries. In Samoa I worked with the Bureau of Statistics and the National University of Samoa, and for the Solomon Islands research I worked with Pacific Community, the Ministry of Finance, the Ministry of Health and Medical Services. These local partnerships allowed me to discuss the research plans with people working in-country and ensure they were locally relevant and appropriate, and also helped with the research logistics. This local engagement also provided an opportunity for staff, students, and volunteers at local organisations to be involved in
research, thus helping to build local research capacity. Each publication included key in-country collaborators.
References

17. Popkin BM. Relationship between shifts in food system dynamics and acceleration of the global nutrition transition. Nutrition reviews. 2017;75(2):73-82.


56. Ezeamama AE, Viali S, Tuitele J, McGarvey ST. The influence of socioeconomic factors on cardiovascular disease risk factors in the context of


86. CASP. Systematic review checklist 2013 [8 April, 2016]. Available from: http://media.wix.com/ugd/dded87_a02ff2e3445f4952992d5a96ca562576.pdf


Chapter 3: Paper 1

How food insecurity could lead to obesity in LMICs

When not enough is too much: a realist review of how food insecurity could lead to obesity in low- and middle-income countries

Penny Farrell1,*, Anne Marie Thow2, Seye Abimbola1, Neha Faruqui1, and Joel Negin1

1Sydney School of Public Health, A27 Edward Ford Building, Fisher Road, The University of Sydney, Sydney, NSW 2006, Australia and 2Menzies Centre for Health Policy, D17 Charles Perkins Centre, University of Sydney, NSW 2006, Australia

*Corresponding author. E-mail: penny.farrell@sydney.edu.au

Summary

While food insecurity is a well-known cause of under-nutrition and stunting, in recent decades it has also been linked with obesity. Understanding and thus minimising the risk factors for obesity in low- and middle-income country contexts, which often lack the health system capacity to treat the consequent obesity-related illnesses, is crucial. This study adopted realist review methodology because it enabled us to analyse and organise the evidence from low- and middle-income countries into a coherent scheme. By comparing this evidence to existing theory on food security and nutrition, we aimed to provide a richer understanding of the nuances and the socio-demographic nature of the food insecurity–obesity relationship. The review generated 13 peer-reviewed articles which studied the relationship between food insecurity and overweight/obesity in low- and middle-income countries. Affordability of high-energy, processed foods was identified as a main mechanism, which determined whether or not food insecurity leads to obesity in low- and middle-income countries. Other mechanisms identified were: quantity and diversity of food consumed; spatial-temporal access to nutritious food; inter-personal food choice and distribution; and non-dietary behaviours. Despite the limited empirical evidence available, our review presents meaningful and policy-relevant insights into the food insecurity–obesity relationship in from low- and middle-income countries. Interventions to address the food insecurity–obesity link need to address diet quality, and demand a broad understanding across a variety of experiences.

Key words: food insecurity, obesity, overweight, low-income country, middle-income country

BACKGROUND

Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (Food and Agriculture Organization of the United Nations, 2008). Although the world has enough food to feed everyone (BRIDGE, 2014; World Health Organization, 2015a),
nearly 800 million people are unable to access enough food to meet their basic daily requirements (Food and Agriculture Organization of the United Nations, 2015), and the number of people whose full nutritional needs are unmet is much higher (Pinstrup-Andersen, 2009).

While food insecurity is a well-known cause of under-nutrition (Tanumihardjo et al., 2007) and stunting, in recent decades it has also been linked with obesity in high-income countries (Dinour et al., 2007; Franklin et al., 2012). Whether this relationship also exists in low- and middle-income countries (LMICs) is not clear and more research is needed (Hough and Sosa, 2015). The relationship between food insecurity and obesity in LMICs is the focus of this review.

The World Health Organization (WHO) defines obesity as a preventable condition where Body Mass Index (BMI) is higher than 30 kg/m² (World Health Organization, 2015b). Obesity increases the risk of several adverse health consequences—including cardiovascular disease, diabetes, cancer and poor pregnancy outcomes (Kamal et al., 2015; World Health Organization, 2015b). In high-income countries, obesity disproportionately affects socioeconomically disadvantaged populations (Franklin et al., 2012; Kamal et al., 2015). Obesity has been proposed to be a disease of affluence in LMICs (Kamal et al., 2015)—but socio-demographic risk factors for obesity in LMICs are complex (Subramanian and Smith, 2006) and appear to vary between countries (Jones-Smith et al., 2012). The majority of the increase in obesity globally is predicted to take place in LMICs (Wells et al., 2012). Understanding and thus minimising the risk factors for obesity in LMIC contexts, which often lack the health system capacity to treat the consequent obesity-related illnesses, is crucial.

An interplay of social and contextual factors determines whether food insecurity leads to underweight or to obesity. This is true both in developed and developing country contexts: Franklin et al.’s (2012) review of 19 Northern American studies on the association between food insecurity and obesity described the relationship between food insecurity and obesity as ‘non-linear’ and stressed that it relied on ‘mediators’ such as gender and marital status.

Realist review methodology was adopted in this review because it enabled us to analyse and organise the evidence from LMICs into a coherent scheme and compare this evidence to existing theories to provide a more nuanced understanding of the socio-demographic nature of the food insecurity–obesity relationship (Wong et al., 2013). Realist review is a theory-based approach which is focused on understanding the mechanisms (M) that explain the differing relationships between contextual factors (C) and outcomes (O)—referred to herein as CMO relationships. Realist reviews aim to provide policymakers with an understanding of the mechanisms by which (how) changed conditions (in this case differing levels of food insecurity) lead to outcomes (obesity), and how that relationship may vary in different contexts (Wong et al., 2013). This paper starts to elucidate the conditions that could cause food insecurity to lead to obesity in LMICs at different levels from societal to individual, by looking at the most important CMO relationships that arise in the literature.

METHODS
Identifying the research question
The review methodology was guided by Wong et al. (2013), who call for an iterative approach to the literature search and to focusing the review. We performed two rounds of literature searches, an initial search and a main search. Our initial research question sought to examine the association between food insecurity and obesity in adults and adolescents in the LMICs of the Asia-Pacific. We searched the Web of Science search engine with the terms ‘food insecurity’, ‘obesity’, ‘Asia’ and ‘Pacific’. We noticed a research gap in the Pacific, so we expanded the focus of the research question and of the main search to include literature from LMICs in other regions.

Search strategy and inclusion and exclusion criteria
In the main search PubMed, Web of Knowledge and Google Scholar were used to identify peer-reviewed journal articles that studied the relationship between food insecurity and obesity in LMICs. The search terms used were ‘food security’, ‘food insecurity’, ‘obesity’, ‘body mass index’, ‘food access’, ‘Asia’, ‘Pacific’, ‘developing country’, ‘low- and middle-income country’, ‘low-income country’ and ‘middle-income country’. In order to collect a range of recent evidence from LMICs, the review spanned papers published in the last decade (2006–2015 inclusive), however reference searching led us to include an additional key paper published in 2003 (Guilliford et al., 2003). Only English language papers were included. We included articles with adult and/or adolescent study populations, but not those with only children under 15. Wong et al. (2013) state that ‘providing the necessary evidence to demonstrate a theory is coherent and plausible does not necessarily require the unearthing of every document about that theory’.
The search was continued until it reached theoretical saturation (Wong et al., 2013).

Studies were appraised by screening for relevance and rigour (Pawson et al., 2005; Wong et al., 2013). Articles from LMICs that measured food insecurity and included overweight and/or obesity as outcome measures were deemed relevant. Rigour was assessed using the Critical Appraisal Skills Programme appraisal tool (CASP, 2013) for the review papers and an adaptation of the UK National Institute for Health and Care Excellence appraisal checklist, Appendix G (NICE, 2015) for the cross sectional papers (see Table 2 for details on each study type). Two authors assessed articles separately against this checklist and discrepancies were discussed and resolved.

Data extraction
Next, papers included in the final review were entered into a data extraction template containing the fields in Tables 1 and 2 below; as well as headings to record the context, mechanism and outcome factors described by each article.

A key tenet of realist synthesis is to draw from sections of documents which are relevant to the review question (Pawson et al., 2005), that is, ‘How could food insecurity lead to obesity in adult populations in low- and middle-income countries?’. For the multi-country cross-sectional papers we included (Tanumihardjo et al., 2007; Hough and Sosa, 2015), the review focused on the findings from LMICs. Similarly, for the one study which surveyed adult and child populations (Isanaka et al., 2007), we analysed the findings related to food insecurity and obesity in adults, but not children.

Formulating the initial theoretical framework
Once the data had been entered into the data extraction template, data were organised into CMO relationships through an iterative process of examining the data extraction template for patterns and debating the relationships amongst the research team, which included researchers who had previously published realist reviews; and in the areas of obesity, nutrition and food security. During this process, we took into account the following three theoretical frameworks; and considered which, if any, would be suitable to test and refine with evidence from our review (Wong et al., 2013).

1. Freedman et al.’s multicomponent model of nutritious food access (Freedman et al., 2013), which was developed in the USA with the aim of addressing the lack of a unifying conceptual model of nutritious food access.
2. Hendricks’ (2015) Continuum of food insecurity, coping strategies and interventions, which combines scales of food insecurity, coping strategies and suitable interventions. For example, a person who is experiencing ‘Acute hunger’ (the second most severe point on the food insecurity scale) is predicted to ‘Sell off productive assets’ (the strongest coping strategy on the scale), and an appropriate intervention for a person in this situation would be ‘Relief interventions: sell off food and other basic assets’.
3. The UNICEF framework for malnutrition (World Bank, 2016), which is a flowchart stemming from the three proximal (individual-level) causes of child stunting (inadequate food intake, low weight at birth and poor health status). The framework lists the household (inadequate food quantity and quality, low household resources, family size and structure, inadequate practices, inadequate healthcare, inadequate services) and community-level (economic social infrastructure, educational services, health services, water and sanitation services) factors which have influence on these proximal factors.

RESULTS
Review overview
The search was performed in March 2016. About 1090 titles were reviewed from PubMed, 79 from Web of Science and 1200 from Google Scholar. Through title screening, 335 articles were shortlisted due to their potential relevance to the research question. After reviewing the abstracts of the shortlisted papers, 64 articles were identified as potentially relevant to the research question and full text versions of these articles were reviewed. Seven additional articles were located by reference list screening of shortlisted articles and of these, two were included. Most exclusions were because articles were about food insecurity or obesity but not both; or because they were not LMIC focussed. None of the 13 articles were excluded due to poor quality as each met the minimum overall inclusion criteria for relevance and rigour (see Supplementary Table S1).

The review generated 13 peer-reviewed articles which added theoretical insight to potential associations between food insecurity and overweight/obesity in adults in LMICs, published between 2003 and 2015—although the majority (9) were published in or later than 2011. Of the 10 studies that reported empirical evidence (all single country cross-sectional studies), four found a positive association between food insecurity and obesity/overweight; five found no association; and the
<table>
<thead>
<tr>
<th>Study title</th>
<th>Country</th>
<th>Urban/rural (percentage, where published)</th>
<th>Gender</th>
<th>+ve/−ve/no association between FI and overweight/obesity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual Burden of Underweight and Overweight among Women in Bangladesh: Patterns, Prevalence, and Sociodemographic Correlates (2015)</td>
<td>Bangladesh</td>
<td>Predominantly rural (74%)</td>
<td>Female</td>
<td>No association</td>
</tr>
<tr>
<td>Food insecurity and the metabolic syndrome among women from low income communities in Malaysia (2014)</td>
<td>Malaysia</td>
<td>Both (51% rural)</td>
<td>Female</td>
<td>Negative</td>
</tr>
<tr>
<td>Nutritional outcomes related to household food insecurity among mothers in rural Malaysia (2013)</td>
<td>Malaysia</td>
<td>Rural</td>
<td>Female</td>
<td>No association</td>
</tr>
<tr>
<td>Obesity and household food insecurity: evidence from a sample of rural households in Malaysia (2005)</td>
<td>Malaysia</td>
<td>Rural</td>
<td>Female</td>
<td>Positive association between at-risk waist circumference and food insecurity; none between food insecurity and obesity.</td>
</tr>
<tr>
<td>Severe food insecurity is associated with obesity among Brazilian adolescent females (2012)</td>
<td>Brazil</td>
<td>Both (71% urban)</td>
<td>Female</td>
<td>Positive. Severe but not mild or moderate food insecurity was significantly and independently associated with excessive weight.</td>
</tr>
<tr>
<td>Mild but Not Light or Severe Food Insecurity Is Associated with Obesity among Brazilian Women (2011)</td>
<td>Brazil</td>
<td>Both (73% urban)</td>
<td>Female</td>
<td>Positive. There was an overall association between food insecurity and obesity for light and mild food insecurity but not severe food insecurity.</td>
</tr>
<tr>
<td>Household food insecurity, diet, and weight status in a disadvantaged district of Ho Chi Minh City, Vietnam: a cross-sectional study (2015)</td>
<td>Vietnam</td>
<td>Urban</td>
<td>Male and female</td>
<td>No statistically significant association</td>
</tr>
<tr>
<td>Food insecurity is highly prevalent and predicts underweight but not overweight in adults and school children from Bogota, Colombia (2007)</td>
<td>Colombia</td>
<td>Urban</td>
<td>Male and female (but review only included information about adult women [the mothers])</td>
<td>No statistically significant association</td>
</tr>
<tr>
<td>Food insecurity, food choices, and body mass index in adults: nutrition transition in Trinidad and Tobago (2003)</td>
<td>Trinidad and Tobago</td>
<td>Urban and peri-urban</td>
<td>Male and female</td>
<td>No association</td>
</tr>
</tbody>
</table>
remaining study found a negative association (Table 1). From the Asian studies: one reported a negative association, three reported no association and one study reported a positive association. Both Brazilian studies reported a positive association in some of their study populations.

A variety of methods were used to measure food insecurity in the single country cross-sectional studies—from surveys that had been extensively tested for internal validity in the study populations (Veláez-Melendez et al., 2011; Kac et al., 2012; Shariff et al., 2014)—to those that used very simple measures using just one question: ‘have you had to ask for food from your neighbours in the last 12 months?’ (Kamal et al., 2015) (Table 2). BMI was used to measure obesity/overweight by all 10 single-country cross-sectional studies: eight studies measured it directly and two measured it through self-reported weight and height (Table 2). No clear pattern between the level of rigor of measurement of food insecurity and BMI, and whether the studies reported a positive or lack of/negative association between food insecurity and obesity/overweight, was observed. Sample sizes for the single country cross-sectional studies ranged from just over 200 households (Shariff et al., 2014) to over 16 000 respondents (Kamal et al., 2015). We found no pattern between sample size and whether the studies reported a positive or lack of/negative association between food insecurity and obesity/overweight. No link between sex of the study participants and whether the studies reported a positive or lack of/negative association between food insecurity and obesity/overweight was found.

Summary
During the process of comparing emergent CMO relationships to existing theories, it became clear that Freedman et al.’s Multicomponent Model of Nutritious Food Access was the most appropriate pre-existing model upon which to anchor our analysis (Freedman et al., 2013). The model frames the relationship between food insecurity and obesity as a way to examine associations between the social determinants of health and obesity—which matches the premise for our review. Factors related to access to nutritious food are divided into ‘domains’ (in oval to left in figure below) and ‘dimensions’ (in rectangles to right). These domains and dimensions work across individual, community and country levels.

Five main mechanisms arose from our review explaining how food insecurity was or was not linked to obesity and overweight in LMICs. These were: (i) affordability of energy dense, processed foods; (ii) quantity and diversity of food consumed; (iii) spatial-temporal access to nutritious food; (iv) inter-personal

---

Table 1: (Continued)

<table>
<thead>
<tr>
<th>Study title</th>
<th>Country</th>
<th>Urban/rural (percentage, where published)</th>
<th>Gender</th>
<th>+ve/−ve/no association between FI and overweight/obesity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household food insecurity access: a predictor of overweight and underweight and underweight among Kenyan women (2014)</td>
<td>Kenya</td>
<td>Both</td>
<td>Female</td>
<td>Positive</td>
</tr>
<tr>
<td>Associations of economic and gender inequality with global obesity prevalence: Understanding the female excess (2012)</td>
<td>Obesity surveys from 74 countries</td>
<td>Both</td>
<td>Male and female</td>
<td>Not measured by this study</td>
</tr>
<tr>
<td>Poverty, Obesity, and Malnutrition: An International Perspective Recognizing the Paradox (2007)</td>
<td>Review of studies from high- and low-income countries</td>
<td>Both</td>
<td>Male and female</td>
<td>Presented some studies which showed a positive relationship</td>
</tr>
<tr>
<td>Food choice in low income populations—A review (2015)</td>
<td>Review of studies from high- and low-income countries</td>
<td>Not stated</td>
<td>Male and female</td>
<td>Presented some studies which showed a positive relationship</td>
</tr>
<tr>
<td>Title</td>
<td>Study type</td>
<td>Data source</td>
<td>Food insecurity (FI) prevalence, Obesity prevalence in study population</td>
<td>Method to measure food security; HH versus individual level</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>----------------------------------</td>
<td>------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>------------------------------------------------------------</td>
</tr>
<tr>
<td>Dual Burden of Underweight and Overweight among Women in Bangladesh: Patterns, Prevalence, and Sociodemographic Correlates (2015)</td>
<td>Country-specific cross sectional</td>
<td>2011 DHS (16 273 participants)</td>
<td>FI: 33%; Overweight: 13.5%; Obese: 2.9%</td>
<td>By asking the question, ‘have you had to ask for food from your neighbours in the last 12 months?’, four categories of answers; Household level</td>
</tr>
<tr>
<td>Food insecurity and the metabolic syndrome among women from low income communities in Malaysia (2014)</td>
<td>Country-specific cross sectional</td>
<td>Primary study (62.5 households)</td>
<td>FI: 78.4%; Overweight: 3.5%; Obese: 235</td>
<td>Radimer/Cornell Hunger and Food Insecurity instrument; Household level</td>
</tr>
<tr>
<td>Nutritional outcomes related to household food insecurity among mothers in rural Malaysia (2013)</td>
<td>Country-specific cross sectional</td>
<td>Primary study (223 households)</td>
<td>FI: 83.9%; 52% overweight or obese</td>
<td>Radimer/Cornell hunger and food insecurity instrument; Household level</td>
</tr>
<tr>
<td>Obesity and household food insecurity; evidence from a sample of rural households in Malaysia (2005)</td>
<td>Country-specific cross sectional</td>
<td>Primary study (200 households)</td>
<td>FI: 58%; Overweight: 21.5%; Obese: 27.5%</td>
<td>Radimer/Cornell Hunger and Food Insecurity Instrument; Household and individual levels</td>
</tr>
<tr>
<td>Severe food insecurity is associated with obesity among Brazilian adolescent females (2012)</td>
<td>Country-specific cross sectional</td>
<td>2006–2007 DHS (1529 participants)</td>
<td>FI: 40.8%; overweight 12.9% and obesity 9%</td>
<td>Brazilian Food Insecurity Scale—validated for Brazilian use but the scale reflects a relative measure of the conditions experienced by all individuals living; Household level</td>
</tr>
<tr>
<td>Mild but Not Light or Severe Food Insecurity Is Associated with Obesity among Brazilian Women (2011)</td>
<td>Country-specific cross sectional</td>
<td>2006–2007 DHS (10 226 participants)</td>
<td>FI: 40.9%; Overweight: 29%; Obesity: 17.4%</td>
<td>Brazilian Food Insecurity Scale—validated for Brazilian use; Household level</td>
</tr>
<tr>
<td>Household food insecurity, diet, and weight status in a disadvantaged</td>
<td>Country-specific cross sectional</td>
<td>Primary study (250 households)</td>
<td>FI: 34.4%; 42.4% overweight or obese</td>
<td></td>
</tr>
</tbody>
</table>

(continued)
## Table 2: (Continued)

<table>
<thead>
<tr>
<th>Title</th>
<th>Study type</th>
<th>Data source (sample size)</th>
<th>Food insecurity (FI) prevalence, Obesity prevalence in study population</th>
<th>Method to measure food security; HH versus individual level</th>
<th>Outcome(s) measured and methodology; BMI cut-off</th>
</tr>
</thead>
<tbody>
<tr>
<td>district of Ho Chi Minh City, Vietnam: a cross-sectional study (2015)</td>
<td>Country-specific cross sectional</td>
<td>Primary study (2359 households)</td>
<td>FI: 76%; 25% of mothers overweight but not obese; 6% obese</td>
<td>Latin American and Caribbean Household Food Security Scale (ELCSA) tool; Household level</td>
<td>BMI: Self-reported weight and height; BMI ≥23 kg/m² for overweight or obese</td>
</tr>
<tr>
<td>Food insecurity is highly prevalent and predicts underweight but not overweight in adults and school children from Bogota, Colombia (2007)</td>
<td>Country-specific cross sectional</td>
<td>Primary study (631 participants)</td>
<td>FI: 2.5%; 34% overweight, 26% obese</td>
<td>Blumberg et al.’s short form of the Household Food Security Scale; Household level</td>
<td>Measurements of height and weight were taken by the nutritionists and food demonstrators from the Nutrition Division of the Ministry of Health; ≥25 kg/m² for overweight and ≥30 kg/m² for obese</td>
</tr>
<tr>
<td>Food insecurity, food choices, and body mass index in adults: nutrition transition in Trinidad and Tobago (2003)</td>
<td>Country-specific cross sectional</td>
<td>Primary study with structured questionnaire (649 participants)</td>
<td>70.1% severely food insecure, 21.9% were moderately food insecure, and 4% were mildly food insecure; Overweight: 26.0%, Obese: 9.1%</td>
<td>Household Food Insecurity Access Scale; Household level</td>
<td>BMI: Measured by research team; ≥25 kg/m² for overweight and not given for obese</td>
</tr>
<tr>
<td>Household food insecurity access: a predictor of overweight and underweight and underweight among Kenyan women (2014)</td>
<td>Country-specific cross sectional</td>
<td>Primary study with structured questionnaire (649 participants)</td>
<td>FI: Not reported; Obesity estimate: 10.4%</td>
<td>Not measured by this study</td>
<td>Secondary data with obesity prevalence as outcome</td>
</tr>
<tr>
<td>Associations of economic and gender inequality with global obesity prevalence: Understanding the female excess (2012)</td>
<td>Multi-country cross-sectional study</td>
<td>Obesity data from International Obesity Task Force website; social and demographic data from individual country surveys (74 countries)</td>
<td>FI: Not reported; Obesity estimate: 10.4%</td>
<td>Not measured by this study</td>
<td>Secondary data with obesity prevalence as outcome</td>
</tr>
<tr>
<td>Food choice in low income populations—A review (2015)</td>
<td>Review</td>
<td>‘papers published in 23 different journals’</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Poverty, Obesity, and Malnutrition: An International Perspective Recognizing the Paradox (2007)</td>
<td>Review</td>
<td>Peer-reviewed and grey literature</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
food choice and distribution; and (v) non-dietary behaviours. These mechanisms broadly align with the domains in Freedman et al.’s framework (Figure 1) but have been reconfigured to present in realist terms (Wong et al., 2013) in Figure 2 and in the text below the most pertinent insight from LMICs from the existing literature. Numerous relationships between these five mechanisms (M) and contextual factors (C) (the coloured lines in Figure 2), were identified to be potentially influential in the development of overweight/obesity or not (the outcome [O]). These CMO relationships explain how the association between an individual’s food insecurity status and obesity risk could be modified by different household and community-level and country-level contextual factors.

**Mechanism 1: affordability of energy dense, processed foods**

All 13 research articles reported the influence of type of food consumed to be relevant to the relationship between food insecurity and obesity, and four studies presented evidence directly from their study populations (Guilliford et al., 2003; Shariff and Khor, 2005; Isanaka et al., 2007; Vuong et al., 2015). The most common food types discussed were energy-dense, heavily processed foods. The studies which found a positive relationship between food insecurity and obesity proposed high consumption of energy dense, heavily processed foods as a reason for increased BMI amongst food insecure groups (Shariff and Khor, 2005; Velásquez-Meléndez et al., 2011; Kac et al., 2012; Keino et al., 2014). Shariff and Khor (2005) empirically compared type of food consumed between food secure and food insecure groups and found that food insecure groups had higher energy intake than the food secure group, although the difference was not statistically significant. On the other hand, three studies that found a negative or lack of relationship between food insecurity and obesity suggested that energy dense foods and/or beverages were consumed in equal or lower amounts in food insecure groups and found that food insecure groups had higher energy intake than the food secure group, although the difference was not statistically significant. On the other hand, three studies that found a negative or lack of relationship between food insecurity and obesity suspected that energy dense foods and/or beverages were consumed in equal or lower amounts in food insecure compared to food secure participants (Guilliford et al., 2003; Kamal et al., 2015). For example, Isanaka et al. (2007) found that households that experienced food insecurity consumed less commercially processed snacks and high-fat foods than food secure ones.

Economic accessibility of high-energy, processed foods is a major reason for their consumption (Tanumihardjo et al., 2007; Kac et al., 2012; Hough and Sosa, 2015). Affordability of high-energy, processed foods was thus identified as a main mechanism which determined whether or not food insecurity leads to obesity in LMICs. This mechanism aligns with Freedman’s et al.’s ‘Economic access’ domain (Freedman et al., 2013).

Food pricing and income levels emerged as the most important contextual factors to influence affordability of these foods. Those studies which showed a positive relationship between food insecurity and obesity were more likely to come from settings where high-energy, commercially processed foods were low-cost. This was articulated by Kac et al. (2012), who stated: ‘it seems that only when the nutrition transition reaches a stage at which energy-dense foods become available at affordable prices does food insecurity become a risk factor for overweight or obesity’. Consumption of these foods is likely to increase if they are cheaper than more nutritious foods in local markets; or included in food aid or subsidy programs (Tanumihardjo et al., 2007). There was a tendency for studies which reported a lack of, or a negative association, between food insecurity and obesity to be either from lower-income countries at the start of the nutrition transition (Kamal et al., 2015)— or from disadvantaged communities within MICs with income levels too low to access obesogenic diets (Isanaka et al., 2007; Shariff et al., 2014; Vuong et al., 2015).

**Mechanism 2: quantity and diversity of food consumed**

Quantity and diversity of food consumed was proposed to be linked to obesity in food insecure individuals via three pathways. In one, changes in diet diversity (i.e. proportionate quantities) led to a weight gain-
promoting intake ratio of foods high in energy, compared to foods high in other nutrients (Shariff and Khor, 2005). In that study, diet diversity score decreased as food insecurity worsened. Second, cycles of food under-consumption caused by food insecurity may lead to periods of over-consumption which can cause obesity (Shariff et al., 2014). The third proposed pathway involved metabolic adaptations which lead to storage of more body fat as a result of variations in eating patterns (Kac et al., 2012).

When this mechanism was viewed through the lens of Freedman et al.'s ‘Service delivery’ domain, the ‘Quality and variety of foods sold’ dimension (Freedman et al., 2013) was of some relevance in our review, although the literature tended to focus on this from the perspective of food quantity consumed by individuals, as opposed to exploring in detail what food was available in markets.

The contextual factors that appeared to modify the action of food quantity and diversity on obesity in LMICs were: level of chronicity of food insecurity; age; and food price. Shariff et al. (2014) proposed that the negative relationship seen between food insecurity and obesity in their study could be explained by households experiencing chronic (i.e. consistent) rather than sporadic or fluctuating food insecurity. At the individual level, age may affect the amount of time an individual has been living in a particular food insecure environment. Food price can lead to unbalanced quantities of food consumption—with higher than recommended

---

**Fig. 2. Context-mechanism interactions.**
intake of energy dense foods and suboptimal proportions of more nutritious foods such as fruit and vegetables. Hough and Sosa’s 2015 review cited findings of a WHO and Food and Agriculture Organization workshop; and a food pricing study from three low-income communities in South Africa—and both demonstrated that cost is a major barrier to fruit and vegetable consumption in LMICs.

**Mechanism 3: spatial-temporal access to nutritious food**

Distance lived from food sources, and physical ability to travel that distance, were proposed to influence the relationship between food insecurity and obesity in our review but the evidence was sparse. This mechanism is aligned with the Spatial-temporal domain in Freedman et al.’s framework (Freedman et al., 2013).

Guilliford et al.’s (2003) study in Trinidad and Tobago, which found a strong statistical association between physical limitation and food insecurity, noted that physical disability may limit an individual’s ability to access food, both financially and physically. Keino et al.’s (2014) study in Kenya found a positive relationship between food insecurity and obesity, and that urban women were more likely to be obese. The study did not empirically measure the role of physical activity in these relationships, but the authors proposed that physical activity levels influenced by proximity to food markets could be a contributing factor here as rural women were often required to travel further to access shops and other amenities.

**Mechanism 4: inter-personal distribution of food**

Human behaviour around food choice and food distribution was found to have important influence on obesity risk amongst food insecure individuals in LMICs. This mechanism is encompassed by Freedman et al.’s Social access domain, in particular the ‘Cultural foodways, traditions and norms’ and ‘Discriminatory practices reducing access’ dimensions (Freedman et al., 2013).

Cultural acceptability and social attitudes towards food consumption and distribution are the predominant contextual factors affecting this mechanism.

The high level of social acceptance of energy-dense foods is a reason why they are often distributed as part of food subsidy programs (Hough and Sosa, 2015), which may in turn lead to obesogenic overconsumption of energy. Showing the reverse of this, Vuong et al. (2015), who found no correlation between food insecurity and increased BMI, suggested that this could have been because lower income, food insecure populations in urban Vietnam were ‘relatively “conservative” with respect to the consumption of Western-style foods and potentially more “faithful” to traditional foods, contributing to very low consumption proportions of the Western-style [energy dense, processed] foods’—a mechanism previously described by Le (2008).

Distribution of food between household or community members, often influenced by cultural and social norms, can exaggerate or downplay the individual effect of household food insecurity. For example, one or more household member may absorb food availability stress by allocating healthy food to other household members (Kac et al., 2012). Age is likely to play a role here: Kac et al. (2012) proposed that the association found between food insecurity and excess weight in adolescent women severely food insecure participants only—compared to the link seen between moderate food insecurity and obesity in adult populations in Brazil Velásquez-Meléndez et al. (2011)—could be explained by parents in food insecure households sheltering their children from food insecurity.

Additional contextual factors suggested to influence food distribution within households were gender and marital status. Keino et al. (2014) reported that married women living in male-headed households were more likely to be overweight than single, divorced or separated women in female-headed households, but did not describe a clear causation pathway for this relationship.

**Mechanism 5: non-dietary behaviours**

The review identified one variable operating at the individual level that can downplay or exacerbate the effect of food insecurity on obesity risk: physical activity level. This fits within the ‘Health status’ dimension of Freedman et al.’s (2013) Personal access domain.

The relationship between food insecurity and physical activity levels is likely to be multi-directional. Shariff and Khor (2005) attributed physical inactivity as a contributing co-factor to the positive relationship seen between food insecurity and obesity because food insecure participants spent less time doing physical leisure activities. Kac et al. (2012) proposed that physical inactivity could have been a contributing factor in the association between food insecurity and obesity in the Brazilian adolescent females in their study, but did not directly measure physical activity levels in their study population. This mechanism was not discussed in enough detail to examine contextual factors, aside from the effect of rural versus urban residence on...
physical activity levels which was discussed under Mechanism 3.

DISCUSSION
Context–mechanism–outcome relationships
This review sought to understand how the interplay between certain contextual factors and mechanisms could determine whether food insecure populations will become obese or not. Affordable access to high-energy, processed foods (Mechanism 1) and variation in food quantity and diversity (Mechanism 2) were identified as dominant mechanisms.

Thirteen studies were included in the review—11 cross-sectional studies (10 single-country and one multi-country); and two review articles. The two review articles and the multi-country cross-sectional study brought a broad overview perspective which was helpful in orientating our analysis; as well as some specific insights to the CMO relationships described. Among the country-specific cross-sectional studies, a fairly even number of articles reported positive (four)—as negative (one) or no association (five)—between food insecurity and overweight/obesity (Table 1). In the reviewed studies, there was no clear divide in the relationship between food insecurity and obesity between low- and middle-income countries; region the study was based in; method used to measure food security; sample size; or gender of study population. This is likely to be because differences in the relationship between food insecurity and obesity depend upon the interplay between the mechanisms and context-specific factors described in this review, and probably additional mediators that have not yet been uncovered by the small amount of research in this area to date.

Five generative mechanisms emerged which appeared to moderate the link between food insecurity and obesity in LMICs. As mentioned above, coverage of evidence ranged from broad (mechanism 1, which was discussed by every article), to medium (mechanisms 2 and 4), to sparse (mechanisms 3 and 5). Assessing the strength of evidence about generative mechanisms in realist reviews has its challenges—owing to their theoretical nature, they are not possible to measure directly (Wong et al., 2013), and this may in part explain the low level of empirical evidence for each mechanism in our review. It is, however, possible to use available evidence to analyse and prioritise the importance of mechanisms in relation to each other (Wong et al., 2013) and the studies included in this review allowed us to start to do this for the first time using evidence from LMICs.

While the premise behind mechanism 1—that if food insecure populations are more likely to have affordable access to high-energy, processed foods, food insecurity can lead to obesity in LMICs—is very likely, there is currently insufficient empirical evidence from LMICs to validate it. Nonetheless, this mechanism is likely to have importance in LMICs and should be a focus area for future research for two reasons. The first reason is the suggestion of the importance of this mechanism by all study authors in our review. The second reason is that there were similarities between this mechanism as proposed by publications in our review and the broader global literature. For example, the suggestion by one study that food subsidy programs in LMIC contexts (the example of Mexico was used), unless very carefully designed to include non-obesogenic food types, may contribute to obesity (Tanumihardjo et al., 2007) resonates the findings of two studies in Franklin et al.’s (2012) USA review.

Variation in food intake quantity and diversity (the second mechanism described in this review) was suggested by numerous studies to have a role in the food insecurity-to-obesity relationship. Length of time an individual or household is exposed to food insecurity, and price of food, are likely to be the two most important contextual factors to influence this mechanism. Skipping breakfast, another form of irregular food consumption, has been linked to overweight and obesity in Asian and Pacific populations (Horikawa et al., 2011)—and that study proposed the underconsumption–overconsumption cycle and metabolic adaptations as possible causation pathways.

The need for more research into mechanisms 1 and 2 is summarised well by Tanumihardjo et al. (2007), who emphasise that in order to strengthen policy, intervention and research efforts, it is important to understand ‘the ramifications of having a diet that provides adequate or excessive energy yet insufficient diversity and nutritional quality’. This is echoed by the two main reviews which have studied the food insecurity-obesity relationship in the USA (Dinour et al., 2007; Franklin et al., 2012).

Inter-personal distribution of food (mechanism 4) is in theory an important mechanism to consider in the LMIC context, owing to the myriad and varied cultural practices and traditions which influence food consumption and distribution. Contextual factors which are likely to affect the relationship between food insecurity, inter-personal distribution of food and obesity are social and cultural acceptability, gender, age and possibly marital status—but coverage of each factor by the reviewed studies was weak with each discussed by only one or
two studies, making them difficult to prioritize. Nonetheless, the suggestion that individuals who are older than others within their household are likely to reallocate the more nutritious food resources to younger household members may predispose older people to obesity (Kac et al., 2012) has been previously described in the literature from the USA and has been termed the ‘sacrifice theory’ (Franklin et al., 2012).

Spatial–temporal access to nutritious food (mechanism 3) and non-dietary behaviours (mechanism 5) were each only discussed by a handful of studies as being influential in whether or not food insecurity leads to obesity—presenting another research gap for LMICs.

Gender is a contextual factor deserving of highlighted attention in this policy space. Household nutritional status is positively influenced by women’s level of control over household finances (UNICEF, 2011). Women worldwide disproportionately experience food insecurity (BRIDGE, 2014), 60% of undernourished people worldwide are female (Asian Development Bank, 2013), and worldwide obesity prevalence is 50% higher in women than in men (Wells et al., 2012). Women may also be more vulnerable to the poor health outcomes associated with food insecurity due to physiological differences which may predispose women to obesity (Power and Schulkin, 2008). Franklin et al. (2012) described consistent links between food insecurity and obesity in females in their US review, whereas the link was less clear for men. This is backed by other research from high-income countries: a study in France found food insecurity was associated with obesity in women but not men (Martin-Fernandez et al., 2014). Dinour et al.’s (2007) review found the relationship between food insecurity and obesity to be strongest for adult women.

Food access framework
Overall we found that our evidence from LMICs fit within Freedman et al.’s food access framework—all domains in the framework except for the service delivery domain emerged as relevant to the relationship between food insecurity and obesity in LMICs. Notably, economic access to nutritious foods emerged as being of considerable importance in our review as well as in the food access framework. But while our results were generally aligned with Freedman et al.’s framework, there were some differences in focus, or assumptions of relevance behind the ‘domains’. These can largely be attributed to the fact that Freedman et al.’s framework was developed in a high-income setting. For example, when mechanisms 1 and 2 were examined through Freedman et al.’s framework, it became apparent that store incentives, service provided by staff and food presentation were not focused on by the studies in our review.

Freedman et al.’s model also helped identify an important research gap in LMICs: when analysing mechanism 5 in relation to Freedman et al.’s model, we found that the ‘Food and nutrition knowledge’ dimension was not explored in enough depth by the studies in our review to incorporate into a CMO relationship. The role of education in obesity prevention is of vital importance in LMICs (Jones-Smith et al., 2012).

Measuring food security
Despite variations in definitions, we were still able to perform meaningful analysis as a shared characteristic of the least food secure people in all reviewed articles was a lack of empowerment to make optimal food choices. As Hendricks (2015) points out, the notion of food security is complex and crosses multiple disciplines, including economics, health and sociology, so it is unsurprising that there is not yet an internationally agreed upon tool or measurement system to measure it (FAO, 2015). There was significant variation in tools and methods for measuring presence and degree of food insecurity between the studies in our review (Table 2). Because of this, our analysis was at the level of some degree of food insecurity existing or not—it was not possible to look for patterns in the results between studies that reported mild, moderate or severe food insecurity.

There is a tendency for consistency in food security measurement to be present when comparing studies from the same country in our review, however it would be useful to continue to strive towards international consensus on the measurement of food security. Another challenge of current food security measurement tools is their ability to distinguish between acute and chronic food insecurity (Franklin et al., 2012) and changes in levels of food security with time (Hendricks, 2015). The ability to do so is important, especially given the relevance of level of chronicity of food insecurity to Mechanism 2 in this review.

The CMO relationships that emerged in our review operated across individual, community and country levels, which reflects the real-life effects of food insecurity. Despite this, the review’s studies measured food insecurity at the household level, which is a sub-optimal platform from which to study mechanisms that operate at the individual level such as the effect of stress on individual patterns of food consumption, and this should be taken into account in any research that studies such mechanisms more deeply.
Limitations
Our review was limited by challenges with gathering empirical evidence to support the CMO relationships, and the complexities of food security measurement which are discussed above.

It is ideal for realist reviews to include various study types in order to present a 'rich picture' of the evidence (Pawson et al., 2005). Although our search strategy was open to all types of research study, the majority of included studies were cross-sectional. The limitations of cross-sectional studies, namely, that they present evidence from a snapshot in time and not the food insecurity–obesity relationship is a continuum, were widely acknowledged by the studies in our review. Ours was not the only review with this challenge: Franklin et al.'s (2012) review also included mainly cross-sectional studies. Further research in this area should use a longitudinal study design wherever possible, with detailed qualitative information about food selection behaviour.

All studies used BMI to measure weight status. BMI is an imperfect measure of obesity as it does not measure body fat, and there is a lack of consensus over the cut-off for different ethnicities. There was minor variation in cut-off points used for BMI to indicate obesity and overweight (Table 2) and two articles in our review (Isanaka et al., 2007; Vuong et al., 2015) used self-reported weight data, which could have led to under- or over-reporting of BMI. Despite these limitations, BMI is a convenient and relatively reliable proxy measure for obesity at the population level and in such research environments as in our included studies, BMI is an appropriate measure of obesity.

Recommendations for future research
The way we measure food access–obesity relationships needs further research. In-depth studies which collect detailed information about food choices and dietary intake, as well as prospective studies which collect data over multiple points in time, are likely to deepen understandings of the mode of action of these relationships. New frameworks for studying food access, like that proposed by Penney et al. (2015), which will give a framework to answer questions around how, for whom, and under what circumstances a change in food availability influences diet, are likely to also assist in making sense of the complexities of the food insecurity–obesity relationship in different contexts.

CONCLUSIONS
The relationships between socio-demographic factors, food security and obesity are complex and depend upon the country’s stage of the nutrition transition. Our review provides an initial framework for policy makers and researchers to identify which mechanisms and contextual factors may be at play in different food insecure populations in LMICs. Despite the limited empirical evidence available, our review presents meaningful and policy-relevant insights into the food insecurity–obesity relationship in LMICs, which should also be of use in designing future research. Affordability of high-energy, processed foods was identified as a main mechanism which determined whether or not food insecurity leads to obesity in low- and middle-income countries. This mechanism is likely to work in varying combinations with the other context–mechanism relationships described, depending on the contextual factors present.

In many settings such as the Asia Pacific region, ‘the most fundamental food crisis ... is one of poor diets, and this affects the obese just as much as the undernourished’ (Weinberger et al., 2009). Countries at the early stages of the nutrition transition have the opportunity to learn from the experiences of other countries to stop their populations from shifting from underweight to obese in less than one generation. Interventions to address the food insecurity–obesity link need to address diet quality, and demand a broader understanding across a variety of experiences than interventions addressing underweight, which are more narrowly focused on fixing the dietary energy gap (Hendricks, 2015). There is an urgent need to ensure consistent access to balanced diets that meet nutrient and fruit and vegetable requirements, especially for those with socio-demographic barriers. The socio-demographic mechanisms involved in obesity development are just as, or more, important to understand than the physiological mechanisms, especially in LMIC settings which simply do not have the health system capacity to treat the growing burden of obesity and consequent diseases. We need to look beyond clinical settings and work across multiple platforms, including food markets, cultural norms, intra- and inter-household economics and education.

SUPPLEMENTARY MATERIAL
Supplementary material is available at Health Promotion International online.

FUNDING
Penny Farrell was funded by an Australian Postgraduate Award Scholarship.
### REFERENCES


sity, and malnutrition: an international perspective recogniz-


Chapter 4: Paper 2

Associations between sociodemographic and behaviour factors, and dietary risk factors for overweight and obesity, in Samoan women

Penny Farrell\textsuperscript{a,}\textdagger, Joel Negin\textsuperscript{a}, Mamaru Awoke\textsuperscript{b}, Anne Marie Thow\textsuperscript{c}, Malaefono Tua\textsuperscript{d}, Taiaopo Faumuina\textsuperscript{d}, Seema Mihrshahi\textsuperscript{e}, Pavle Vizintine\textsuperscript{e}, Justin Richards\textsuperscript{a}

\textsuperscript{a} Sydney School of Public Health, Edward Ford Building A27, The University of Sydney, NSW, 2006, Australia
\textsuperscript{b} Amref Health Africa, P.O. Box 1702, Addis Ababa, Ethiopia
\textsuperscript{c} Menzies Centre for Health Policy, Charles Perkins Centre D17, The University of Sydney, NSW, 2006, Australia
\textsuperscript{d} Samoa Bureau of Statistics, P.O. Box 1151, Apia, Samoa
\textsuperscript{e} National University of Samoa Chancellery, P.O. Box 1622, Le Papaigalagala Campus, To’omatangi, Samoa

\textbf{ARTICLE INFO}

\textbf{Keywords:}
Samoa
Pacific
Women
Diet
Obesity
Demographic

\textbf{ABSTRACT}

Adults in Samoa have the third highest obesity prevalence in the world, and the prevalence is higher in women than men. The nutritional status of a household in most low- and middle-income countries is positively influenced by the level of control women have over financial resources. Our analysis examined how consumption of specific dietary groups was associated with different sociodemographic and individual health risk factor groups for women who participated in the 2014 Samoa Demographic and Health Survey.

Our research question was explored through multivariate analysis of the 2014 Samoa Demographic and Health Survey dataset. The sociodemographic and health behaviour groups included in our analysis were: urban vs. rural residence, wealth quintile, education level, participation in physical activity program, lives with husband/partner, household size, parity, age, smoking, and alcohol consumption. The following diet variables were included: fruit, vegetables, seafood, high-fat food, sugary drinks, high-salt food, and high-sugar food consumption.

There was a high prevalence of unhealthy food consumption and unhealthy dietary patterns among a) a large proportion of the population, and b) across sociodemographic and health behaviour groups, with a higher prevalence of particular at-risk patterns in some specific groups including women of younger age and women of higher wealth.

Our analysis highlighted some specific opportunities for policy action, including the need to create an enabling environment for healthier food consumption for Samoan women.

1. Introduction

1.1. Burden and causes of obesity

The global burden of non-communicable diseases is rapidly increasing and is predicted to account for nearly three-quarters of deaths worldwide by 2020 (\textit{WHO}, 2018a). Over 85% of deaths from non-communicable diseases occur in low- and middle-income countries (\textit{WHO}, 2017) – leading to significant personal and societal loss and increasing pressure on health systems and national economies. Obesity is a preventable condition that increases the risk of many non-communicable diseases including cardiovascular disease, diabetes and several types of cancer (Kyrgiou et al., 2017; \textit{WHO}, 2015). Adults in Samoa, a Pacific Island country of approximately 200,000 people, have the third highest obesity prevalence in the world (43%) (\textit{IFPRI}, 2016) – with a prevalence as high as 75% for women in their thirties (\textit{SBS}, 2016).

Diet is a well-known contributor to obesity (\textit{SBS}, 2016; \textit{WHO}, 2003) and the 2016 \textit{Global Nutrition Report} stated that “malnutrition and diet are now the largest risk factors for the global burden of disease” (\textit{IFPRI}, 2016). For more than fifty years, diets in the Pacific Island region, and notably in Samoa, have been transitioning rapidly away from traditional subsistence-based diets high in seafood, fruits, nuts, root crops and leafy green vegetables towards processed, energy-dense, and often imported foods such as rice, sugar-sweetened beverages and white flour (Thow et al., 2011). Because these diets often contain above-
recommended amounts of fat, simple carbohydrates, sugar and salt, they are contributing to the increasing burden of non-communicable diseases (Charlton et al., 2016; DiBello et al., 2009; Seiden, Hawley, Schulz, Raifman, & McGarvey, 2012).

1.2. Identifying those most at risk

To develop policies and programs for overweight and obesity prevention, it is important to know what makes people vulnerable to dietary causes of obesity in particular contexts. Studying the sociodemographic patterns of diet and obesity using country-specific data is a way to identify those most at risk of non-communicable diseases and to develop and eventually evaluate targeted policies for their prevention. A 2015 systematic review showed that sociodemographic barriers to healthy food consumption are a key mechanism in the development of obesity in low- and middle-income countries (Hawkes et al., 2015), and a 2006 study from Samoa reported that high socioeconomic status was associated with increased odds of obesity (Ezeamama, Viali, Tuitele, & McGarvey, 2006). However, while the associations between sociodemographic and dietary risk factors for obesity are well documented and have proven importance for health policy and programs in high-income countries, our understanding of these relationships in low- and middle-income countries is limited (Allen et al., 2017; Hough & Sosa, 2015). Because of variation among and within low- and middle-income countries (Sengupta, Angeli, Syamala, Dagnelie, & van Schayck, 2015), analyses of contemporary, context-specific data on the population patterns of non-communicable diseases and their risk factors is a crucial step in designing prevention programs and policies (Ebrahim et al., 2013; Subramanian, Perkins, Ozaltin, & Davey Smith, 2011).

Women in low- and middle-income countries have an obesity prevalence up to double that of men (WHO, 2018b), and the nutritional status of a household is positively influenced by the level of control women have over financial resources (UNICEF, 2011). Several studies conducted in high-income countries have reported the link between lack of access to nutritious food and likelihood of developing obesity to be stronger in women than in men (Franklin et al., 2012; Martin-Fernandez, Caillavet, Lhuissier, & Chauvin, 2012). Increased Body Mass Index (BMI) in mothers is a strong predictor of overweight and obesity in their offspring, and optimal BMI in mothers is protective of childhood overweight and obesity (Williams, Mackenzie, & Gahagan, 2014).

1.3. Study overview

In order to inform policy to address these fundamental challenges, we used the 2014 Samoa Demographic and Health Survey (DHS) dataset to examine associations between sociodemographic and health risk factor groups (the independent exposure variables), and diet (the outcome). Our analysis aimed to answer the following overarching question for Samoan women of reproductive age: which of each specified sociodemographic or health behaviour group are more fruit, vegetables, high-fat foods, salty foods, high-sugar foods, high-sugar beverages, and seafood, and healthy foods in combination, compared with the women in the referent sociodemographic or health behaviour group?

2. Materials and methods

2.1. Data collection for 2014 Samoa demographic and Health Survey

We conducted secondary analysis of data collected by the Samoa DHS: a cross-sectional survey conducted in Samoa in 2014. Data collection for the 2014 Samoa DHS adopted a two-stage cluster sampling design based on the master sample frame from the 2011 Samoa Population and Housing Census (SBS, 2016). In the first stage, clusters were identified from the master sample; and in the second stage, households were systematically selected for participation from each cluster. In our analysis, the dataset was weighted to be nationally representative. Each model was adjusted for the differences between the four census regions in the Samoa DHS survey (Apia Urban area, North West Upolu, the Rest of Upolu, and Savaii) (SBS, 2016).

The seven dietary variables were measured as follows: For i) fruit and ii) vegetable consumption, respondents were asked how many serves they ate per week. One serve of fruit or vegetables was described during the interview as an adult's fist size. For iii) fish/seafood, iv) fried/high fat foods, v) sugary drinks, vi) high-salt foods, and vii) high-sugar foods, respondents were asked how frequently each was consumed and responses were categorised into one of the following groups: a) Never, b) Once a week, c) Twice a week, d) Three or more times per week.

2.2. Data analysis

Multivariate analysis was used to answer our research question. The study sub-sample used for our analysis included all women aged 15–49 who participated in the 2014 Samoa DHS. We focussed on women of reproductive age because of the high prevalence of obesity reported in this age group in Samoa (SBS, 2016), and because of the association between maternal and childhood obesity described by previous research (Williams et al., 2014). The number of included participants was 4805.

The following sociodemographic and health behaviour variables were included in our analysis because of their potential to influence diet behaviour (referent categories in brackets): age 30 to 49 (15–29), urban residence (rural), rich and richest wealth quintile (poorest, poor and middle), tertiary and vocational education (primary and secondary), smokes (does not smoke), drinks alcohol (does not drink alcohol), participates in government physical activity program (does not participate), lives with husband/partner (does not live with husband/partner), household size of 7–33 members (0–6 members), and has had children (has not had children). The wealth quintiles were created using information on household ownership of consumer items such as television or car ownership, and dwelling characteristics including sanitation facilities. More details can be found in the Government of Samoa DHS 2014 Report (SBS, 2016). The urban category was the same as the ‘Apia Urban area’ census region mentioned above, and the rural category consisted of the ‘North West Upolu’, ‘Rest of Upolu’, and ‘Savaii’ regions (SBS, 2016). Parity was categorised into the groups 0 children vs. 1 or more children as previous research has shown that maternal weight gain sets in with the first birth and the effect doesn’t increase with subsequent pregnancies (Abrams, Heggeseth, Rechkopf, & Davis, 2013).

The dietary variables included in our analysis were fruit, vegetables, seafood, high-fat food, sugary drinks, high-salt food, and high-sugar food consumption. Further details on these categories are included in the Supplementary Table. Variables were dichotomised into consumption of 0–1 times vs. 2 or more times; and 0 to 6 serves vs. 7 or more serves per week for fruit and vegetables. In the linear regression analysis for association between sociodemographic or health behaviour factors and vegetable and fruit consumption, fruit and vegetable consumption were analysed as continuous variables.

To study clustering of healthy diet patterns further we created a new “healthy diet” variable. We drew on WHO dietary guidelines (WHO, 2015), adapted for the limitations of the variables available in the dataset. Our algorithm for healthy diet divided women into two groups: 1) those who ate high sugar foods less than three times a week, fried/high fat foods less than three times a week, sugary drinks less than three times a week, fruit seven or more times a week, and vegetables seven or more times a week; and 2) those who did not meet these criteria.

For each logistic regression model, we performed the following analysis steps: Step 1) bivariate analysis models with each input variable and the outcome variable; Step 2) multivariate analysis including those variables that returned p-values ≤ 0.05 in the bivariate analysis;
and Step 3) a final, “best fit” multivariate analysis including the variables that had returned p-values less than 0.05 in Step 2 (where there was more than 1 variable remaining). The results were tabulated and are presented in the Results section. For the linear regression model, two steps were performed: Step 1) A multilinear regression model with all variables included; and Step 2) A multilinear regression model including the variables that had returned p-values less than 0.05 in Step 1. In order to ensure the results were nationally representative, our analyses were adjusted for the different strata, clusters and sample weights in the DHS survey. Analyses were performed using SPSS version 23 (IBM Analytics - Australia) and STATA SE version 14.1 (Stata Corporation, College Station, Texas, USA).

2.3. Ethics and permissions

The 2014 Samoa DHS was conducted by the Samoa Bureau of Statistics – the official data collection agency of the Samoan Government and was officially exempt from ethical approval by the Samoan Government. Participants signed informed consent forms prior to participating in the survey (SBS, 2016). Our secondary analysis on anonymised data from the 2014 Samoa DHS was formally exempted from review by the University of Sydney Human Research Ethics Committee.

3. Results

3.1. Sample characteristics

The distribution of socio-demographic variables for Samoan women who participated in the 2014 DHS is presented in Table 1A. Just over half of participants (55%) were aged 15–29 years. Most individuals (79%) lived in rural settings, and over half lived with their husband/partner (60%). The majority demonstrated positive self-reported non-dietary health behaviours in terms of not smoking (88%), not drinking alcohol (92%), and participation in a government physical activity program (56%). The wealth quintile distribution in the study sub-sample was near-even, with 59% of participants in the poorest three quintiles – indicating that the sub-sample was representative of the broader sample in terms of wealth quintiles. Thirty-eight percent of participants had not had children, and 62% of participants had had 1 or more children.

Table 1B shows the number of serves of vegetables and fruit consumed per week; and the frequency of consuming salty foods, high sugar foods, sugary drinks, fried foods and seafood. Fruit and vegetable consumption was low. One percent of women ate 21 or more serves of fruit per week, 6% ate 14 or more serves of fruit per week, and 21% of participants ate 7 or more serves per week. One percent of women ate 21 or more serves of vegetables per week, while 7% ate 14 or more serves, and 42% ate 7 or more serves.

3.2. Diet patterns

The results of our multivariate analysis are presented in Table 2A onwards. The association between sociodemographic and health behaviour factors and vegetable and fruit consumption is presented in Table 2A. Both vegetable consumption and fruit consumption were significantly higher in: participants aged 30 to 49 compared with those aged 15 to 29, urban residence compared with rural, and those in the rich and richer wealth quintiles compared with poor to middle. Urban as opposed to rural residence was the strongest predictor of both vegetable (Beta coefficient 2.6, 95% CI 2.3 to 2.9, \( p < 0.001 \)) and fruit consumption (Beta coefficient 1.8, 95% CI 1.4 to 2.1, \( p < 0.001 \)).

Table 2B provides the associations between the socio-demographic and health behaviour factors and consumption of salty foods, high sugar foods, sugary drinks, fried/high fat foods and seafood. Consumption of both high-sugar foods and high-sugar drinks was significantly greater amongst participants: aged 15 to 29, in the richest wealth quintiles, living in urban areas, and those who did not live with a partner or husband. Fried/high fat food consumption was also highest amongst those in the younger age group and the richer wealth quintile groups, and amongst those who drank alcohol as opposed to those who did not. Women who had completed at least tertiary level education were more likely to eat high-salt foods than those in the lower education group. Seafood consumption was significantly greater in the older age group, and less common in those who lived in urban than rural areas.

Table 3 shows which sociodemographic and health behaviour groups had increased odds of meeting the healthy diet criteria. 270 (6%) of participants met the criteria for healthy diet and 4201 (94%) did not. Women aged 30 to 49 had significantly increased odds of meeting these diet criteria (OR 2.3, 95% CI 1.8 to 2.9, \( p < 0.001 \)) than women aged 15 to 29, as did those who participated in the physical activity campaign (OR 1.9, 95% CI 1.6 to 2.4).

4. Discussion

4.1. Overall diet patterns and likely implications

This analysis of the 2014 Samoa DHS adds novel insight to the current literature by assessing the associations between dietary patterns against a wide range of sociodemographic and health behaviour factors. Of particular note was the high prevalence of unhealthy food consumption and unhealthy dietary patterns a) across a large proportion of the population, and b) in particular sociodemographic groups, with notable at-risk diet patterns associated with age, wealth status, living with a partner, and urban vs. rural residence.

The overall diet patterns in our study suggest a heightened risk of overweight and obesity in the study population. Our analysis of...
Table 1B
Distribution of food consumption.

<table>
<thead>
<tr>
<th>Vegetables and fruit – number of serves per week N [unweighted] (% [weighted])</th>
<th>0 to 9 serves</th>
<th>10 to 19 serves</th>
<th>20 to 29 serves</th>
<th>30 to 49 serves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetables</td>
<td>3423 (84.8%)</td>
<td>556 (14.3%)</td>
<td>36 (0.9%)</td>
<td>2 (&lt; 0.01%)</td>
</tr>
<tr>
<td>Fruit</td>
<td>3620 (89.9%)</td>
<td>526 (8.4%)</td>
<td>65 (1.6%)</td>
<td>6 (&lt; 0.01%)</td>
</tr>
</tbody>
</table>

Salty foods, high sugar foods, sugary drinks, fried foods and seafood: Number of times consumed per week [unweighted] % within group [weighted]

<table>
<thead>
<tr>
<th>Salty foods, high sugar foods, sugary drinks, fried foods and seafood</th>
<th>0 times</th>
<th>1 time</th>
<th>2 times</th>
<th>3 or more times</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-sugar foods</td>
<td>764 (17.1%)</td>
<td>1519 (33.8%)</td>
<td>953 (21.1%)</td>
<td>1232 (28.0%)</td>
</tr>
<tr>
<td>High-sugar drinks</td>
<td>584 (13.1%)</td>
<td>1205 (26.8%)</td>
<td>1093 (24.3%)</td>
<td>1587 (35.8%)</td>
</tr>
<tr>
<td>Fried foods</td>
<td>198 (4.5%)</td>
<td>1111 (24.8%)</td>
<td>1494 (33.2%)</td>
<td>1668 (37.6%)</td>
</tr>
<tr>
<td>Salty food</td>
<td>434 (9.9%)</td>
<td>1182 (26.4%)</td>
<td>1244 (27.6%)</td>
<td>1599 (36.1%)</td>
</tr>
<tr>
<td>Seafood</td>
<td>494 (11.3%)</td>
<td>1839 (41.3%)</td>
<td>1560 (23.5%)</td>
<td>1079 (24.0%)</td>
</tr>
</tbody>
</table>

Table 2A
Best-fit linear regression for association between socio-demographic factors and vegetable and fruit consumption.

<table>
<thead>
<tr>
<th>Socio-demographic factor (referent category in brackets)</th>
<th>Vegetable consumption</th>
<th>Fruit consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta coefficient (95% CI)</td>
<td>P value</td>
<td>Beta coefficient (95% CI)</td>
</tr>
<tr>
<td>Aged 30–49 (15–29)</td>
<td>0.51 (0.29–0.74)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Urban residence (Rural)</td>
<td>2.56 (2.27–2.86)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Participates in physical activity (Does not participate)</td>
<td>0.34 (0.1–0.57)</td>
<td>0.008</td>
</tr>
<tr>
<td>Rich and richest wealth quintile (Poorest, poor, middle)</td>
<td>0.81 (0.48–1.15)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Tertiary or vocational level education (Primary or secondary)</td>
<td>0.65 (0.1–1.21)</td>
<td>0.024</td>
</tr>
</tbody>
</table>

* Smoking, Alcohol consumption, Cohabitation status and Household size (and Has had children for Fruit consumption) were excluded from the final “best fit” linear regression models because they produced P values greater than 0.05 in linear regression analysis Step 1 in the analysis for both vegetable and fruit consumption (see Methods).

Consumption of unhealthy food groups revealed a high frequency of consumption overall, with fried foods being the most frequently consumed group. Conversely, while the WHO recommends adults consume five serves of fruit or vegetables per day (WHO, 2015), we found that only 1% of Samoan adult women consumed 21 or more serves each of fruit and vegetables per week, suggesting that the proportion meeting the WHO requirement is very low. Comparing these findings with the literature reveals a concerning diet pattern for the health of our study population. A 2012 global systematic review and meta-analysis showed that increased dietary sugar intake (from both high-sugar foods and high-sugar drinks) rapidly increases weight gain in adults (Te Morenga, Mallard, & Mann, 2013); and rising consumption of foods that are energy-dense and high in fat have been implicated in the rise in overweight and obesity globally. There is evidence to suggest consuming fruits and vegetables reduces body fat in already-overweight and obese adults (Ledoux, Hingle, & Baranowski, 2011), as well as preventing other non-communicable diseases – for example, green leafy vegetable consumption has been shown to reduce the risk of developing type 2 diabetes (Carter, Gray, Troughton, Khunti, & Davies, 2010). Seafood consumption significantly varied between some groups and this is notable because this food group has been theorised to have a protective effect against overweight and obesity if it is consumed instead of other foods commonly eaten as a result of the rapidly transitioning food environment in Pacific Island countries such as instant noodles and canned meats (Charlton et al., 2016). Wang and colleagues’ recent analysis of a highly comprehensive food frequency questionnaire dataset from Samoa suggests that consumers of a diet containing some traditional, locally produced foods such as seafood and coconut are more likely to have a lower abdominal circumference than those whose diets consisted of mainly processed and imported foods (Wang et al., 2017).

4.2. Specific groups vulnerable to poor diets

The finding that the younger age group had less healthy eating patterns than the older age group (lower fruit and vegetable consumption and lower odds of meeting the healthy diet criteria, as well as higher consumption of fried foods, sugary foods, and sugary beverages), adds to the already existing evidence of unhealthy consumption patterns amongst young people in Samoa – for example the 2011 Global School Food Survey reported that more than half (53%) of school-age girls in Samoa drank soft drinks one or more times per day during the 30 days leading to the survey (WHO, 2011). This apparent trend is particularly concerning because of the implications for future generations and warrants further research and policy attention.

Women in the rich and richer wealth quintiles ate significantly more fruit and vegetables, but also consumed more high-sugar food, fried food, and high-sugar beverages than those in the lower income groups. Cultural factors are likely to play a role here, as imported, energy-dense foods can be viewed as high-prestige foods in Samoa (Hardin, 2015). The finding is in line with Allen and colleagues’ review of socioeconomic status and non-communicable disease behavioural risk factors in low-to-middle-income countries, which reported that higher status socioeconomic groups consumed more processed foods and foods high in fat and salt than individuals of low socioeconomic status (Allen et al., 2017).

Urban residents were significantly more likely to consume high-sugar food and beverages, and less likely to eat seafood; but urban as opposed to rural residence was the strongest predictor of both fruit and vegetable consumption. The higher consumption of fruit and vegetables in urban areas is notable but policy makers should bear in mind that the most important finding is that consumption is too low across Samoa – in both urban and rural areas – and further investigation of the reasons for this should be a priority for future research. The difference in consumption between urban and rural areas seen in our study is likely to be
### Table 2B

Best-fit logistic regression for association between socio-demographic factors and dietary factors.

<table>
<thead>
<tr>
<th>Socio-demographic factor (referent category in brackets)</th>
<th>Dietary variable 2 or more times a week vs. 0 to 1 times a week</th>
<th>Odds Ratio (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rich and richest wealth quintile (Poorest, poor, middle)</td>
<td>1.44 (1.27 to 1.64); p = 0.001</td>
<td>1.50 (1.06 to 2.06); p = 0.001</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Urban residence (Rural)</td>
<td>1.71 (1.50 to 1.95); p = 0.001</td>
<td>1.81 (1.44 to 2.28); p = 0.001</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Tertiary or vocational level education (Primary or secondary)</td>
<td>0.98 (0.81 to 1.20); p = 0.24</td>
<td>1.08 (0.84 to 1.39); p = 0.38</td>
<td>0.55</td>
</tr>
<tr>
<td>Drinks alcohol (does not drink alcohol)</td>
<td>1.07 (0.79 to 1.43); p = 0.54</td>
<td>1.09 (0.76 to 1.57); p = 0.69</td>
<td>0.56</td>
</tr>
<tr>
<td>Lives with partner (Does not live with partner)</td>
<td>0.74 (0.58 to 0.96); p = 0.01</td>
<td>0.72 (0.56 to 0.91); p = 0.02</td>
<td>0.03</td>
</tr>
<tr>
<td>Participates in physical activity (Does not participate)</td>
<td>1.08 (0.83 to 1.42); p = 0.25</td>
<td>1.09 (0.84 to 1.42); p = 0.29</td>
<td>0.56</td>
</tr>
</tbody>
</table>

Household size and smoking status are not presented here because they produced P values greater than 0.05 in the bivariate analysis step for all food variables. Step 1 in explanation of multivariate analysis steps in method section.

# 4.3. Study limitations

Our study had some important limitations which should be considered when interpreting the results. As the Demographic and Health Survey is a cross-sectional dataset, it is not possible to establish causation between sociodemographic and health behaviour factors, and diet.

Our study was limited to the diet-related variables available in the DHS dataset. In the DHS survey, for all dietary variables aside from fruit and vegetable consumption, respondents were asked to recall their typical weekly frequency of consumption but not the daily number or size of servings, which made it difficult to compare diet data with international guidelines in our study. The vegetable category did not actively exclude starchy root crops.

Fruit and vegetable consumption was very low overall in our study population and this should be borne in mind in relation to our analysis using these variables. The algorithm we used to define “healthy eating” was limited by the overall low level of fruit and vegetable consumption, meaning the algorithm we used included below-recommended fruit and vegetable consumption levels. When we attempted to apply the stricter criteria of consumption of high-sugar foods, high-fat foods, and sugary drinks less than three times a week, and consumption of 14 or more serves of fruit and vegetables each per week, only 1% of participants (n = 64) met the criteria.

Analysis of Body Mass Index (BMI) data was not performed in this study as BMI data were missing for 31% (n = 1466) of the dataset, and the difference between those with existing and missing BMI data was significant for some variables, which would likely introduce bias.

# 4.4. Conclusions

Despite these limitations, our study presents useful information to further obesity prevention efforts in Samoa and other Pacific Island Countries, and adds to the associations between dietary and sociodemographic factors and obesity in low- and middle-income countries. The high frequency of consumption of high-sugar and high-fat foods, high-sugar beverages, and the very low consumption of fruits and vegetables, call for a strengthening of nation-wide policies that aim to reverse these diet trends. Our analysis highlighted some specific opportunities for policy activity, most importantly in creating an enabling environment for healthier food consumption amongst all Samoan women with a focus on vulnerable groups, such as women of younger age. These groups should also be a focus of future research, for example as target populations for qualitative research about food consumption. Specific policy approaches have been discussed in detail elsewhere, but should focus on food pricing (Jones, Dempewolf, Armstrong, Gallucci, & Tavana, 2011; Thow, Downs, & Jan, 2014), increasing the availability of nutritious food (Thow et al., 2011), and increasing cultural desirability of locally produced diets low in processed, energy-dense and high-fat foods, and lean body shape (Hardin, 2015).

### Declaration of interest

Declarations of interest: none.
Table 3

<table>
<thead>
<tr>
<th>Socio-demographic factor (referent category in brackets)</th>
<th>Odds Ratio (95% CI)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aged 30–49 (15–29)</td>
<td>2.27 (1.79–2.88)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Participates in physical activity (Does not participate)</td>
<td>1.92 (1.56–2.37)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Rich and richest wealth quintile (Poorest, poor, middle)</td>
<td>[1.45 (0.95–2.19)]</td>
<td>[0.08]</td>
</tr>
<tr>
<td>Tertiary or vocational level education (Primary or secondary)</td>
<td>[1.27 (0.89–1.80)]</td>
<td>[0.16]</td>
</tr>
<tr>
<td>Lives with partner (Does not live with partner)</td>
<td>[1.41 (0.99–1.88)]</td>
<td>[0.01]</td>
</tr>
<tr>
<td>Household size 7 to 33 people (1–6 people)</td>
<td>[0.86 (0.69–1.07)]</td>
<td>[0.17]</td>
</tr>
<tr>
<td>Has had children (Has not had children)</td>
<td>[0.87 (0.50–1.54)]</td>
<td>[0.62]</td>
</tr>
</tbody>
</table>

* Smoking, Alcohol consumption, and Urban vs. rural residence are not presented here because they returned p-values of more than 0.05 in the bivariate analysis step (Step 1 in explanation of multivariate analysis steps in Methods). Results in square brackets indicate results that returned P values greater than 0.05 in Step 2. These were not included in Step 3 (the best fit model), the results of which are presented in bold above.

Author contributions

PF performed the conception and design, data analysis and prepared the manuscript; JN contributed to the conception and design, data analysis, interpretation and writing of the manuscript; MA contributed to the data analysis and interpretation and reviewed the manuscript; AMT contributed to the preparation of the manuscript; MT assisted with access to the dataset and preparation of the manuscript; TF was involved in the data collection and compilation and contributed to the analysis; SM contributed to the analysis and reviewed the manuscript; PV contributed to the manuscript; JR contributed to the data analysis and preparation of the manuscript.

Funding

The corresponding author was supported by an Australian Postgraduate Award scholarship.

Data statement

The Samoa Demographic and Health Survey 2014 dataset is available upon reasonable request from the Samoa Bureau of Statistics.

Acknowledgements

The authors would like to thank the Samoa Bureau of Statistics for providing the 2014 DHS dataset, and information and insight about the data collection process.

Appendix. Indicative examples of each food category

<table>
<thead>
<tr>
<th>Food category in Samoa DHS</th>
<th>Indicative given in Samoa Demographic and Health survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish/seafood</td>
<td>Crab, octopus, sea cucumber, lobster, eel etc.</td>
</tr>
<tr>
<td>Fried foods/high fat foods</td>
<td>Fried chicken/fish, turkey tails, pancakes, cake, doughnuts, mutton, corned beef, coconut cream, etc.</td>
</tr>
<tr>
<td>High sugar foods</td>
<td>Cakes, lollies, ice cream cookies, coconut jam</td>
</tr>
<tr>
<td>High Salt foods</td>
<td>Noodles with seasoning, corned beef, sausages, meat pie, eleni (tinned fish in natural oil), tw stiffes, soy sauce, tomato sauce</td>
</tr>
<tr>
<td>High sugar drinks</td>
<td>Cordial/Raro/Soft drinks/Commercial Fruit drinks</td>
</tr>
</tbody>
</table>

References


Chapter 5: Paper 3

Access to a Nutritious Diet in Samoa: Local Insights

Penny Farrell, Anne Marie Thow, Suzie Schuster, Pavle Vizintin & Joel Negin

To cite this article: Penny Farrell, Anne Marie Thow, Suzie Schuster, Pavle Vizintin & Joel Negin (2019) Access to a Nutritious Diet in Samoa: Local Insights, Ecology of Food and Nutrition, 58:3, 189-206, DOI: 10.1080/03670244.2019.1582528

To link to this article: https://doi.org/10.1080/03670244.2019.1582528

Published online: 08 Apr 2019.
Access to a Nutritious Diet in Samoa: Local Insights

Penny Farrell, Anne Marie Thow, Suzie Schuster, Pavle Vizintin, and Joel Negin

Sydney School of Public Health, The University of Sydney, Sydney, Australia; Menzies Centre for Health Policy, The University of Sydney, Sydney, Australia; Department of Education, National University of Samoa, Apia, Samoa; National University of Samoa Chancellery, Le Papaigalagala Campus, To’omata, Samoa

ABSTRACT
The adult obesity prevalence in Samoa is the third highest globally, and diet is a significant contributor. Our study aimed to explore the behavioral and demographic factors which influence diets in Samoa. The most important findings for strategic policy design were: i) cost was the most important reason for food choice, ii) participants reported high rates of consumption of sugary and fatty energy foods – along with high rates of food insecurity, and iii) the food frequency questionnaire findings from our small sample are in line with the existing evidence that the nutrition transition is underway in Samoa.

KEYWORDS
Samoa; obesity; food access; diet

Introduction
Poor diet is the leading risk factor for mortality worldwide (Forouzanfar, Alexander, and Anderson et al. 2015) and diets containing excess energy and fat are a key contributor to the global obesity epidemic (WHO, 2017). Obesity increases the risk of several non-communicable diseases (NCDs) such as cardiovascular disease and diabetes (WHO, 2016). Preventing obesity in low- and middle-income countries is particularly urgent because these countries often have inadequate health system capacity to manage the resultant NCDs (Islam et al. 2014).

Food and nutrition policy making has the potential to strengthen obesity prevention at the population level, through creating and supporting non-obesogenic food environments for populations (Hawkes et al. 2015). However, designing effective policies is challenging as it requires navigation of the complex and ever-changing nature of food markets, human society, behavior, and culture (Hawkes et al. 2015). Global nutrition research to date has focussed primarily on what people eat, and a knowledge gap remains in the areas of food access and utilization, especially in low- and middle-income nations (Hough and Sosa 2015) including those in the Pacific Islands (Charlton et al. 2016).
Further complicating action on obesity prevention is the positive association between food insecurity and obesity (Farrell et al. 2017; Hough and Sosa 2015), which is stronger in women than in men (Dinour, Bergen, and Yeh 2007; Franklin et al. 2012; Martin-Fernandez et al. 2014). The prevalence of obesity worldwide is 50% higher in women than men (Wells et al. 2012), and it has been shown that household nutritional status is linked to the level of household economic autonomy in women (UNICEF 2011). There is growing global recognition that research on nutrition must increasingly engage with the nexus between food insecurity, nutrition, and obesity; in particular, through “more context-specific assessments … to identify the links between household food security and nutrition” (FAO 2017, 3).

This study was conducted in Samoa, a small Pacific Island Country (PIC) with a population of just over 192,000 people. NCDs cause the majority of deaths in Samoa (IHME 2017), and adult obesity prevalence is the third highest in the world (IFPRI 2016). The types of foods available to the Samoan population have undergone a steep transition over the past six decades, from subsistence-based diets high in nutritious foods including root crops and other vegetables, fresh fruit, nuts, and locally sourced lean meats, to obesity-promoting diets high in non-traditional, often imported foods such as white rice and bread, and high-fat meats (Thow et al. 2011, 2017a; Wang et al. 2017). The Samoan economy is currently in transition from a subsistence-based to a cash-based economy (Amosa and Samson 2012), and those in cash-based economies have greater access to imported, processed foods (Charlton et al. 2016). Previous research from the Pacific describes increases in NCDs and NCD risk factors occurring concurrently with increases in imported processed food consumption (Brownell and Yach 2006; Hughes and Lawrence 2005; Seiden et al. 2012; Snowdon et al. 2013). Between 1978 and 2013, obesity prevalence in Samoa almost doubled – increasing from 28% to 53% in men and from 44% to 77% in women (Lin et al. 2017).

Research to date in Samoa has highlighted the urgent need for contextual, effective policy action on both food insecurity and obesity – and identified a lack of evidence regarding food purchasing and consumption patterns to inform such policy development (Ezeamama et al. 2006; Seiden et al. 2012; Thow et al. 2011). The present study sought to address these evidence gaps. The study focussed on women because in Samoa, obesity prevalence is almost 25% higher in women than in men (Lin et al. 2017); those living in female-headed households are less likely to have adequate nutrient intakes than male-headed households (Martyn et al. 2017); and women are more vulnerable to falling below the poverty line than men (Amosa and Samson 2012).

The specific aims were to: 1) explore the behavioral and demographic factors, and cultural values, which may influence diets in the study population – in other words, what are people eating, why are they eating it, and when, how, and where; 2) assess dietary behaviour to identify traditional and non-traditional dietary patterns in adult women; and 3) use a food security measurement tool to measure participants’ access to a nutritious diet.
Methods

Study design

This was a qualitative study that drew on validated instruments for data collection regarding food consumption, dietary patterns (DiBello et al. 2009), and food security (Shoae et al. 2007). We collected data from each participant by working through a structured questionnaire with three components, designed to address the study aims:

Aim 1: Explore factors which may influence diets in the study population. 1A) General questions about each participant’s demographic characteristics and information about exercise frequency, alcohol consumption, and smoking. 1B) A series of semi open-ended questions exploring the reasons for participants’ diet patterns, and how and where food is acquired, to assess decision-making and reasons for dietary patterns. Questions were based on the following topics: i) what foods constituted typical meals in the morning, during the day, and in the evening, and where and how these foods were acquired; ii) what participants perceive to be a healthy diet; iii) the place of food in Samoan culture; iv) what would need to change in order for participants to consume each food group in proportions that matched the “healthy plate” guidelines recommended by the Samoa Ministry of Health at the time of the survey (50% protective foods, 25% starchy energy foods, 25% bodybuilding foods) (pers comm Christina Soti-Ulberg, Principal Nutrition Officer, Samoa Ministry of Health; Everyday Health 2016); v) how availability of cooking equipment influenced participants’ diets; and vi) whether participants’ diets differed from what their grandparents ate.

Aim 2: Assess dietary behavior to identify traditional and non-traditional dietary patterns in our study population. The design of our food frequency questionnaire was based on the questionnaire used in a study of 785 adults in Samoa (DiBello et al. 2009) with input from Samoa-based members of our research team. The aim of our questionnaire was to ascertain patterns of food consumption in our study participants in order to then explore the reasons for such diet patterns, not to quantify exact dietary intake levels, which has been done elsewhere (DiBello et al. 2009; Wang et al. 2017).

Aim 3: Use a food security measurement tool to measure participants’ access to a nutritious diet. Our food security measurement tool was an adapted Radimer/ Cornell food security measurement tool informed by that used by Shoae et al. (2007).

Data collection

We conducted in-depth interviews with 41 women. The study population was mothers and female carers of children attending a primary school in Apia, the capital of Samoa. The school was selected as its attendees represent a broad range of demographic groups, including those who live in peri-urban
areas and those who commute to Apia from rural villages on a daily basis. We used a convenience sampling method led by school staff and participants were recruited via invitation letters. Participants were given detailed information about the study during an orientation session conducted by the study coordinators. Participation was voluntary and participants signed consent forms. No invitees refused to participate or withdrew during the study. The study was conducted in Apia in September 2016.

Participants were interviewed one at a time in a confidential environment (closed and empty room) on the school grounds. Interviews were performed and transcribed in English by two members of the research team. The interviewers discussed interpretation of the survey questions in detail prior to, during, and after the interviews to ensure consistency of interpretation. Trained research assistants were also present at each interview and translated the questions and responses into Samoan when it was required. All participants had sufficient English proficiency and translation was only occasionally required to clarify the meaning of certain words or phrases. Participants were reimbursed for their time with 30 WST (USD 12) per participant.

**Data analysis**

Aim 1: Questions about diet patterns, and facilitators and barriers to healthy eating, were analyzed and categorized in Microsoft Excel in order to determine the most important food consumption patterns in terms of overweight and obesity risk, and the reasons for these in the study population.

Aim 2: Food frequency result categorization was informed by the Pacific dietary guidelines (SPC 2002), which categorizes foods as: 1. energy foods, which are subdivided into starchy, sugary, and fatty energy foods – the former is recommended to be eaten frequently while consumption of sugary and fatty energy foods should be limited, 2. bodybuilding foods (protein), and 3. protective foods (fruit and vegetables). We included a fourth category for sugar-sweetened beverages. In our analysis bodybuilding foods were categorised into “more healthy” (stir-fried beef, beef curry, stir-fried chicken, chicken in earth oven, chicken cooked with fresh coconut, tinned fish, fish in fresh coconut cream, roasted pork, pork baked in earth oven) and “less healthy” (tinned corn beef, salted beef, barbequed chicken, fried chicken, fried fish, turkey tail, barbequed lamb chop, mutton, barbequed sausage) categories based on mode of preparation. Foods cooked in fresh coconut were included in the “more healthy” group due to the small quantity of coconut milk or cream, if any, consumed when foods are prepared in this way. We also note here the findings of DiBello et al.’s 2009 study, which reported that diets high in coconut products were not associated with an increased risk of metabolic syndrome in Samoa, although the mechanism for this is not known. Tinned fish was also included in the “more healthy” group as it has been found to be a good source of protein for populations in the Pacific and is
unlikely to lead to obesity (Charlton et al. 2016). Data for each food category was grouped by frequency of consumption in Microsoft Excel using simple descriptive statistics to identify the most common patterns of consumption.

Aim 3: Based on the food security questionnaire responses, each participant was categorized as household, individual, and/or child food insecure. Results were analyzed in Microsoft Excel to produce simple descriptive statistics and descriptive two-by-two tables to compare food security levels with three different demographic indicators: income levels, household decision-making status, and age.

Ethical approval was obtained from the National University of Samoa University Research Ethics Committee in July 2016 under the research project titled ‘Understanding the socio-demographic determinants of access to healthy food in urban Samoa’. Permission to conduct the research was also granted by the Government of Samoa Ministry of Education, Sports and Culture in August 2016.

Results

Sample characteristics

The 41 study participants were women whose ages ranged from 21 to 63 years, and the mean age was 39 years. Twenty percent (n = 8) of participants were engaged in paid employment and the remaining 80% (n = 33) cared for family full time and did not have their own source of income. Seventeen percent (n = 7) of participants had primary school as their highest education level, 76% (n = 31) participants had secondary school as their highest education level, none had an undergraduate degree as their highest level of education, and 7% (n = 3) had a postgraduate university degree. The number of adults in participants’ households ranged from 1 to 16, with a mean of 4 and a median of 3; and the number of children ranged from 1 to 35, with a mean of 4 and median of 3.

Seven percent of participants (n = 3) did no regular exercise, 15% (n = 6) reported exercising less than once per week, 41% (n = 17) exercised 1–3 times per week, and 34% (n = 14) reported exercising more than 3 times per week. Seventeen percent of participants (n = 7) drank alcohol regularly, and 15% (n = 6) smoked.

Facilitators and barriers to healthy eating

Food consumption patterns

Of the three food categories, the majority of participants ate only energy foods in the morning (n = 31, 76%) and throughout the day (n = 26, 63%). Meals eaten in the morning commonly consisted of an energy food item and a hot drink with sugar added. Examples included panikeke (deep-fried dough balls containing flour, sugar and mashed bananas) and coffee, or bread and...
butter with tea. Typical foods consumed during the day were pre-prepared Chinese food from a local stall, or donuts from the school shop.

Meals eaten in the evening were more diverse. Half (51%, n = 21) of participants reported typically consuming an energy food with a bodybuilding food in their evening meal, and a further 17% (n = 7) ate an energy food with a bodybuilding food and a fruit or vegetable. Common examples of evening meals were chicken with soy sauce and taro in fresh coconut cream, or tinned tuna cooked either in fresh coconut milk or in oil with bread and butter, or white rice with chicken fried in oil. If the meal included vegetables, these were usually prepared in a soup.

For foods eaten in the morning and during the day, the most common source was a grocery store, followed closely by a local shop or the school canteen. Just under half of the foods eaten in the morning and during the day were typically prepared at home, and just over half were pre-prepared convenience foods. The most common source of food for the evening meal was a grocery store, followed by home-grown.

The two most commonly cited reasons for food item choice were affordability and physical availability. Social influences were also reported to be important, for example, one participant stated: “the ladies at school eat panikeke, so I join in as a social thing” (57-year-old participant).

Ease of storage and cooking was also reported to have an important influence on which energy food was eaten in the evening, especially for white rice. The main reasons given for the most common meat choices consumed in the evening were affordability and healthiness for tinned fish, and affordability and taste for chicken. Ease of cooking was also given as a reason for choosing some meats such as sausages.

**Access and convenience**

In response to questions about what would need to change for participants to meet the “healthy plate” guidelines (50% protective foods, 25% energy foods, 25% bodybuilding foods (Everyday Health 2016), more than half of responses cited affordability (financial accessibility) (60%, n = 21). The other reasons given in order of the number of mentions were: taste (23%, n = 8), overcoming habits (9%, n = 3), availability (6%, n = 2) and convenience (3%, n = 1). A typical response was: “I need the money to buy it all. There is not enough money to eat all food groups so I mainly eat meat and carbohydrates” (57-year-old participant).

When asked whether the cooking equipment available to participants would affect the type of meals they prepared, around half reported they would and the other half reported they would not. The affirmative comments indicated that cooking equipment may influence diet diversity: “Yes I would definitely cook differently – I would cook all kinds of foods that we would want to eat and it
would be easier to do my job” (41-year-old participant); “Yes – if I had a baking oven I could bake and prepare different types of food” (44-year-old participant).

**Nutrition transition**

There was evidence that a transition from traditional to non-traditional diets had taken place over the previous two decades. When respondents were asked whether their diet was different to that of their grandparents when they were their age, 73% (n = 30) said it was, whereas 15% (n = 6) said it was not. Twelve percent (n = 5) were undecided.

Some statements from participants who reported that their diets were different from those of their grandparents were: “Because my grandparents ate taro and banana with fresh coconut but nowadays we eat a lot of food like rice and bread” (30-year-old participant), “In the old days people ate what they found at their hands. Nowadays it depends on money” (51-year-old participant), and “My grandparents weren’t sick and now most people are sick” (27-year-old participant).

Participants who reported their diet was not different from their grandparents’ diet cited health reasons, for example, “I follow my grandparents’ footsteps eating balanced food with not too much sugar. I don’t like sugar and the diseases caused by sugar” (41-year-old participant).

**Knowledge and culture**

Responses to the question “What would you eat if you were going to eat a healthy and balanced meal?” varied. Fifteen percent (n = 6) reported that they would eat an energy food with a bodybuilding food and vegetables. Twenty-seven percent (n = 11) of respondents stated they would eat a meal that contains fruit and/or vegetables only, 22% (n = 9) would eat a meal containing a bodybuilding food and fruit or vegetables, 22% (n = 9) described a meal containing an energy food and vegetables, 10% (n = 4) would eat a meal containing an energy food with a bodybuilding food, and 5% (n = 2) would eat a meal containing an energy food only.

Responses to the question “What does food mean in Samoan culture?” fell into five key themes. The first theme was that food is the center of Samoan culture: “food is the most important thing in Samoan culture” (57-year-old participant), “In Samoa, food means your life depends on the food you eat … and your family status” (47-year-old participant). The second theme was the view of food as a transactional tool to offer as a gift, and an indicator of social status: “when people come to my place the first thing I think to do is feed them” (50-year-old participant), “I feel shy and ashamed if we have no food to serve” (46-year-old participant). The third theme was that food is essential for survival and health: “food means in the Samoan way (fa’a Samoa), eat for your life” (30-year-old participant). The fourth theme was that food cannot be wasted: “It’s a must to use leftovers…” (25-year-old participant); “It’s
a must to use the food – don’t waste it.” (29-year-old participant). The fifth theme was pride in Samoan food: “Our own local food is better for health and even for Samoan people to be stronger. If we eat overseas food we will get fat – it’s not good for the body.” (41-year-old participant); “Our local foods are healthy – not like the overseas food” (41-year-old participant [different participant to the one that gave the previous quote]).

**Food frequency questionnaire results**

The most commonly eaten energy foods were white rice, white bread, taro, green cooking bananas, and *panikeke* (Figure 1). Seventy-three percent of participants (n = 30) reported consuming white bread five or more times per week, and the same proportion consumed white rice five or more times per week. Around one-third of participants consumed taro and green cooking bananas five or more times per week, respectively (37% [n = 15] for taro and 34% [n = 14] for green cooking bananas).

Of the sugary and fatty energy foods (SPC 2002), the most frequently consumed were *panikeke*, cheese curl snacks, and instant dried noodles. Almost three-quarters of participants (73%, n = 30) ate 7 or more different types of sugary or fatty energy foods at least once a week each.

![Bar chart showing the most commonly eaten energy foods amongst study participants.](image)

*Figure 1.* Most commonly eaten energy foods amongst study participants.
All participants ate bodybuilding foods at least once a week. Diversity was high: more than three-quarters of participants (n = 32, 78%) ate chicken, fish, and beef at least once a week. All participants ate chicken at least sometimes, 90% (n = 37) for beef and 95% (n = 39) for fish. Ninety percent of participants (n = 37) ate at least 3 or more “more healthy” bodybuilding meals per week, and 88% (n = 36) ate 3 or more “less healthy” bodybuilding meals every week.

Forty-six percent (n = 19) ate less than one serving per day of vegetables. Fifty-nine percent of participants (n = 24) ate less than one serving per day of fruit. All participants reported eating vegetables at least once per week. Eighty-eight percent (n = 36) reported eating fruit at least 1–2 times per week, while two participants reported never eating fruit. The fruits and vegetables most commonly mentioned were pawpaw, mangoes, cabbage, and local spinach (*laupele*).

Ninety-five percent of participants (n = 39) reported some consumption of sugar-sweetened beverages, and 80% of participants (n = 33) consumed them daily. The most common beverage types consumed were sugar added to a hot drink, which was consumed daily by just under a third of participants (32%, n = 13), followed by 3-in-1 coffee sachets, which were consumed daily by 22% of participants (n = 9).
**Food security**

Eighty-five percent of participants (n = 35) reported experiencing household food insecurity, 73% (n = 30) were individually food insecure and the same proportion (73%, n = 30) reported insecurity in their ability to provide food for their children. Participant food security results grouped by income range, household decision-making status, and age are presented in Table 1.

**Table 1.** Participant food security status grouped by income range, household decision-making status, and age.

**Income range and food security**

<table>
<thead>
<tr>
<th>Income range per week</th>
<th>Household food insecure % (n)</th>
<th>Individual food insecure % (n)</th>
<th>Child food insecure % (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 300 WST (&lt;120 USD)</td>
<td>100% (11/11)</td>
<td>100% (11/11)</td>
<td>82% (9/11)</td>
</tr>
<tr>
<td>300 to 499 WST (120 to 200 USD)</td>
<td>82% (9/11)</td>
<td>64% (7/11)</td>
<td>82% (9/11)</td>
</tr>
<tr>
<td>500 to 700 WST (201 to 281 USD)</td>
<td>82% (9/11)</td>
<td>91% (10/11)</td>
<td>82% (9/11)</td>
</tr>
<tr>
<td>800 to 2000 WST (322 to 804 USD)</td>
<td>75% (6/8)</td>
<td>63% (5/8)</td>
<td>38% (3/8)</td>
</tr>
</tbody>
</table>

**Household decision making and food security**

<table>
<thead>
<tr>
<th>Decision making status</th>
<th>Household food insecure % (n)</th>
<th>Individual food insecure % (n)</th>
<th>Child food insecure % (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant decides</td>
<td>81% (13/16)</td>
<td>69% (11/16)</td>
<td>69% (11/16)</td>
</tr>
<tr>
<td>Joint decision</td>
<td>83% (10/12)</td>
<td>58% (7/12)</td>
<td>58% (7/12)</td>
</tr>
<tr>
<td>Other HH member decides</td>
<td>89% (8/9)</td>
<td>89% (8/9)</td>
<td>89% (8/9)</td>
</tr>
<tr>
<td>Husband decides</td>
<td>100% (4/4)</td>
<td>100% (4/4)</td>
<td>100% (4/4)</td>
</tr>
</tbody>
</table>

**Age and food security**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Household food insecure % (n)</th>
<th>Individual food insecure % (n)</th>
<th>Child food insecure % (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 to 29</td>
<td>82% (9/11)</td>
<td>64% (7/11)</td>
<td>55% (6/11)</td>
</tr>
<tr>
<td>30 to 39</td>
<td>83% (10/12)</td>
<td>67% (8/12)</td>
<td>67% (8/12)</td>
</tr>
<tr>
<td>40 to 49</td>
<td>88% (7/8)</td>
<td>75% (6/8)</td>
<td>88% (7/8)</td>
</tr>
<tr>
<td>50 and to 63</td>
<td>90% (9/10)</td>
<td>90% (9/10)</td>
<td>90% (9/10)</td>
</tr>
</tbody>
</table>

**Discussion**

Our study aimed to inform health and nutrition policy design by providing a deeper understanding of dietary risk factors for obesity in Samoa. We investigated dietary patterns and influences on food choice in 41 women in Samoa. The three most important findings for strategic policy design follow: i) cost was the
most important reason for food choice for foods consumed throughout the day and in the evening. This was the most important reason for low fruit and vegetable consumption, ii) participants reported high rates of consumption of sugary and fatty energy foods (snack foods), and sugar-sweetened beverages – along with high rates of food insecurity, and iii) the food frequency questionnaire findings from our small sample are in line with the existing evidence that the nutrition transition is underway in Samoa. Amongst our participants, traditional staple foods such as root crops had largely been replaced with non-traditional staples, particularly rice and white bread.

One of the most policy-relevant findings from our study was that cost was the most important influence on food choice. This finding is in line with those of Fa’alili-Fidow, McCool, and Percival (2014) who interviewed stakeholders in Samoa and New Zealand about the implications of Samoa’s free trade agreements and the lack of economic means to choose healthier food options in Samoa was raised as a key concern. It also adds important insight to the questions posed by Seiden et al. (2012) who called for further research on reasons for the influence of food price on food consumption behavior in Samoa. In particular, cost was the most important reason for the low fruit and vegetable consumption amongst our participants, and consumption was especially low throughout the day when food was often purchased on an as-needed basis. Fruit and vegetable consumption was reported to be low amongst our study participants, with around half reporting eating vegetables less frequently than once per day. The 2014 Samoa Demographic and Health Survey reported that Samoan women fell far short of the WHO-recommended fruit and vegetable intake with only 1% of Samoan women reported consuming the recommended five or more servings per day (Government of Samoa 2015). A recent study conducted by the Food and Agriculture Organization based on 2013/2014 Samoa Household Income and Expenditure Survey data found that lowering the price of local fruit, vegetable, and animal products would increase their consumption (Martyn et al. 2017).

The seemingly contradictory co-occurrence of high rates of food insecurity found in our study, given the already known high obesity rate amongst women in Samoa (Lin et al. 2017), may be explained by the high rates of consumption of low-cost, energy-dense foods such as white bread and packaged, imported snack foods, and sugary beverages seen in this study. In our study panikeke was one of the most frequently consumed energy foods, and the majority of participants ate sugary or fatty energy foods (snack foods) seven or more times per week. Fatty meat consumption was high. These foods were also found to be frequently consumed in larger, more statistically rigorous studies in Samoa (DiBello et al. 2009; Wang et al. 2017). Based on our simple descriptive statistics, all types of food insecurity occurred at a higher rate among the lowest income group in our study than in the highest income group. This is an area in need of further research but it is
possible that this effect could be working in two directions: the consumption of low-cost, energy-dense foods amongst food-insecure people is a likely mechanism in the food insecurity-obesity link seen in low- and middle-income countries (Farrell et al. 2017), while dependence on food imports may increase vulnerability to food insecurity in the Pacific (Hughes and Lawrence 2005). Low level of women’s autonomy within the household has the potential to exacerbate this issue. We found that where our study participants were involved in decision-making about household spending on groceries, there was a lower level of food insecurity reported than if the participant’s husband or another household member decided, although we note our findings are based on a small qualitative study and further detailed research on a larger scale is required in this area which considers in detail factors such as family roles and social norms of extended families.

The majority (80%) of our participants were not engaged in paid employment. In Samoa, as a result of social, economic and cultural factors, men tend to hold greater power within and outside the home, and women’s vulnerability is increasing with the move to a cash economy because women are usually engaged in unpaid family care and are underrepresented in the paid workforce (Amosa and Samson 2012). This reflects the findings of various studies worldwide – a 2011 United Nations Children’s Fund report cited evidence from South Asia, Latin America, the Caribbean, and sub-Saharan Africa of an improvement in nutritional status in children in households with increased women’s within-household decision-making power (UNICEF 2011).

Recent evidence from Samoa indicates that consumption of diets higher in traditional, local foods instead of imported foods may help prevent metabolic syndrome – a measure of risk for NCDs (Wang et al. 2017). The preference for local foods and belief that local foods were healthier that was evident among participants in this study – similar to that found by Jones et al. (2011) – suggests that policy intervention to increase access to affordable, healthy food may serve to stimulate demand. In particular, such demand could be leveraged to enhance the economic competitiveness and physical availability of local foods.

In light of recent research identifying opportunities for strategic nutrition policy that targets consumer behavior (Hawkes et al. 2015; Thow et al. 2017b), a number of other findings from this study can inform policy design in Samoa. First, the finding that food eaten throughout the day was often not prepared in the home; and the fact that such foods were typically energy dense, high-fat foods suggests that interventions that focus on increasing physical and economic availability of pre-prepared healthy food options close to schools and workplaces have strong potential to improve food consumption behavior in our study setting. This supports the conclusions of other recent research in Samoa, that recommended availability of healthy foods such as fresh fruit and vegetables be improved through policy interventions
targeting the informal food market, as well as the formal sector (Thow et al. 2017a). Second, knowledge of what constitutes a healthy meal was low in the present study. When asked what constituted a healthy and balanced meal, only 15% of the participants described a balanced meal. Low nutrition education has been attributed to contribute to poor health in other PICs, for example, Dancause et al.’s (2013) study examined obesogenic diet behavior patterns in Vanuatu and recommended nutrition policies place priority on education and messaging. Charlton et al.’s 2016 review on food security in the Pacific showed that lack of nutrition education was an important barrier to healthy eating in the Pacific (Charlton et al. 2016). Third, Samoan culture must be considered when designing food policy. Some aspects of Samoan culture have the potential to be leveraged in diet improvement interventions, for example, the strong practice of sharing foods in a social setting suggests people will have similar dietary habits as their families and peer groups – a factor which should be taken into account when designing nutrition education policy and programs. Some cultural norms described by our study participants could encourage obesogenic dietary behaviours, such as the notion that “e sau lava taeao ma ona ‘ai” (tomorrow will come with its own food), meaning food prepared to be eaten should be eaten at the time and not stored for later – which may lead to overconsumption (Fiti-Sinclair 2004), and nutrition education policy and programs should be sensitive to such conventions.

Our study strengthens current evidence that food pricing should be a priority in nutrition policy making in Samoa – both in the form of taxes to increase the price of unhealthy foods and beverages, and subsidies to reduce the cost of healthy foods such as vegetables (Jones et al. 2011; Thow, Downs, and Jan 2014; Thow et al. 2017a). It is important that such policies are developed using a transparent and scientifically rigorous approach to rank all foods available on the market, both local and imported, from most to least healthy. It is also important for inter-sectoral collaboration to take place when developing food policy, for example, between health and finance sectors within-country, as well as the need for the health sector to engage actively with international trade negotiations (Thow et al. 2017a). In 2016 the Samoan government introduced a new tax on high-sugar and some high-salt foods (Samoa Arrangement of Provisions 2016), and it will be important to monitor food consumption at a national level to measure its impact (Thow, Downs, and Jan 2014). On the side of subsidies for healthy food consumption, a 2015 study into food policy options to prevent NCDs in Samoa was conducted in partnership between the Ministry of Health Samoa, the World Health Organization, and the Food and Agriculture Organization. The study recommended two other policy approaches aside from increasing availability of healthy foods in the formal and informal food markets. These were: i) increased focus on nutrition in agricultural production programs, and ii) including designated support for fruit and vegetable consumption in
social welfare benefits (Thow et al. 2017a). A prospective cohort study using data from 18 low- and middle-income countries published in The Lancet found that legume consumption was inversely associated with cardiovascular and non-cardiovascular mortality (Miller, Mente, and Dehghan et al. 2016). This food group may be a suitable alternative where fresh fruit and vegetables are difficult to access due to cost and storage and transport challenges.

**Limitations**

This study fills an important policy-relevant gap in the literature through exploring the interaction between women in Samoa and their food environments. The strength of qualitative nutrition research is in increasing our understanding of why and how people follow certain diet behaviors (Swift and Tischler 2010). The present study was designed to understand dietary patterns, preferences, and interactions with food environments (as per our analysis and discussion), not exact food intake levels. Because the comparisons between food security and income, household expenditure decision-making, and age are descriptive and cross-sectional, and our sample was not statistically representative of the Samoan population, it is not possible to ascertain causation. These relationships should be a focus of larger studies in the future.

The food frequency questionnaire relied on self-reported information, which could have introduced bias. The method used for income measurement also relied on participant self-reporting and did not account for funds unavailable for expenditure due to household debt, traditional social wealth distribution systems or church obligations (Amosa and Samson 2012). The food security measurement tool was based on the best available resources, however, there is no officially validated food security measurement tool for Samoa.

Our study population included families who lived in peri-urban or semi-rural environments who commuted to Apia daily. We did not disaggregate our analysis by these groups because by commuting to Apia daily, all participants had access to the urban food environment. Additional forces are likely to be at play for those who live entirely in rural settings, such as higher vulnerability to cash flow fluctuations with a change in local produce prices, and higher prices of imported foods due to high transport costs (Amosa and Samson 2012). As people living in rural areas constitute 81% of the Samoan population (SBS 2017), future research should examine on a larger scale and in detail the differences between the food environments of those who live in rural areas and infrequently access the capital, and those with daily access to the urban food environment.

**Conclusions**

We used a multi-pronged approach to measure food access and explore the relationships between socio-demographic moderators of dietary patterns
associated with obesity in women in order to gain a nuanced and context-specific understanding of this complex issue. By collecting primary data on influencers of food access from a cohort of 41 women in urban Samoa, we found that cost was the most important reason for food choice, food insecurity levels were high, and participants reported high rates of consumption of sugary and fatty energy foods (snack foods), and sugar-sweetened beverages.

The myriad factors shown to contribute to food consumption patterns explored in our study indicates that any one policy approach alone is very unlikely to work. Rather, future nutrition policy making in Samoa should focus on a package of policy approaches, including: i) increasing prices of obesogenic foods which currently make up too high a portion of Samoan diets, along with decreasing prices of healthy foods such as vegetables, ii) increasing the amount of affordable healthy food options available from both formal and informal food vendors, iii) improving and continuing to monitor food security, especially amongst high-risk members of the population such as women and those on low incomes, iv) education campaigns with clear messaging, including differentiation between staple energy foods which should be eaten regularly, and sugary energy foods which should be eaten only occasionally (SPC 2002), which promote traditional diets high in local fruits and vegetables. It is important to continue to strive for cross-sectoral action including input of the health sector into trade decisions, and acknowledging the likely health benefits of increasing women’s paid employment (Fa’alili-Fidow, McCool, and Percival 2014). Prospective studies on monitoring impact of these policy interventions will be very valuable to improving nutrition policy further in Samoa, with lessons potentially adaptable to other low- and middle-income country settings.

Data sharing policy

The data that support the findings of this study are available from the corresponding author, PF, upon reasonable request.

Disclosure statement

The authors declare no conflict of interest.

Funding

This work was supported by the National University of Samoa; a Training Program Stipend Scholarship awarded by The University of Sydney; and a James Kentley Memorial scholarship awarded by The University of Sydney.
References


Chapter 6: Paper 4

Acquisition and affordability of fruit and non-starchy vegetables in Solomon Islands: a cross-sectional analysis

Penny Farrell\textsuperscript{a,\*}, Michael K. Sharp\textsuperscript{b}, Anne Marie Thow\textsuperscript{c}, Mamaru Awoke\textsuperscript{d}, Samson Kanamoli\textsuperscript{e}, Joel Negin\textsuperscript{a}

\* Corresponding author. Sydney School of Public Health, Edward Ford Building A27, The University of Sydney, NSW, 2006, Australia. E-mail address: penny.farrell@sydney.edu.au (P. Farrell).

\textsuperscript{a} Sydney School of Public Health, Edward Ford Building A27, The University of Sydney, NSW, 2006, Australia

\textsuperscript{b} Pacific Community, BP D5, Noumea Cedex 98848, New Caledonia

\textsuperscript{c} Menzies Centre for Health Policy, Charles Perkins Centre D17, The University of Sydney, NSW, 2006, Australia

\textsuperscript{d} Amref Health Africa, P.O. Box 1702, Addis Ababa, Ethiopia

\textsuperscript{e} National Statistics office, Ministry of Finance & Treasury, P.O. Box G6, Honiara, Solomon Islands
Abstract

Background
Solomon Islands has the highest reported rate of undernourishment in the Pacific region, and one-third of children are stunted. At the same time, the population is confronted by a high and rising burden of non-communicable diseases. Solomon Islands is in the midst of the nutrition transition, and a key cause of the rising non-communicable disease burden is increasing consumption of cheap, often imported foods containing high amounts of processed starch, fat, and salt, such as noodles.

Methods
We analysed the nationally representative Solomon Islands Household Income and Expenditure Survey from 2012-13 to: a) study how acquisition of fruit and non-starchy vegetables varied across sociodemographic groups; b) examine fruit and non-starchy vegetable price and affordability and use this to determine which sociodemographic groups were associated with acquiring fruit and non-starchy vegetables to the value of the minimum requirement (400g or 5 serves).

Results
A key contributor to inadequate fruit and non-starchy vegetables acquisition was low relative affordability of fruit and non-starchy vegetables compared with other foods, especially amongst the lower income urban portion of the population. Household wealth was the most consistent predictor of fruit and non-starchy vegetable acquisition. Rural households were more likely to acquire fruit and non-starchy vegetables to the value of the minimum requirement, and fruit and non-starchy vegetables are usually acquired with cash in urban areas, suggesting that a strong enabler of adequate fruit and non-starchy vegetable acquisition in Solomon Islands is the ability to access home grown foods.

Conclusions
Cash-based food acquisition is increasingly important in Solomon Islands especially in urban areas, meaning improving affordability of healthy foods like fresh fruit and vegetables should be a major priority area for policy makers. Efforts are required across multiple sectors in order to increase fruit and non-starchy vegetable consumption. Policies and programs such as subsidies which aim to facilitate higher fruit and non-starchy vegetable consumption should prioritise vulnerable groups including those in low-income households and those in large households in urban areas.
Background

Non-communicable diseases (NCDs) currently account for around three-quarters of deaths in Pacific Island Countries (PICs) [1] leading to significant societal, economic, and personal loss. Between 1975-2014, increases in Body Mass Index (BMI) for women in PICs were amongst the largest globally [2]. In many Pacific countries, including Solomon Islands, a country in the South-West Pacific consisting of just over 600,000 people [3], the situation is further complicated as there is a combined burden of NCDs, micronutrient deficiencies, and stunting [4, 5]. Solomon Islands has the highest reported rate of undernourishment in the Pacific region [6], and one-third of children are stunted [4]. At the same time, the population is confronted by a high and rising burden of NCDs: diabetes is now the leading cause of death and disability in Solomon Islands, and diabetes care accounts for approximately 20% of the government’s annual health care expenditure [7], placing significant strain on an already overstretched health system [4, 8].

Foods that are of low nutritional quality (containing large amounts of calories but low amounts of vitamins and minerals, otherwise referred to as micronutrients) are contributing to high and rising rates of NCDs and micronutrient deficiencies [9]. For the past half-century, populations in PICs have been transitioning away from diets high in locally-grown fresh vegetables and fruit, seafood, starchy root crops, and nuts – and towards energy-dense, processed, and often imported foods [10-13]. These foods are often high in refined sugar, fat, and salt, and low in nutrients; meaning they are a major contributing factor to the very high and increasing burden of obesity and NCDs such as cardiovascular disease and diabetes in the region [12, 14-17]. Solomon Islands is in the midst of this nutrition transition, and a
key cause of the rising NCD burden is increasing consumption of cheap, often imported foods containing high amounts of processed starch, fat, and salt, such as noodles [4, 9, 18].

The World Health Organization (WHO) and the Pacific Guidelines for Healthy Living recommend consuming at least five serves, which WHO equates to 400 grams total [10, 19], of fruit and/or vegetables per day – excluding starchy vegetables such as cassava and potato [19, 20]. Yet in Solomon Islands, fruit and non-starchy vegetable (FNSV) consumption is reportedly low – the latest STEPwise approach to surveillance (STEPS) survey showed that 93% of the population ate less than 5 serves of fruit and/or vegetables per day, with the average daily consumption being 0.8 serves of fruit and 1.3 serves of vegetables [21].

Increased consumption of fruit and vegetables can reduce the risk of developing various NCDs and micronutrient deficiencies [22]. There is strong worldwide evidence that increased fruit and vegetable consumption decreases risk of heart disease [23], as well as increasing evidence that FNSV consumption can help reduce the risk of developing other NCDs such as diabetes [24-26], unhealthy weight increase [27, 28], and depression [29]. The current Pacific Guidelines for Healthy Living recommend diet change where fresh fruit and vegetables replace less nutritious, more calorie-dense foods as a way to reduce body mass index [10].

Economic modernisation, migration and changes in population size, post-Colonial culture, and food imports have had a large impact on traditional social structures and the food system in PICs [30, 31]. One factor contributing to the rapid change in diets in Solomon Islands is the fact that there is significant rural-to-urban migration and an urban growth rate
of 5% [32], and with this an increasing dependence on a cash rather than subsistence economy for attainment of food [32]. There is now recognition amongst the global food policy community that focus is needed on improving factors in the food environment that are contributing to poor diets, such as physical availability and price of healthy foods [33-35].

By studying social and demographic drivers of FNSV acquisition such as the difference between urban and rural food acquisition, and the difference between those who have a cash income and those who do not, our study aims to inform targeted policy intervention to increase FNSV consumption. We analysed the nationally representative Solomon Islands Household Income and Expenditure Survey (HIES) from 2012-13 to: a) study how acquisition of FNSV varied across sociodemographic groups; b) examine FNSV price and affordability and use this to determine which sociodemographic groups were associated with acquiring FNSV to the value of the minimum requirement (400g or 5 serves) [19].

Methods

Context

Solomon Islands is an archipelago in the South-West Pacific consisting of about 1000 islands, with nine provinces: Guadalcanal (which contains Honiara – the national capital city), Choissel, Central, Isabel, Makira and Ulawa, Malaita, Rennell and Bellona, Temotu, and Western [36]. The population is 93% Melanesian, 4% Polynesian, 1.5% Micronesian, and the remaining 1.5% a combination of other ethnicities [37]. Solomon Islands is a Least
Developed Country [38], ranking 152 of 189 countries in the Human Development Index [39].

Solomon Islands Household Income and Expenditure Survey (HIES) 2012-2013 dataset

In this study we conducted a secondary analysis of the Solomon Islands HIES 2012-2013 dataset. The HIES collects a comprehensive set of demographic, gender, health, and economic information on individuals, and a broad spectrum of household level data. The HIES adopted a stratified sampling methodology using the 2009 Census frame, including rural and urban areas of each province [40]. The data were weighted to be nationally representative. A sample size of 4,478 households was included. In our dataset, the majority of the population was in rural areas (81%, weighted n=501,353), with 19% (weighted n=114,451) in urban areas. In the HIES, food acquisition information is collected from individual households captured through a 2-week diary that records food acquisition quantity and value by differing source – cash purchases, home production and in-kind (gifts). The food acquisition data is at the household level, so this study used sociodemographic variables derived from households.

Analysis

To address our research questions, we analysed food acquisition data from the HIES dataset as a proxy for food consumption. We included all at-home food acquisition, which was classified in the HIES dataset as: i) cash purchases, ii) home production, and iii) in-kind (gifts) received. We excluded cafe/restaurant acquisition as this was largely not coded into food
groups and was not possible to distinguish from alcohol and tobacco. This category was less than 2% of overall food acquisition.

In our classification of FNSV, we excluded starchy vegetables (kumara, cassava, yam, sweet potato, corn, breadfruit, plantain bananas) as these are classified as energy foods [10]. Dried fruit and canned fruit and vegetables were excluded as the Pacific Guidelines for Healthy Living recommends limiting or avoiding these foods, and recommends consuming fresh and locally grown fruit and vegetables [10]. Fresh coconut was also excluded due to its high fat content [10] and for consistency with similar research in the Pacific which did not classify coconut as a fruit or a vegetable [41]. Juices were excluded as the dataset did not distinguish between fresh and packaged juices, as were herbs that are usually used in very small amounts as a garnish.

Acquisition data were analysed in grams of each food item acquired. In order for our analysis of acquisition data available in the HIES dataset to most closely replicate food consumption measurement (i.e. to account for non-edible components of the fruit and vegetables), acquisition quantity was converted into edible portion. This was done by multiplying the reported acquisition quantity from the HIES dataset by edible portion conversion factors from the Pacific Nutrient Database [Pacific Nutrient Database 2018, unpublished. SPC Noumea, FAO, and University of Wollongong].

Food acquisition data were at the household level in the HIES dataset. In order to compare acquisition accounting for the differences in age and sex makeup of each household, per-household acquisition was converted to the unit of per-Adult Male Equivalent (AME) acquisition in line with similar previous studies [13, 42], using equivalence ratios recommended for use in Household Consumption and Expenditure Surveys (HCES)/HIES.
analysis [43]. The household size information from the HIES dataset was then used to convert the food acquisition data into comparable per AME estimates of inter-household food acquisition. Results figures are presented in 2013 Solomon Islands Dollars (SBD) per AME (0.14 USD).

To determine how sociodemographic characteristics were associated with acquisition of fruit and non-starchy vegetables, a multivariate linear regression model was built, where per-AME fruit and non-starchy vegetable acquisition was the continuous outcome variable. Two steps were performed: Step 1) A multilinear regression model with all variables included; and Step 2) A multilinear regression model including the variables that had returned p-values less than 0.1 in Step 1.

To determine which sociodemographic groups were associated with acquiring FNSV to the minimum value of 400g, we first determined the cost of acquiring 400g of FNSV per AME per day. Food prices from the HIES dataset were used to generate the cost of acquiring an edible portion. Price per gram data for each individual food commodity was cleaned by identifying outliers 3 standard deviations beyond mean price per gram. If an outlier was identified we imputed the median price for that item. Of the 316,581 food transactions in the dataset, 2.12% of prices were imputed. We then used a multivariate logistic regression model, where “acquires 400g or more FNSV” vs. “does not acquire 400g or more FNSV” were the binary outcome variables. To calculate the cost of acquiring 400g of the minimum value FNSV, we took the median price for each FNSV item from the HIES dataset and calculated the cost of 80 edible grams each of the 2 cheapest fruit, the 2 cheapest vegetables plus the next cheapest fruit or vegetable, as was done by Jones and Charlton [41]. The cost of an 80 gram edible portion was calculated separately for urban and rural...
areas and these separate costs were included in our statistical model so that the urban price was used for urban households and the rural price was used for rural households. The multilogistic analysis followed these steps: Step 1) bivariate analysis models with each input variable and the outcome variable; Step 2) multivariate analysis including those variables that returned p-values ≤0.1 in the bivariate analysis; and Step 3) a final, “best fit” multivariate analysis model including the variables that had returned p-values less than 0.1 in Step 2.

The sociodemographic variables included in our analysis were: Age of household head (40-93 vs. 15-39); Gender of household head (male vs. female); Highest education attainment of household head (senior secondary and tertiary vs. preschool to junior secondary); Marital status of household head (married vs. never married, defacto, divorced, separated, widowed); Household has a wage income source vs. household does not have a wage income source; Participation in agriculture (participates vs. does not participate); Participation in fishing (participates vs. does not participate); Household size (7 and above vs. 0-6); Income (top 50% vs. bottom 50%); Region (urban vs. rural); has a vegetable garden vs. doesn’t have a vegetable garden. The variable for household size was dichotomised using the mean which was just under 6. The top and bottom 50% income variable was created by converting household income to AME income and using the weighted median income to dichotomise households into top and bottom groups.

All statistical outputs were weighted to ensure they were nationally representative. The weighting accounted for population weights and survey design features (two-stage sample). The statistical analysis was performed using STATA version 14.2 (Stata Corporation, College Station, Texas, USA).
Formal permission to access the anonymised dataset was granted by the Solomon Islands National Statistics Office. Our secondary analysis on anonymised data from the 2012-2013 Solomon Islands HIES dataset was officially exempted from review by the University of Sydney Human Research Ethics Committee.

**Results**

*Descriptive results*

Among the urban population, 30% (607,033,777 SBD) of annual household acquisition in 2012-2013 was food. Of urban food acquisition, 84% was acquired via cash, 10% was home produced, and the remaining 6% was from gifts received. Of the rural population, 56% (2,409,946,725 SBD) of annual household acquisition was on food. Of this, 35% was acquired via cash and 56% was home produced, and the remaining 8.9% gifts received. There was an overall trend towards more foods being home produced in rural areas than urban areas – especially for fruit and vegetables, meat, seafood, and dairy products. Bread and cereal was mostly bought with cash in both urban and rural areas.
Table 1: Total value of annual household food acquisition (SBD/year) in urban areas

<table>
<thead>
<tr>
<th>Food item</th>
<th>SBD/Year</th>
<th>Cash</th>
<th>Home produced</th>
<th>Gifts received</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bread and cereals</td>
<td>236,101,089</td>
<td>98%</td>
<td>0%</td>
<td>2%</td>
</tr>
<tr>
<td>Meat</td>
<td>57,081,791</td>
<td>87%</td>
<td>3%</td>
<td>10%</td>
</tr>
<tr>
<td>Fish and seafood</td>
<td>113,202,635</td>
<td>83%</td>
<td>8%</td>
<td>9%</td>
</tr>
<tr>
<td>Milk, cheese, and eggs</td>
<td>6,647,060</td>
<td>93%</td>
<td>4%</td>
<td>3%</td>
</tr>
<tr>
<td>Oils and fats</td>
<td>10,053,224</td>
<td>98%</td>
<td>0%</td>
<td>2%</td>
</tr>
<tr>
<td>Fruit (fresh)</td>
<td>22,992,496</td>
<td>66%</td>
<td>24%</td>
<td>9%</td>
</tr>
<tr>
<td>Fruit (processed, dried)</td>
<td>17,353,261</td>
<td>58%</td>
<td>30%</td>
<td>12%</td>
</tr>
<tr>
<td>Vegetables (fresh)</td>
<td>49,996,336</td>
<td>80%</td>
<td>16%</td>
<td>4%</td>
</tr>
<tr>
<td>Vegetables (processed, starchy)</td>
<td>64,363,448</td>
<td>44%</td>
<td>44%</td>
<td>13%</td>
</tr>
<tr>
<td>Sugar, jam, honey, confectionary</td>
<td>22,255,424</td>
<td>98%</td>
<td>0%</td>
<td>3%</td>
</tr>
<tr>
<td>Other foods</td>
<td>6,987,013</td>
<td>96%</td>
<td>0%</td>
<td>3%</td>
</tr>
<tr>
<td>Total</td>
<td>607,033,777</td>
<td>84%</td>
<td>10%</td>
<td>6%</td>
</tr>
</tbody>
</table>
Table 2: Total value of annual household food acquisition (SBD/year) in rural areas

<table>
<thead>
<tr>
<th>Food item</th>
<th>SBD/Year</th>
<th>Cash</th>
<th>Home produced</th>
<th>Gifts received</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bread and cereals</td>
<td>603,163,519</td>
<td>88%</td>
<td>0%</td>
<td>12%</td>
</tr>
<tr>
<td>Meat</td>
<td>111,332,238</td>
<td>37%</td>
<td>35%</td>
<td>28%</td>
</tr>
<tr>
<td>Fish and seafood</td>
<td>435,899,659</td>
<td>29%</td>
<td>62%</td>
<td>8%</td>
</tr>
<tr>
<td>Milk, cheese, and eggs</td>
<td>8,103,168</td>
<td>43%</td>
<td>47%</td>
<td>10%</td>
</tr>
<tr>
<td>Oils and fats</td>
<td>10,682,869</td>
<td>97%</td>
<td>0%</td>
<td>3%</td>
</tr>
<tr>
<td>Fruit (fresh)</td>
<td>74,750,594</td>
<td>10%</td>
<td>82%</td>
<td>8%</td>
</tr>
<tr>
<td>Fruit (processed, dried)</td>
<td>181,926,903</td>
<td>5%</td>
<td>89%</td>
<td>6%</td>
</tr>
<tr>
<td>Vegetables (fresh)</td>
<td>167,228,659</td>
<td>12%</td>
<td>84%</td>
<td>5%</td>
</tr>
<tr>
<td>Vegetables (processed, starchy)</td>
<td>746,309,574</td>
<td>6%</td>
<td>88%</td>
<td>6%</td>
</tr>
<tr>
<td>Sugar, jam, honey, confectionary</td>
<td>57,154,130</td>
<td>90%</td>
<td>0%</td>
<td>10%</td>
</tr>
<tr>
<td>Other foods</td>
<td>13,395,412</td>
<td>90%</td>
<td>1%</td>
<td>9%</td>
</tr>
<tr>
<td>Total</td>
<td>2,444,171,738</td>
<td>36%</td>
<td>55%</td>
<td>9%</td>
</tr>
</tbody>
</table>

Sociodemographic associations

The associations between household sociodemographic factors and vegetable and fruit acquisition are presented in Table 3. The factors that produced a statistically significant positive association were household wealth status and urban vs. rural residence. The factors that produced a statistically significant negative association were age of household head and household size. The strongest association was for wealth: fruit and non-starchy vegetable acquisition was significantly greater in those households in the higher wealth category than those in the lower wealth category (Beta coefficient 301, 95% CI 242 to 360, \( p < 0.001 \)).
Table 3: Association between household sociodemographic grouping and FNSV acquisition

<table>
<thead>
<tr>
<th>Sociodemographic factor (referent category in brackets)†</th>
<th>Beta coefficient (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household head aged 40+ (15 - 39)</td>
<td>-85.2 (-156.3 to -14.0)</td>
<td>0.019</td>
</tr>
<tr>
<td>Household has 7 or more members (0-6)</td>
<td>-203.9 (-244.3 to -163.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Higher 50% wealth households (Lower 50% wealth households)</td>
<td>300.7 (241.7 to 359.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Urban (Rural)</td>
<td>110.2 (37.8 to 182.6)</td>
<td>0.003</td>
</tr>
<tr>
<td>Male household head (Female)</td>
<td>28.3 (-41.1 to 97.8)</td>
<td>0.420</td>
</tr>
<tr>
<td>Household head has junior secondary education (Tertiary)</td>
<td>0.8 (-54.5 to 56.1)</td>
<td>0.978</td>
</tr>
<tr>
<td>Household head married (unmarried)</td>
<td>-16.6 (-99.0 to 65.8)</td>
<td>0.690</td>
</tr>
<tr>
<td>Household has a wage income</td>
<td>-19.6 (-73.2 to 33.9)</td>
<td>0.470</td>
</tr>
<tr>
<td>Household participates in agriculture (Does not participate)</td>
<td>-39.6 (-122.6 to 43.4)</td>
<td>0.347</td>
</tr>
<tr>
<td>Household participates in fishing (Does not participate)</td>
<td>-67.6 (-165.1 to 29.9)</td>
<td>0.172</td>
</tr>
<tr>
<td>Household has a vegetable garden (Does not have a vegetable garden)</td>
<td>40.8 (-62.3 to 143.9)</td>
<td>0.434</td>
</tr>
</tbody>
</table>

† Variables in non-bold were excluded from the final linear regression model (Step 2) because they produced p values greater than 0.1 in linear regression analysis Step 1 (see Methods). Results in bold are results from final “best fit” model (Step 2)

Fruit and non-starchy vegetable affordability

FNSV are more expensive in urban than rural areas. In urban areas, the minimum cost of acquiring 400g FNSV is SBD 2.48 per person per day (0.35 USD); in rural areas the cost of acquiring 400g FNSV is SBD 1.62 (0.23 USD). Table 4 shows relative affordability of FNSV in urban and rural areas. FNSV were more affordable in rural areas and for those in the higher income group.
Table 4: Daily mean per-AME acquisition (SBD)

<table>
<thead>
<tr>
<th></th>
<th>Daily FNSV acquisition</th>
<th>Daily food acquisition</th>
<th>Daily total goods acquisition</th>
<th>FNSV acquisition as % of food acquisition</th>
<th>FNSV acquisition as % of total goods acquisition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban: Higher 50% income</td>
<td>11.14</td>
<td>24.62</td>
<td>91.45</td>
<td>10%</td>
<td>3%</td>
</tr>
<tr>
<td>Urban: Lower 50% income</td>
<td>7.49</td>
<td>12.11</td>
<td>25.89</td>
<td>20%</td>
<td>10%</td>
</tr>
<tr>
<td>Rural: Higher 50% income</td>
<td>9.06</td>
<td>29.36</td>
<td>63.24</td>
<td>6%</td>
<td>3%</td>
</tr>
<tr>
<td>Rural: Lower 50% income</td>
<td>6.23</td>
<td>13.28</td>
<td>21.77</td>
<td>12%</td>
<td>7%</td>
</tr>
</tbody>
</table>

Higher household wealth was significantly positively associated with acquiring FNSV to the value of the 400g of the least expensive fruit and non-starchy vegetables (OR 2.31, \( p < 0.001 \)) (Table 5). Members of households with a household head aged 40 and above, members of households that participate in fishing, members of households with 7 or more members, and members of households in urban areas had significantly lower odds of acquiring FNSV to the value of 400g of the least expensive FNSV compared with those in the respective referent groups.
### Table 5: Associations between household sociodemographic grouping and whether or not household members meet minimum requirement for 400g fruit or non-starchy vegetables per day

<table>
<thead>
<tr>
<th>Sociodemographic factor (referent category in brackets)†</th>
<th>Does acquire 400g FNSV per day vs. does not</th>
<th>Odds Ratio (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household head aged 40+ (15-39)</td>
<td></td>
<td>0.752 (0.588 to 0.961)</td>
<td>0.023</td>
</tr>
<tr>
<td>Household participates in fishing (Does not participate)</td>
<td></td>
<td>0.682 (0.545 to 0.853)</td>
<td>0.001</td>
</tr>
<tr>
<td>Household has 7 or more members (0-6)</td>
<td></td>
<td>0.439 (0.350 to 0.549)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Higher 50% wealth households (Lower 50% wealth households)</td>
<td></td>
<td>2.311 (1.920 to 2.782)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Urban (Rural)</td>
<td></td>
<td>0.531 (0.439 to 0.642)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Household head has junior secondary education (Tertiary)</td>
<td></td>
<td>0.995 (0.800 to 1.24)</td>
<td>0.965</td>
</tr>
</tbody>
</table>

† Sex of household head, marital status of household head, household has a wage income, household participates in agriculture, household has a vegetable garden status are not presented here because they produced p values greater than 0.1 in the bivariate analysis step (Step 1 in explanation of multivariate analysis steps in Methods). Results in non-bold indicate results that returned p values greater than 0.1 in Step 2. These were not included in Step 3 (the best fit model), the results of which are presented in bold above.

### Discussion

**Summary of results and likely implications**

We used the most recent Solomon Islands HIES dataset to analyse price and affordability of FNSV, then used this information to determine which parts of the Solomon Islands population were most vulnerable to inadequate FNSV acquisition. Our results showed that higher household wealth was positively associated with sufficient acquisition of FNSV and the following were negatively associated: households with a head aged 40 and above, households that participated in fishing, households in urban areas, and households with 7 or more members.
When all variables were accounted for, household wealth was the most consistent predictor of FNSV acquisition. Our multivariate analysis showed that higher household wealth was the variable most strongly associated with fruit and non-starchy vegetable acquisition as a continuum, as well as with acquiring 400g of the least expensive fruit or non-starchy vegetables. This finding suggests that financial affordability of FNSV is important to ensure access throughout the population. More complex mechanisms are also likely to be at play here as those households with higher wealth are likely to also have access to land to grow FNSV. Our findings are consistent with previous research from the Pacific and worldwide. A recent study in Samoa showed that higher wealth was associated with higher fruit and vegetable consumption [44]. A study in semi-urban Tanzania found that those with high incomes were more likely to have high fruit intake [45]. Evidence from Europe shows a strong link between low sociodemographic status and low fruit and vegetable consumption [46].

Urban versus rural residence presented a mixed picture in terms of FNSV acquisition in our study. The most important result for policy makers to note is the fact that those in urban areas compared with those in rural areas are significantly less likely to acquire the minimum sufficient amount of FNSV. This difference is very likely to be due to the differing ways food is acquired between urban and rural areas. FNSV in rural areas were 82% and 84% home produced respectively, whereas in urban areas FNSV were acquired 66% and 80% via cash respectively. Most other foods in our dataset followed this pattern – of urban food acquisition overall, the vast majority was acquired via cash, compared with just over a third of food acquisition in rural areas. Additionally, a higher percentage of participants from
urban areas acquired only 1 or 2 serves per day than those in rural areas – but a higher percentage of participants from rural areas acquired 5 or more serves.

Taken together, the combination of findings that rural households were more likely to acquire FNSV to the value of the minimum requirement of 400g of the least expensive FNSV per day, and the finding that FNSV were usually acquired with cash in urban areas, suggests that a strong enabler of adequate fruit and non-starchy vegetable acquisition in Solomon Islands is the ability to access home grown foods. It has previously been reported that access to home grown foods is less common in population-dense urban areas in Solomon Islands and is a recognised food security issue [18, 47]. The higher risk of developing NCDs associated with this lower FNSV acquisition in urban areas is likely to be exacerbated by the lower levels of physical activity experienced by those living in urban areas of the Pacific, where factors like car use and sedentary work are more common [31].

The relative cost of buying FNSV was higher in urban areas which suggests an affordability challenge facing urban dwellers, especially those with low incomes. The fact that those in urban areas were less likely to acquire FNSV to the minimum value of 400g is likely to be due to differences in the comparative affordability of other foods such as imported rice and noodles. In Solomon Islands the per capita national annual consumption of imported cereals, nearly all rice, doubled between 2002 and 2007 [48]. More research is needed here, but it should be noted that increasing financial access to, and affordability of, fresh fruit and vegetables, especially in urban areas, is likely to have positive health effects for the Solomon Islands population.
The importance of economic access related to food cost in influencing food choice has been recognised in PICs for at least two decades: a 2001 study from Tonga reported that cost was a key driver of the shift away from traditional foods and towards imported, high-carbohydrate, high-fat, low-nutrient foods like bread, rice, and fatty meats [49]. Worldwide evidence is also consistent with this: a recent Lancet study of 18 countries in varying income categories showed that consumption of fruit and vegetables decreased as their cost increased [50].

Larger household size (7 members and above) was associated with lower acquisition of FNSV in our study. This is likely to be due to sharing of resources amongst household members. In Solomon Islands society, the Wantok system means there is a social requirement to share resources including housing and food amongst extended kin. Cooking meals to feed many mouths can mean foods like rice and noodles are commonly used to create a high volume of food at low cost. The stretching of resources amongst many people often leads to consumption of meals with low nutrient value [4]. This phenomenon is likely to be exacerbated by the rapid rural-urban migration rate, and large households in urban areas should be a priority area for public health nutrition policies and programs aiming to increase FNSV consumption. Recent research from Vanuatu examined price and affordability of purchasing 400g FNSV and also found that households with more household members were less likely to have adequate FNSV consumption than households with fewer members [41].
Policy recommendations

Our findings suggest that key contributors to inadequate FNSV acquisition were low relative affordability of FNSV compared with other foods, especially amongst the lower income urban portion of the population. The apparent link between home production and increased FNSV acquisition suggests that enabling community members access to land to grow FNSV may increase consumption. Policies that support marketplaces to sell FNSV at affordable prices relative to other foods available have good potential to increase FNSV consumption. Research from a low-income area of the United States has shown that an intervention where mobile markets sell fruit and vegetables, combined with an education program, significantly increased consumption [51].

In order to successfully increase FNSV consumption in Solomon Islands, coordinated action is required across multiple sectors. Kaufer and colleagues [52] found that in the Federated States of Micronesia a 2-year community level intervention supporting agriculture, education, and messaging around eating local foods increased households’ frequency of consumption of local vegetables and fruit.

Strengths and limitations

Our study harnessed detailed data from the Solomon Islands HIES 2012-2013 dataset, standardised to per-AME and per gram, and compared this across the population. It provides policy relevant information to a previously very data constrained area of the literature.
The main limitation of our study is that our data provides detailed information on FNSV acquisition rather than volume acquired. In line with previous research, we have interpreted these data using the minimum value of 400g of fruit and vegetables on a per-AME basis [13, 41, 42]. The strength of this approach is that it provides a constant baseline by which to assess household expenditure. However, the fact that households are likely to acquire FNSV of varying value, means that we may overestimate the proportion of the population acquiring 400g FNSV. Our study accounts for this limitation as the primary aim of our study was not to determine the proportion of the population that acquire 5 serves of FNSV a day, but rather to explore patterns of adequate FNSV acquisition amongst different sociodemographic groups.

The constraints of the HIES dataset meant that we could not measure consumption, but rather we used data on participant-reported acquisition as a proxy for consumption. The scope of the dataset also meant that our study could not measure intra-household distribution of food. Our use of income as a measure of wealth may have introduced some measurement inaccuracy as income is subject to underreporting, however if we had used expenditure instead, this would also be subject to reporting bias [40]. In addition, the sociodemographic variables corresponded with the household head, so were not at the level of the individual. We also note that in the HIES dataset, there is variation of food prices between provinces, as well as between urban and rural areas – and our study only captured the difference between urban and rural areas. The 2-week food diary did not account for seasonal differences in acquisition, however these differences were captured across the dataset by running the HIES throughout the year.
Conclusions

Our study provides novel insight into the links between social and economic factors and FNSV acquisition in Solomon Islands, and our findings are relevant to stakeholders interested in influencing diet-linked health outcomes in Solomon Islands. Insights from our study design and findings are relevant to other low- and middle-income settings, especially those experiencing similar trends in subsistence-to-cash economies, and rural-urban migration.

Cash-based food acquisition is increasingly important in Solomon Islands especially in urban areas, meaning improving affordability of healthy foods like fresh fruit and vegetables should be a major priority area for policy makers. Efforts are required across multiple sectors in order to increase FNSV consumption. The findings from this study would be complemented by research that examines in more detail complex issues influencing food acquisition such as how social attitudes to food are influenced by post-colonial changes to economies, as discussed by McLennan and Ulijaszek [35]. Policies and programs such as subsidies which aim to facilitate higher FNSV consumption should prioritise vulnerable groups including those in low-income households and those in large households in urban areas.

List of abbreviations

AME Adult Male Equivalent
BMI Body Mass Index
FNSV Fruit and non-starchy vegetables
Declarations

Ethics approval and consent to participate

Formal permission to access the anonymised dataset was granted by the Solomon Islands National Statistics Office. Our secondary analysis on anonymised data from the 2012-2013 Solomon Islands HIES dataset was officially exempted from review by the University of Sydney Human Research Ethics Committee.

Consent for publication

Not applicable

Availability of data and materials

The datasets used during the current study are available from Solomon Islands Ministry of Finance, the data custodian, on reasonable request.

Competing interests

The authors declare that they have no competing interests.
Funding

Penny Farrell was supported by an Australian Postgraduate Award scholarship.

Michael Sharp was supported by the Australian Centre for International Agricultural Research (ACIAR) project FIS/2016/300.

Acknowledgements

The authors would like to thank Solomon Islands Government Statistician Mr Douglas Kimie for providing the anonymised Household Income and Expenditure Survey 2012-13 dataset.

Authors’ contributions

PF analysed and interpreted the data, and wrote the manuscript. MS analysed and interpreted the data, and contributed to the manuscript. AMT contributed to the study design and writing of the manuscript. MM contributed to the data analysis. SK contributed to the manuscript. JN contributed to the study design and writing of the manuscript. All authors read and approved the final manuscript.

Availability of data and materials

The dataset supporting the conclusions of this article is available upon reasonable request to the Solomon Islands Ministry of Finance.
References


Supplementary table – annual mean value of acquisition of fruit and non-starchy vegetables, by demographic group SBD/AME/year (simple descriptive)

<table>
<thead>
<tr>
<th></th>
<th>National</th>
<th>Urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age group</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 to 39</td>
<td>922</td>
<td>1,029</td>
<td>893</td>
</tr>
<tr>
<td>40+</td>
<td>713</td>
<td>918</td>
<td>676</td>
</tr>
<tr>
<td><strong>Sex of household head</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>959</td>
<td>1326</td>
<td>849</td>
</tr>
<tr>
<td>Male</td>
<td>783</td>
<td>920</td>
<td>755</td>
</tr>
<tr>
<td><strong>Education group</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preschool to junior secondary</td>
<td>749</td>
<td>855</td>
<td>735</td>
</tr>
<tr>
<td>Senior secondary to university</td>
<td>944</td>
<td>1,103</td>
<td>859</td>
</tr>
<tr>
<td><strong>Marital status</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>943</td>
<td>1,269</td>
<td>848</td>
</tr>
<tr>
<td>Married</td>
<td>784</td>
<td>929</td>
<td>755</td>
</tr>
<tr>
<td><strong>Has a wage paying job</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>753</td>
<td>1,139</td>
<td>746</td>
</tr>
<tr>
<td>Yes</td>
<td>831</td>
<td>967</td>
<td>780</td>
</tr>
<tr>
<td><strong>Participates in agriculture</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>930</td>
<td>950</td>
<td>892</td>
</tr>
<tr>
<td>Yes</td>
<td>772</td>
<td>1,025</td>
<td>753</td>
</tr>
<tr>
<td><strong>Participates in fisheries</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>913</td>
<td>993</td>
<td>875</td>
</tr>
<tr>
<td>Yes</td>
<td>681</td>
<td>690</td>
<td>681</td>
</tr>
<tr>
<td><strong>Has a vegetable garden</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1,007</td>
<td>975</td>
<td>1,282</td>
</tr>
<tr>
<td>Yes</td>
<td>776</td>
<td>972</td>
<td>757</td>
</tr>
<tr>
<td><strong>Household size</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;=6 persons</td>
<td>927</td>
<td>1,149</td>
<td>883</td>
</tr>
<tr>
<td>&gt;=7 persons</td>
<td>534</td>
<td>670</td>
<td>500</td>
</tr>
<tr>
<td><strong>Income 50%</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below</td>
<td>519</td>
<td>527</td>
<td>518</td>
</tr>
<tr>
<td>Above</td>
<td>1,083</td>
<td>1,066</td>
<td>1,090</td>
</tr>
<tr>
<td><strong>Geographic domain</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>764</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>974</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Chapter 7: Paper 5

Farrell P, Thow AM, Rimon M, Roosen A, Vizintin P, Negin J. “Today, we live on money and depend on processed food from the shop”: Healthy food access in peri-urban Honiara. Under review
Title

“Today, we live on money and depend on processed food from the shop.”: analysis of healthy food access amongst women in peri-urban Honiara

Authors

Penny Farrell MIPH, Anne Marie Thow PhD, Mia Rimon MPPM, Andy Roosen PhD, Pavle Vizintin MIPH, Joel Negin PhD

Discipline

Public Health

Word count

3 149 words
Abstract

Highly processed, energy dense foods are contributing to the high and rising rates of non-communicable diseases and nutrient deficiencies in Solomon Islands. Non-communicable diseases currently cause 69% of deaths in Solomon Islands and the rate is rising, fuelled in part by a limited health system capacity to treat these conditions. Solomon Islands also has the highest reported undernourishment rate in the Pacific. Recent decades have seen a number of factors change the food and economic environment in Solomon Islands. Importantly, rural-to-urban migration has caused a disconnect between urban residents and access to land and home gardens. This study aimed to examine the complexities of nutritious food access in urban Solomon Islands. Data were collected from 32 women in Honiara using a novel survey instrument. The three most important findings were: i) the dominant influencers of the diet patterns described by participants in this study were food affordability and access to land on which to grow it; ii) all participants experienced food insecurity; iii) and reported diet patterns reflected unhealthy diets which were particularly high in processed and sugary energy foods. These findings suggest a need for improvements in the food environment in Honiara.

Keywords: diet, Pacific, Solomon Islands, nutrition transition, non-communicable disease, Pacific Island Countries and Territories

Abbreviations and Acronyms

NCD = Non-communicable disease

PICTs = Pacific Island Countries and Territories

STEPS = STEPwise approach to surveillance
Introduction

Non-communicable diseases (NCDs) including cardiovascular disease and diabetes are the leading cause of death and disability in the Pacific region, imposing significant economic strain, pressure on overstretched health systems, and high levels of societal loss from premature deaths.\textsuperscript{1,2} Highly processed, energy dense foods which contain low amounts of micronutrients are contributing to the high and rising rates of NCDs and nutrient deficiencies in Pacific Island Countries and Territories (PICTs) including Solomon Islands.\textsuperscript{1,3} Solomon Islands is an archipelago country in the South-West Pacific with around 1 000 islands and a population of 600 000.\textsuperscript{4} NCDs currently cause 69\% of deaths in Solomon Islands and the rate is rising, and the problem is exacerbated by a limited health system capacity to treat these diseases.\textsuperscript{5-7} Solomon Islands also has the highest reported total population undernourishment rate in the Pacific at almost 14\%, and the rate has risen 2\% in the last decade.\textsuperscript{5} The country currently faces a triple burden of malnutrition: anaemia in adult women and children is around 40\%, 33\% of children are stunted, and over half of adults are overweight and 25\% are obese.\textsuperscript{9-12}

Recent decades have seen a number of factors change the food and economic environment in Solomon Islands. Half a decade of civil unrest in 1998 to 2003, the global financial crisis, rapid population growth, natural disasters, and urbanisation are contributing to ongoing cultural and economic change.\textsuperscript{3} Solomon Islands ranks 152 of 189 countries in the Human Development Index.\textsuperscript{13} Approximately 80\% of people in Solomon Islands live in rural areas and access food via subsistence agriculture,\textsuperscript{14,15} however an urban population growth of 5\% has caused a disconnect between urban residents and access to land and home gardens.\textsuperscript{15-17} Cash poverty is common in Solomon Islands and food prices are high relative to monetary earnings.\textsuperscript{15}

There is a significant lack of data on food and nutrition security in PICTs,\textsuperscript{18} including Solomon Islands, and the lack of data is hampering efforts to build effective policies and regulatory frameworks to improve food systems.\textsuperscript{3} The present study was designed to provide policy-relevant insight to start to address this research gap. The study focuses on women, as there is worldwide evidence that autonomy of women is positively linked with their household’s nutritional status.\textsuperscript{19} Women are more vulnerable to food insecurity than men, and the prevalence of obesity worldwide is 50\% higher in women than in men.\textsuperscript{20,21} Between 1975-2014, increases in Body Mass Index for women in PICTs were amongst the largest globally.\textsuperscript{22} Prevalence of overweight and obesity is higher in women in Solomon Islands than in men.\textsuperscript{7} Importantly, women in Solomon Islands
experience strong inequalities in access to resources and control of household decision making within households.¹⁵

This study aimed to gain nuanced understanding into some of the complexities of nutritious food access in urban Solomon Islands, by: 1) measuring food security and patterns of consumption of key food groups and specific foods; and 2) determining the most important drivers of diet amongst participants, to help inform targeted program and policy design.

**Methods**

*Study design*

This was a study informed by validated tools to collect data on food security and food consumption patterns.²³,²⁴ Data were collected using a structured questionnaire (see Appendix) starting with questions about demographic characteristics and general health indicator information. Food security was measured with an adapted Radimer/Cornell tool based on that used by Shoae et al.²³ This included a series of questions pertaining to household, self, and child food insecurity, and participants were asked to answer “always”, “sometimes” or “never” to each question. Diet patterns were assessed using a shortened version of a food frequency questionnaire used in a published study of 785 adults in Samoa.²⁴ The aim of this data collection was not to quantify exact dietary intake levels but to ascertain broad patterns of food consumption in our study participants in order to then explore the reasons for such diet patterns. Participants were then asked a series of open-ended questions about their diet patterns, which explored drivers and barriers to consumption of a nutritious diet.

*Data collection*

The study took place in the national capital Honiara. In-depth interviews were conducted with 32 women with children in their care attending local primary schools. Participants were recruited using convenience sampling directed by school staff. Invited participants were given detailed information about the study in the form of a participant information sheet and verbal explanation. Informed consent forms were signed before each interview commenced. There were no withdrawals from the study. Participants were reimbursed with funds to purchase lunch and bus transport.
Participants were interviewed individually in a private room. Interviews were run and transcribed in English by trained members of the research team. Research assistants were also present and translated the questions and responses into Solomon Islands Pijin when required. All participants had good English language skills and translation was only required occasionally to confirm the meaning of certain words.

Data analysis

Interview answers were entered into Microsoft Excel. Food frequency data were classified into energy foods (carbohydrate based foods), protective foods (fruit and vegetables), and body-building foods (foods high in protein) using the Pacific Guidelines for Healthy Living. These guidelines classify energy foods into: “energy foods to choose” (for example root crops, whole grains); “energy foods to limit” (foods high in refined carbohydrate including white bread and white rice), and “energy foods to avoid” (foods high in fat, highly processed, high in sugar including sugar-sweetened beverages). Food security questionnaire responses were used to classify each participant as household, individual, and/or child food insecure.

The answers to the questions about food access and diet patterns were analysed using thematic analysis in order to determine the most important reasons for dietary patterns.

The study was approved by the Solomon Islands National Health Research and Ethics Committee.

Results

Study demographics

The study participants (n=32) were all women living in suburbs and villages close to Honiara. Table 1 summarises the key demographics of the study population. Of note, 60% of participants (n=22) were under the age of 40, and 81% of participants cared for their families full time without a direct source of personal income (n=26). In addition to the demographics presented in Table 1, participants reported the average number of years lived in Honiara was 20, and the average household size was five adults and three children.

Food consumption patterns

Table 2 presents a summary of key food items in participants’ reported diet patterns. The most commonly consumed food group was energy foods, followed by body building foods. The most commonly consumed
energy food was white bread. 86% of participants (n=24) reported consuming this daily. Fish was the most commonly consumed body building food. This was consumed daily by 63% of participants (n=20). Less than a quarter (23%) of participants (n=7) reported consuming fruit daily, and 57% of participants reported consuming vegetables daily (n=17).

**Cooking style**
More than half of participants cooked food in fresh coconut cream three or more times per week. The main foods cooked in coconut were cabbage, fish, and starchy vegetables. Most participants cooked foods in oil at least weekly. The most common cooking oil mentioned was palm oil, and participants also used peanut and vegetable oil. The main foods cooked in oil were fish, cabbage, and chicken. Most participants also prepared foods in soups at least weekly. The main foods prepared as soups were starchy vegetables and chicken. Data not shown.

**Reasons for diet patterns**
Table 3 demonstrates that the most commonly mentioned reason for selection of particular types of food for consumption was affordability (84%, n=27). Other reasons given were cooking facilities and ease of preparation (detailed below), availability of processed food (detailed below), availability of land (44%, n=14), taste (28%, n=9), pursuit of health (19%, n=6), and culture (9%, n=3). When participants explained these drivers of dietary patterns, some specific foods were mentioned as illustrative examples. For example, tinned fish was often selected because of affordability. Vegetables and chicken were often selected because they were homegrown. White bread, white rice, tea with sugar were mentioned in relation to affordability and convenience. Noodles were often consumed because of ease of preparation.

Table 3 shows that 63% of participants (n=20) reported that the cooking facilities available to them influenced the foods they were able to cook. Participant responses were not detailed enough to quantify the most common cooking facilities used, but the most frequently mentioned facilities were firewood, gas stoves and earth ovens.

All participants (n=32, 100%) stated their diets were different to those eaten by their grandparents when they were the same age (Appendix Q5.03). Participant responses described a shift away from diets high in fresh fruit and vegetables and wild caught meat eaten in previous generations, and towards diets high in energy-dense
processed and convenience foods. Table 3 also shows that 44% of participants (n=14) noted increased availability of processed foods high in fat, sugar, and salt as a key driver of contemporary diet patterns.

When participants were asked who in their household decides how much money was spent on food (see Appendix Q7.03; responses not tabulated), 55% of participants reported a joint decision (n=17, 15 of which was with the husband). 23% (n=7) reported not being involved in the decision. Of these, the most common person mentioned who was responsible for this decision was the participant’s husband (n=5). 19% of participants (n=6) reported being solely responsible for the decision. One participant reported their father being responsible for decision making, and the remaining participant did not respond to this question.

Knowledge of what constituted a healthy and balanced meal (see Appendix Q7.08; responses not tabulated) was low overall – when participants were asked to describe what they would eat if they wanted to consume a healthy and balanced meal, just over one-third (40%, n=12) described a meal including energy foods, body building foods, and vegetables.

**Food security**

All participants (n=32, 100%) reported experiencing food insecurity in their household. Of the household food security questions (see Section 8 of Appendix), the question with the most affirmative responses was “I have been worried that our food will run out” (93%, n=28). The majority of participants (n=26, 81%) also reported individual food insecurity, and 75% (n=24) reported child food insecurity.

**Discussion**

**Summary of results and likely implications**

Our study aimed to provide policy relevant insight about access to a nutritious diet in contemporary Honiara in light of the current triple burden of malnutrition and the rapid changes to the urban population size and economy. This was a methodologically novel study in Solomon Islands and the results provide useful information on the under-researched area of food insecurity and diet behaviour in Solomon Islands and other PICTs. The three most important findings were: i) the dominant influencers of the diet patterns described by participants in this study were food affordability and access to land on which to grow fruit and vegetables; ii) all participants experienced food insecurity, meaning they all at least sometimes experienced difficulty accessing
nutritious food, and some regularly skipped their own, or their children’s, meals; iii) reported diet patterns reflected unhealthy diets which were particularly high in processed and sugary energy foods. There were no obvious patterns between socio-demographic characteristics, food security status, and diet patterns observed in this small descriptive study.

These three key findings are deeply interconnected and suggest the study participants are living in a food environment that is not supportive of good health. The dominant story told by the study participants was that they did not have the cash to purchase adequate nutritious food for themselves and their households, nor access to the land to grow it, and that because of these challenges with nutritious food access (otherwise defined as food security), they are consuming inexpensive foods which are energy dense, often highly processed, and low in nutrients. These foods have been implicated as key to the high rates of NCDs and micronutrient deficiencies in the Pacific.\textsuperscript{1,3} There is evidence that in a food insecure environment, consumption of energy dense, highly processed foods is a main mechanism whereby food insecurity can lead to obesity.\textsuperscript{27}

The diet patterns reported in this small study are consistent with grey literature reports that people in Honiara generally purchase food with cash, and as heavily processed, often imported foods are usually less expensive, these are increasingly becoming the main feature of people’s diets.\textsuperscript{3,7,17} The findings from this study reflect reports of a worsening food security situation throughout the Pacific region. Connell reported that food insecurity has increased in the region in recent decades – and due to cost, convenience, and prestige, diets are high in imported and processed foods especially rice.\textsuperscript{28}

The most frequently reported energy foods consumed by the study participants are classified as ‘energy foods to limit’ and ‘energy foods to avoid’ in the Pacific Guidelines\textsuperscript{25}: the most common of these were white bread, white rice, pancakes, and donuts. Of further concern is the fact that the vast majority of participants reported consuming sugar sweetened beverages (usually sugar in tea) at least weekly and almost two-thirds consumed this daily. Sugar sweetened beverages are classified as an energy food to avoid in the Pacific Guidelines for Healthy Living. There are several potential poor health consequences of consuming these ‘energy foods to limit’ and ‘energy foods to avoid’, for example consuming sugar sweetened beverages increases the risk of diabetes.\textsuperscript{29} It is notable that diabetes is now the leading cause of death and disability in Solomon Islands.\textsuperscript{30}
The diet patterns reported by participants in this study suggest that fruit and vegetable consumption is likely to be well below the five servings per day recommended in the Pacific Guidelines for Healthy Living. The most recent STEPwise approach to surveillance (STEPS) survey showed that 93% of the Solomon Islands population ate less than five servings of fruit and/or vegetables per day, with the average daily consumption being 0.8 servings of fruit and 1.3 servings of vegetables. There is evidence from Solomon Islands that households in urban areas and those with low incomes are vulnerable to insufficient fruit and non-starchy vegetable consumption.

In Solomon Islands society, food and land is owned collectively – people are socially required to share food and housing with their extended kin, or Wantok. This has implications for the way resources are distributed, and preparing high-volume, low cost meals often means low-nutrient, high-volume foods like rice are sought. The participants in this study were generally from large households, and although a pattern between household size and diet patterns was not observed in this small descriptive study, recent research from Solomon Islands found that those living in households with seven or more people acquired less fruit and non-starchy vegetables than those in small households.

The relationship between inter-household sharing of resources, poverty, and food security was not explored in this study, but warrants attention in future research. It has been suggested that remittance funds sent to the rural population by their Wantok in Honiara are decreasing due to decreased food affordability in Honiara which demonstrates that urban welfare is connected with national development.

**Strengths and limitations**

This study was designed to understand dietary patterns, food preferences, and interactions with food environments, not exact food intake levels. The food frequency questionnaire results offer indicative descriptive figures only due to the small sample size, and relied on self-reported diet information, which could have introduced bias. The question about vegetable consumption did not distinguish between starchy (an energy food) and non-starchy vegetables (protective foods). The survey was conducted in Honiara only, so may not be representative of all urban areas.
The survey was performed before the most recent Pacific Guidelines for Healthy Living\textsuperscript{25} were published, so its recommendations about portions of energy, body building, and protective foods could not be built into the survey. These were however used when analysing the data – thus making the findings directly applicable for policy makers in the Pacific. The tool used to measure food security was designed based on the best available resources, however, there is no validated food security measurement tool for Solomon Islands.

The question about household decision making in this study was simple and as a result the responses were likely more superficial than the lived reality for participants. Although most participants reported they had some say in household decision making around food purchasing, it should be noted that in Solomon Islands “women are responsible for decisions about raising children, providing food, and running the household, but men have the power to beat them if they get it wrong.”\textsuperscript{15} More time and attention should be given to this vital but highly sensitive topic in the future.

**Recommendations**

The findings of this study call for urgent action in improving access to a nutritious and affordable diet in urban Solomon Islands. As the combination of rural-urban migration, lack of access to garden land, low incomes and high formal unemployment in urban populations is a serious problem in many PICTs,\textsuperscript{3,33} the methods and findings from this study have value across the region. The methodology used in this study may have use as a foundation in gathering further baseline, and subsequent progress information where food systems interventions and policy changes are implemented.

The combined findings of high food insecurity and diets high in processed foods match those of other studies from the Pacific. Connell\textsuperscript{28} declared that food insecurity in PICTs is “an increasingly urban problem” – with the solution embedded in broad economic growth and poverty reduction, and cross-sectoral action not limited to the agriculture or health sectors. The issue of urban food poverty in Solomon Islands is going to affect more and more people as urbanisation continues to grow. The rise in urban population size (rising at a rate of 4.7% per year, faster than the national growth rate of 2.3%) means that poverty reduction and provision of basic services are in need of urgent attention by the national government.\textsuperscript{16}
A 2018 review spanning 172 countries has shown that imports of processed food and sugar significantly increase average Body Mass Index.\textsuperscript{34} The promotion of healthier food imports through consideration of nutrition in trade policy design and input of the health sector in trade policy has strong potential to improve diets in the Pacific region.\textsuperscript{35,36}

Increased alignment between local agriculture and nutrition and health outcomes is needed at high priority.\textsuperscript{3} Policies that provide support for marketplaces to sell fresh local foods at affordable prices relative to other foods on the market; and to facilitate different cooking options for households have potential to increase nutritious food consumption. The findings from this study add to the small amount of existing evidence from Melanesian countries that financial and physical access to nutritious food is an important barrier to its consumption.\textsuperscript{7,32,37}

There is the potential to trial programs which have worked in other countries to address these issues. For instance, research from a low-income area of the United States has shown that an intervention where mobile markets sell fruit and vegetables, combined with an education program, significantly increased consumption of fruit and vegetables.\textsuperscript{38}

Acknowledgements

The authors would like to express their thanks to the study participants, the schools through which they were recruited, The Pacific Community Honiara NCD Warrior team for their support.

Disclosure statement

The authors declare no conflict of interest.

References


**Table 1: Study participant demographics (N=32)**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>20 to 29</th>
<th>30 to 39</th>
<th>40 to 49</th>
<th>No response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16% (5)</td>
<td>55% (17)</td>
<td>29% (9)</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Care for family</th>
<th>Teacher</th>
<th>Retail</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>81% (26)</td>
<td>6% (2)</td>
<td>6% (2)</td>
<td>6% (2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Education</th>
<th>Primary school</th>
<th>High school</th>
<th>University</th>
<th>No response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50% (14)</td>
<td>39% (11)</td>
<td>11% (3)</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Province of origin</th>
<th>Guadalcanal</th>
<th>Malaita</th>
<th>Other</th>
<th>No response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16% (5)</td>
<td>74% (23)</td>
<td>10% (3)</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 2: Reported frequency of consumption of commonly consumed foods (N=32)

<table>
<thead>
<tr>
<th>Food item</th>
<th>Daily % (n)</th>
<th>3 times per week % (n)</th>
<th>Once per week % (n)</th>
<th>Less than once per week % (n)</th>
<th>No response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy foods</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White rice</td>
<td>86% (24)</td>
<td>7% (2)</td>
<td>7% (2)</td>
<td>0% (0)</td>
<td>4</td>
</tr>
<tr>
<td>White bread</td>
<td>61% (19)</td>
<td>16% (5)</td>
<td>23% (7)</td>
<td>0% (0)</td>
<td>1</td>
</tr>
<tr>
<td>Cassava</td>
<td>45% (14)</td>
<td>19% (6)</td>
<td>35% (11)</td>
<td>0% (0)</td>
<td>1</td>
</tr>
<tr>
<td>Energy foods to limit e.g. doughnuts, pancakes</td>
<td>53% (17)</td>
<td>22% (7)</td>
<td>22% (7)</td>
<td>3% (1)</td>
<td>0</td>
</tr>
<tr>
<td>Sugar sweetened hot beverages</td>
<td>65% (20)</td>
<td>6% (2)</td>
<td>23% (7)</td>
<td>6% (2)</td>
<td>1</td>
</tr>
<tr>
<td>Body building foods</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish</td>
<td>63% (20)</td>
<td>19% (6)</td>
<td>16% (5)</td>
<td>3% (1)</td>
<td>0</td>
</tr>
<tr>
<td>Chicken</td>
<td>10% (3)</td>
<td>16% (5)</td>
<td>29% (9)</td>
<td>45% (14)</td>
<td>1</td>
</tr>
<tr>
<td>Protective foods</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit</td>
<td>23% (7)</td>
<td>32% (10)</td>
<td>35% (11)</td>
<td>10% (3)</td>
<td>1</td>
</tr>
<tr>
<td>Vegetables</td>
<td>57% (17)</td>
<td>27% (8)</td>
<td>13% (4)</td>
<td>3% (1)</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 3: Key drivers of diet patterns

<table>
<thead>
<tr>
<th>Driver/s of diet patterns</th>
<th>% (Number) of participants to describe driver as significant</th>
<th>Example quotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affordability of food</td>
<td>84% (27)</td>
<td>We grow our own local sweet potatoes which doesn't cost any money (23 year old participant)</td>
</tr>
<tr>
<td>Availability of land on which to grow food</td>
<td>44% (14)</td>
<td>If I had good soil to grow my own fruits, root crops, and vegetables, I would eat healthy (44 year old participant)</td>
</tr>
<tr>
<td>Availability of processed and convenience food</td>
<td>44% (14)</td>
<td>[my grandparents] depended on food from garden. Today, we live on money and depend on processed food from the shop (34 year old participant)</td>
</tr>
</tbody>
</table>
Type of cooking facilities available, ease of preparation | 63% (20) | Yes [the cooking facilities available to me influence the type of food I prepare], because we only use fire so I tend to boil, fry, and stew our food (33 year old participant)

Perceived healthiness | 19% (6) | Because it is a healthy meal and it is available at home (35 year old participant)

Taste | 28% (9) | [I consume soda because] it tastes good and is cold (43 year old participant)

Culture | 9% (3) | Affordability, culture, and availability [have the strongest influence on my diet patterns] (33 year old participant)

Table 4: Food security status of participants (N=32)

<table>
<thead>
<tr>
<th>Food security status</th>
<th>% of responses (n)</th>
<th>No response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household food insecure</td>
<td>100% (32)</td>
<td>0</td>
</tr>
<tr>
<td>Participant has been concerned household food will run out</td>
<td>93% (28)</td>
<td>2</td>
</tr>
<tr>
<td>Individual food insecure</td>
<td>81% (26)</td>
<td>0</td>
</tr>
<tr>
<td>Participant sometimes does not eat for whole days at a time</td>
<td>43% (13)</td>
<td>2</td>
</tr>
<tr>
<td>Child food insecure</td>
<td>75% (24)</td>
<td>0</td>
</tr>
<tr>
<td>Participant’s children sometimes skipped meals</td>
<td>19% (6)</td>
<td>0</td>
</tr>
</tbody>
</table>
Appendix: Survey instrument

Understanding the socio-demographic determinants of access to healthy food

SURVEY INSTRUMENT FOR INDIVIDUAL INTERVIEWS

CONFIDENTIAL

<table>
<thead>
<tr>
<th>Interviewer name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>School at which interview conducted</td>
<td></td>
</tr>
<tr>
<td>Participant ID</td>
<td></td>
</tr>
</tbody>
</table>

1. Participant consent
   1.01 Information sheet given and verbally explained?
   1.02 Consent form given and signed?

2. Introduction

Thank you for agreeing to participate in this survey. We are Penny Farrell and .... and .... from The University of Sydney in Australia.

We will ask a series of questions about your diet and the interview will go for around an hour.

Your participation is confidential and will not be linked to your child in any way. We will not share the answers with anyone including your child’s school.

You can interrupt the interview at any point to ask questions, voice concerns or end the interview if you wish.

There are contact details for our research team on the participant information sheet which is yours to keep.

3. General information about participant
   3.01 Age (in years, as at last birthday): _____
   3.02 Sex: _____
   3.03 Village & district live in: Village: ________________  District: ________________
   3.04 Could you tell me the final class you graduated from at school or in your education?  Circle one of: Did not finish primary school, finished primary school, finished high school, has university degree)
   3.05 Please briefly explain what you do (e.g. study, type of employment, unemployed, care for family at home) ________________
   3.06 Number of adults including yourself (18 and over) in household ________________
   3.07 Number of children (18 and under) in household ________________
3.08 Did you grow up in Honiara, if not where did you live as a child? ________________

3.09 How long have you been living in Honiara? ________________

3.10 Do you mainly live in Honiara? ________________

4. Food frequency questionnaire

We will now work through a list of food items and ask how often (never, <1/month, few times a month, 1/week, 2-4/week, 1/day, 2-3/day, >4/day) you consume one serve of each item. [Refer to printed card]

How often do you eat one serve of:

MEAT
Beef in soy sauce
Beef curry
Tinned Corned beef
Salt beef
BBQ chicken
Fried chicken
Chicken curry with coconut cream
Chicken in soy sauce
Baked chicken
Roasted pork (if Y, what cut – or do you eat the whole pig?)
Pork baked in earth oven (if Y, what cut – or do you eat the whole pig?)
Fried fish
Boiled fish in coconut cream
Tinned fish
Fish prepared in any other ways – how often
Other seafood (ask to list)
BBQ lamb chop
Mutton in any other form (if yes, what cut and how is it prepared?)
BBQ sausage
Other meat (if yes, what cut and how is it prepared?)

STAPLE/ENERGY
Taro
Potato
Sweet potato
White bread
Wholemeal bread
Cassava
White rice
Green/cooking banana; If yes, how is it prepared
Coco yam
Yam
Cereal; If any, what type
Breadfruit

FRUIT & VEG
How often do you eat 1 serve of fruit? [reiterate serve: half a pawpaw or whole guava, eating banana]
How often do you eat 1 serve of vegetables? [reiterate serve: fistful]

DRINKS
Fruit juice (packaged)
Fruit juice (fresh)
5. **Summary of commonly eaten foods**

5.01 With the most commonly eaten item in each of the 5 categories in the previous question, why do you eat them – what influences your food choices (if need prompting, rank the most important reasons (affordability, availability, advertising, taste, convenience, habit, healthiness, or culture) for eating these foods?)

5.02 [Show flip card of food pyramid.] This is the guideline for the healthy amounts of each food type you should eat. What would help you to eat your meals in these proportions?

5.03 Do you think your overall diet is different to what your grandparents ate when they were your age? Why?

6. **Ways of preparing food**

6.01 Which main type of cooking oil do you use and why?

6.02 How often do you cook with coconut?

6.03 Which are the main foods you cook in coconut?

6.04 How often do you fry foods in oil?

6.05 Which are the main foods you cook in oil?

6.06 How often do you prepare (or eat) soup?

6.07 Which are the main foods you prepare in soups?
6.08 List the type of cooking equipment you have at home: (E.g. open fire, small gas burner, oven etc. Do the cooking facilities in your home influence the food you cook?) How?

7. Food consumption and living situation

7.01 During a typical week day, what do you eat, and where do you get it from? Why do you choose this food? For example, in the morning after you wake up and before you leave home, what do you eat and why? [Continue to prompt until participant has explained source of all foods typically eaten in a day – will ask this open-ended question via interpreter]

7.02 What is their role in food purchasing in their household?

7.03 Who decides how money is spent on food in your household? (Participant, joint decision [with whom]) or someone else’s decision [who])

7.04 What is your household income, including remittances? What proportion of your household income is from remittances?

7.05 What is your personal income?

7.06 Can you estimate how much money you spend on food each week for yourself?

7.07 Can you estimate how much money you spend on food each week for your family?

7.08 Can you describe what is a healthy meal?

7.09 Can you list ways to make a meal healthier and balanced?

7.10 Please point to the body shape you think looks attractive for men [Show flash card]

7.11 Please point to the body shape you think looks most attractive for women [Show flash card]

7.12 Please point to the body shape you think looks most healthy for men [Show flash card]

7.13 Repeat for most healthy for men and most healthy for women [Show flash card]

8. Food security

Participants will be asked to answer the following questions in relation to the past 12 months: (Remind of confidentiality)

<table>
<thead>
<tr>
<th>Household questions</th>
<th>Often true/Sometimes true/Not true</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I have been worried that our food will run out</td>
<td></td>
</tr>
<tr>
<td>2. I have been thinking that I wish I had more money and I could buy more food</td>
<td></td>
</tr>
<tr>
<td>3. When I want to make a meal, the materials needed for making it have run out and</td>
<td></td>
</tr>
<tr>
<td>it’s hard for me to get more</td>
<td></td>
</tr>
<tr>
<td>4. I can’t prepare meals that I think are healthy for my family, because the materials needed to make it have run out, and I don’t have money to buy them again</td>
<td></td>
</tr>
<tr>
<td>5. We eat the same food for several days in a row, because we don’t have enough money to buy different kinds of food</td>
<td></td>
</tr>
</tbody>
</table>
6. I only prepare a few kinds of cheap food and can’t make different food because I don’t have enough money

**Individual adult items – how often are these true for you?**

7. How often are these true for you:
   (a) I have one meal per day
   (b) I have 2 meals per day
   (c) I have 3 meals per day

8. I can’t eat nutritious food because I don’t have money to buy it

9. Due to lack of money and enough food, I only eat bread, rice or noodles

10. Sometimes I don’t eat all day

11. I can’t feed my child/children nutritious food because I don’t have enough money

**Individual child items – how often are these true for the children in your care?**

12. Sometimes my child/children only have bread or rice because I don’t have money to buy more of other foods

13. I know that my child/children sometimes is/are hungry but I don’t have money to buy more food

14. My child/children have their meal sizes cut because I don’t have enough money to buy food

15. Sometimes my child/children don’t eat all day

**Household secure:** Answered ‘not true’ to all questions

**Household insecure:** Answered ‘sometimes true’ or ‘always true’ to one or more question related to household food insecurity (Q’s 1-6).

**Individual adult insecure:** Answered ‘sometimes true’ or ‘often true’ in one or more adult-level items (Q7 – Q11).

**Child hunger:** answered ‘sometimes true’ or ‘often true’ in one or more child-level items (Q12 –Q15).

Adapted from Shoae et al. 2007: Is the adapted Radimer/Cornell questionnaire valid to measure food insecurity of urban households in Tehran, Iran?; Public Health Nutrition: 10(8), 855–861; and Derrickson et al. The core food security module scale measure is valid and reliable when used with Asians and Pacific Islanders; The Journal of Nutrition; Nov 2000; 130, 11.

9. **Health information**

9.01 How frequently do you do exercise where your heart rate is fast for 30 minutes or more?
   - < 1 X a week
   - 1-3 X a week
   - >3 X a week

9.02 Are you pregnant? If pregnant, how many months (number of completed months if known)

9.03 Have you ever been diagnosed with diabetes? (Y/N)
9.04 Have you ever been diagnosed with heart disease or high blood pressure? (Y/N)
9.05 Alcohol consumption (Y/N)
9.06 If Y: How many times a week do you drink, how many drinks do you have on average when you drink? how many drinks per week on average (1-3; 4-7; 8+)
9.07 Do you smoke? (Y/N)
Chapter 8: Discussion

8.1 Summary of findings

This thesis has documented the link between food insecurity and the consumption of inexpensive, high-calorie, often processed foods in the development of obesity in low- and middle-income countries (LMICs). It has also provided essential information on food security and the drivers of access to nutritious food for two Pacific Island Countries (PICs).

In this chapter I discuss the key findings of this thesis, which were that: i. diets were poor overall across the research studies; ii. of the many drivers of diets in the case study countries, economic access was the main driver; iii. the food environment focus of the research in this thesis was an effective way to gain insights into drivers of nutritious food access; and iv. the novel qualitative tool was valuable in identifying key themes around food access (see Table 8.1). I then review what has changed in the global nutrition field since work on this thesis commenced; and also provide an overview of my personal reflections on the strengths and limitations of the research approach. The chapter concludes with a series of recommendations for policy making and for future research, building on the findings in this thesis and recently published literature.
Table 8.1: Overview of specific objectives and main findings of research presented in this thesis

<table>
<thead>
<tr>
<th>Objective</th>
<th>Chapter</th>
<th>Summary of main findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Examine current evidence for the link between food insecurity and obesity in low- and middle-income countries and identify the mechanisms involved in this relationship</td>
<td>Chapter 3</td>
<td><strong>Food insecurity in LMICs</strong>&lt;br&gt; - Emerging evidence this can lead to obesity&lt;br&gt; - Main mechanism for this appears to be access to cheap, energy dense, low nutrient food</td>
</tr>
<tr>
<td>2) Study how patterns of apparent food consumption are affected by socio-demographic circumstances</td>
<td>Chapter 4 and Chapter 6</td>
<td><strong>Nutritious food is inequitably distributed in Samoa and Solomon Islands</strong>&lt;br&gt; - Samoa: wealth status and urban environment linked to mixed healthy and unhealthy diet patterns, younger age more vulnerable to unhealthy diet&lt;br&gt; - Solomon Islands: urban living, cash poverty, large household size important drivers of access to fruit and non-starchy vegetables&lt;br&gt; - Findings support existing evidence for unhealthy diets overall</td>
</tr>
<tr>
<td>3) Identify pertinent inter- and intra-household food access issues for vulnerable community members (women responsible for children in urban environments)</td>
<td>Chapter 5 and Chapter 7</td>
<td><strong>Multiple drivers of unhealthy diet patterns</strong>&lt;br&gt; - Economic access is the dominant driver of diet type&lt;br&gt; - Evidence for unhealthy urban food environments in both countries&lt;br&gt; - Most participants experience food insecurity</td>
</tr>
</tbody>
</table>
8.1.1 Diets were unhealthy overall

This thesis supports the existing evidence around the overall poor quality of diets in the Pacific region.(1-3) In both Samoa and Solomon Islands diet patterns were characterised by low fresh fruit and vegetable consumption, and high consumption of foods high in refined sugar, fat, and salt. Of specific concern, energy dense, nutrient poor foods were overrepresented. These included white bread, white rice, goods containing white flour and white sugar, as well as tea sweetened with white sugar. Diet patterns reflected a general shift away from traditional diets. Unhealthy diet trends were stronger in some socio-demographic groups than others, but were present across the populations overall in the quantitative analysis. Participants in the qualitative studies in both Samoa and Solomon Islands described high relative levels of consumption of foods linked with post-Colonial culture including a variety of fried and baked items based on white flour and sugar; and imported staples such as white rice and noodles, and fatty meats.

The health consequences of these diets are concerning and suggest a significantly heightened risk of overweight, obesity, non-communicable diseases (NCDs), and in some cases micronutrient deficiencies in the populations studied. Incorporation of Western diets has been shown to increase risk of obesity in Pacific Island Countries and Territories (PICTs).(2, 4) High refined sugar intake (from food and/or beverages) is associated with increased weight gain(5), and consuming sugar sweetened beverages increases cancer risk.(6) Consumption of saturated fat is associated with increased risk of cardiovascular disease and mortality.(7, 8) Global scale research has shown that diets low in fruits and vegetables constitute a large proportion of the health risks associated with unhealthy diets.(9) Conversely, increasing fruit, vegetable, and legume consumption incrementally decreases mortality(10) and in many cases NCD risk,(10, 11) even at volumes lower than the recommended 400g per day.(10)

8.1.2 Economic access was the dominant driver of diet
This thesis provides evidence that speaks to the knowledge gap regarding what affects diets in LMICs including PICs. (12-14) Economic access to nutritious food relative to energy dense, nutrient poor food was the dominant driver of diet identified across all angles of enquiry in this thesis. This finding reflects the limited available evidence from the Pacific region. For example, a recent study based on Samoa Household Income and Expenditure Survey (HIES) data modelling found that increased consumption of local foods including animal products, fruit, and vegetables would occur if their price was lowered. (15)

The importance of economic access identified in the case study countries reflects emerging evidence globally which supports the importance of economic access to nutritious food. A 2014 publication from the United States of America showed that pricing of products at supermarkets was a key factor associated with higher fruit and vegetable consumption. (16) Most recently, a landmark study of 176 countries found that pricing of products at supermarkets was a key factor associated with higher fruit and vegetable consumption. (17) In particular, high-sugar snacks were found to be ‘cheap’ or ‘very cheap’ worldwide, whereas fruit and vegetables were ranked ‘expensive’ or ‘very expensive’. Of additional concern, the study showed the relative caloric prices of nutritious foods are generally far more expensive in LMICs than in high income countries. (17, 18) The same study found many associations between food price and diet linked health outcomes, including a close link between the price of sugar-dense foods and adult overweight prevalence, and between pricing of fortified infant cereal and stunting. (17)

The overriding influence of economic access despite the importance placed on traditional foods by participants in the qualitative research in this thesis reflects findings of studies elsewhere in the Pacific. Consistently, people prefer traditional foods and would preferentially eat them if economic access was not an issue. For example, in Tuvalu: “Respondents frequently described knowingly preparing meals that were nutrient poor simply because they were the most cost-efficient way of feeding their household” (19) and similarly in Tonga, participants preferred traditional foods but consumed imported foods because they were more accessible. (20) There
is evidence from the 1980s from Papua New Guinea that as the price of imported staple food compared with local staple food increased, consumption of the traditional starchy root crops increased – adding further evidence that relative affordability is an important determinant of consumption of imported foods.\(^\text{21, 22}\) This phenomenon also occurs in high income countries, for example research from a low socio-demographic area in London, United Kingdom, showed affordable foods are prioritised over those with higher nutritional value.\(^\text{23}\)

8.1.3 A multitude of food environment factors play a role in nutritious food access

The food environment focus of the research in this thesis operationalises recent calls for more nuanced research into drivers of food choice, particularly in LMICs. For example, the 2017 Global Food Policy Report emphasised the need for “more and better information … on people’s diets, appropriately disaggregated. This means disaggregating urban data by socioeconomic status, given the extreme income inequalities in many urban contexts. … Second, better information is needed on drivers of unhealthy diets.”\(^\text{24}\) Another example is the Innovative Methods and Metrics for Agriculture and Nutrition Actions (IMMANA) initiative, which has been set up with the objective to stimulate development of novel methodologies and metrics to improve nutrition and health in food systems.\(^\text{25}\) More recently, Turner and colleagues have emphasised that “food environment research in LMICs must strive to determine the relative importance of availability, accessibility and prices on dietary, nutrition and health outcomes across a range of settings”.\(^\text{13}\)

Reflecting the complexity of food environments \textit{in situ}, or ‘in the real world’, it is perhaps not surprising that the empirical research from Samoa and Solomon Islands showed that diets were influenced by a multitude of proximal-level and external food environment and socio-demographic factors. Despite this, the insights around food access and consumption behaviour provided by this thesis were not previously available for the case study countries. As such they are important contributions for program and policy design in these countries and other LMICs regionally and globally which face similar challenges associated with food environment and socio-
demographic drivers of access to nutritious food. The research also adds to the somewhat limited set of methodologies and tools for measuring food access globally. In addition to the influence of economic access discussed above, a high level summary of the key insights gained from the research, and a comparison with worldwide research in the area follows.

Results from Samoa revealed a need to increase attention to improving the healthiness of food retail in urban food environments. Foods eaten during the day were often acquired from the immediate food environment (as opposed to prepared at home), thus the ‘ready of eat’ foods available outside the home had a strong influence on what was eaten throughout the day. At the national level, those in urban areas were significantly more likely to consume high sugar food and beverages, and less likely to eat seafood, but urban as opposed to rural residence was also the strongest predictor of both fruit and vegetable consumption. The finding that younger women had less healthy eating patterns than the older age group is characteristic of the nutrition transition in LMICs globally, where “individuals of different generations may also respond differently to social and economic changes, with the younger generation adopting new dietary patterns more quickly while the elderly continue to eat in more traditional (and sometimes healthier) ways.”(26) The finding that those in urban areas, especially those with higher cash incomes, consumed more fruit and vegetables but also more high-sugar, high fat foods is in line with diet pattern trends across the world in urban diets compared with rural diets.(24)

The research from Solomon Islands also told a story of difficulties in accessing nutritious food in particular for those in urban areas, and also for those in large households. The key challenges were lack of cash income, pricing of nutritious food such as fresh vegetables compared with less healthy options, and a lack of access to land to grow foods. The lack of affordable and healthy convenience foods to purchase during the day, an obligation to share meals between many mouths, and in some cases a lack of appropriate cooking facilities were also important themes.

The story of challenged nutritious food access for low-income urban populations was a dominant narrative underpinning the findings from both Samoa and Solomon Islands.
Islands in this thesis, and this is consistent with the existing, although somewhat scant, literature on this issue from the Pacific region.(27, 28) With the current strong urbanisation trend of populations worldwide, the framing of SDG 2 in the global agenda has been critiqued for not placing adequate importance on urban food security in LMICs at the global resource allocation level.(29)

The critical importance of access to cash and food price in determining access to nutritious food described in urban areas in LMICs globally(24) resonates with the findings across this thesis.

The higher amount of high-sugar food consumed in urban areas in LMICs compared with rural areas, for which the results from this thesis add to the evidence, is concerning. Increased access to dietary sugar statistically explained the link between urbanisation and diabetes in a study of 173 countries,(30) and there is evidence from multiple LMICs including in West Africa and China for a link between urbanisation and increased diet-associated NCD risk factors.(24, 31, 32) This highlights the importance of the co-existence of the rapidly rising NCD prevalence in PICs(33-35) with high rates of urban migration.(36)

This thesis also addresses a gap in research regarding the differential contribution of different food sources to healthy diets. For example, the role of foods originating from own production has been identified as an under-researched aspect of food environments in LMICs.(37) The quantitative research in this thesis on fruit and vegetable consumption in Solomon Islands showed a stark difference between urban and rural areas in foods acquired by home production in comparison to purchased.

8.1.4 Novel tool for assessment of the drivers of nutritious food access
As discussed in Chapter 2, there is a real need for more information in the area of food and nutrition security in the Pacific region. This gap in data on food security is a barrier to effective policy and planning frameworks for food and nutrition security.(38) The Pacific region is the only region in the world for which there is insufficient data on food security status to track progress.(39, 40) A 2015 paper identified a research gap in the area of empirical food security research from a social-ecological systems
perspective in the region, and stated that “discourse and practice in the Pacific Islands must be cognisant of the great diversity of food security contexts across the region and at different scales, and, therefore, the need to tailor interventions accordingly”.(14)

In this thesis qualitative assessment of food access was performed using a novel survey tool which was designed to measure food security using an established method, and assess diet patterns and drivers of food access. The key strength of this survey tool is in determining the why behind individuals’ specific diet patterns and behaviours in specific contexts and at contemporary points in time. The tool has now been used in two small studies in the Pacific region as a result of the research in this thesis: these studies showed it is effective in performing a rapid check of the food and nutrition security situation (approximately 45 minutes per individual interview).

Food insecurity was reported by the majority of participants in Samoa and by all participants in Solomon Islands. The tool was not designed to formally grade the level of food security. However, as skipping meals is an indicator of more severe food insecurity in the Food Insecurity Experience Scale (FIES),(41) responses from Solomon Islands participants suggested more severe food insecurity as indicated by the fact that almost half of participants reported not eating for whole days at a time. This figure was less than a quarter in the Samoan study. In both countries around three-quarters of participants reported child food insecurity.

The diet patterns reported in both countries (high consumption of energy dense and nutrient poor foods) were consistent with the food consumption patterns of the food insecure across other LMICs described on a broader scale across various LMICs in the review in Chapter 3.

8.2 What has changed in the food and nutrition security field since thesis commenced
The research presented in this thesis resonates with the steadily growing acknowledgement in food and nutrition discourses globally that the consequences of food and nutrition insecurity are not limited to hunger – they can also include diet-related risks for obesity and NCDs, with serious consequences for population health. In line with this, there has been an evolution in the use of the term “malnutrition” in recent years and it is now commonplace to reference obesity as a form of malnutrition. (23) The 2019 SOFI report highlights the need to examine the link between food insecurity and “all forms of malnutrition”, including obesity. (42) This consolidates the significance of the research question and related mechanisms explored in Chapter 3, in particular the role of relative affordability and pricing of energy dense, low-nutrient foods in the food insecurity-obesity relationship.

A related concept that has developed significantly since I commenced work on this thesis is the global recognition of the term ‘double burden of malnutrition’ (synonymous with the ‘double duty’ approach described below). The World Health Organization has stated that the “double burden of malnutrition offers a unique and important opportunity for integrated action on malnutrition in all its forms. Addressing the double burden of malnutrition will be key to achieving the Sustainable Development Goals and the Commitments of the Rome Declaration on Nutrition, within the United Nations Decade of Action on Nutrition”. (43) From a definitional perspective, the ‘double burden of malnutrition’ term in this thesis (which is sometimes referred to as the triple burden when stunting and micronutrient deficiencies are accounted for separately, and has been used in this way in Chapter 7) has been used with the intended meaning at the population level. However it is important to note that due to the multiple mechanisms via which the double burden of malnutrition can eventuate, the double burden can occur at the individual level, for example a person can be obese and also deficient in one or more vitamins – and there is the added complexity that undernutrition early in life may predispose to obesity later in life. The double burden may also exist between individuals within the same household. (23, 43)
Following this, there have been recent calls for “double duty” actions by experts in the health and nutrition space, including in the 2019 Lancet Commission *The Global Syndemic of Obesity, Undernutrition, and Climate Change*;(23) and in a recent British Medical Journal (BMJ) paper(44) on nutrition disparities globally, in which the realist review which forms Chapter 3 was cited.

With this recent increase in global momentum in efforts to solve malnutrition in all its forms, it is clearer than ever that the research presented in this thesis contributes to globally applicable understandings of how food environment factors and drivers of food access can lead to consuming foods associated with malnutrition, especially in relation to LMICs. Advocates for improving the food and nutrition security situation in the case study countries should be aware of these advances in the global discourse in order to situate the issue of malnutrition within global priorities which may assist in advocacy efforts for action and government accountability at the national level.

This thesis did not examine health outcomes directly, but instead was focussed on diet patterns, using the existing evidence on the effects of consuming certain food types on health. This evidence base is a rapidly changing field, and since the program of research in this thesis commenced, further evidence has arisen, which has implications for the findings.

One important area is the increasing evidence for the health benefits, specifically in NCD reduction, of consuming a diet that is healthy overall, meaning a varied diet high in fresh fruit and non-starchy vegetables, legumes, whole grains, nuts, fish, and yoghurt. The benefits of consuming a diet of this description appear to be greater than the benefits of simply restricting single isolated food groups or nutrients such as high-sugar or high-fat foods.(9, 45-47) This new evidence adds weight to the value of measuring diet patterns as a way of identifying NCD and other diet linked health risk factors within populations, the approach which was taken in the Food Frequency Questionnaire (FFQ) data collection this thesis.
The coining of the term “ultra-processed foods” by Brazilian researchers earlier this decade (48) and the very recent evidence about the health consequences of consuming these has also been a significant development. Two papers published in the BMJ in 2019 on ultra-processed foods linked consumption of ultra-processed food with all-cause mortality (49) and cardiovascular disease (50). A 2019 FAO review of research on ultra-processed foods also brought new evidence for the heightened NCD risk associated with ultra-processed food consumption. (51) The research in this thesis did not directly measure consumption of ultra-processed foods, however reported diet patterns did include high consumption of ultra-processed foods – although these were classified in my research as ‘energy foods to limit’ and ‘energy foods to avoid’. Examples of these foods include instant noodles, white bread, donuts, and biscuits. These foods were already a concern because they are generally high in ingredients such as refined sugar and fat, and nutrient poor; but this recent development in evidence suggests there are also potential health consequences of the processing itself in ultra-processed food consumption and is sufficient to warrant further concern and research attention. (52)

Another area with updated evidence about the health implications of consumption is sugar sweetened beverages. A 2019 study with over 100,000 participants from the French NutriNet-Santé prospective cohort showed that consumption of sugar sweetened beverages significantly increased breast and overall cancer risk. (6) Sugar in hot beverages was included in that study as a type of sugar sweetened beverage, and as these were consumed very frequently by the participants in the qualitative studies in both Samoa and Solomon Islands in this thesis, this new global evidence adds extra concern for the health implications of this consumption practice.

8.3 Methodological considerations and reflections on the research approach

8.3.1 Overall approach
This thesis used a broad range of methodological approaches to achieve its objectives, including realist systematic review; multivariate analysis of large, nationally representative databases; direct food security measurement; an adapted shortened FFQ based on one which had been used in published research previously in the Pacific; and semi-open ended questions about food access. Together, this mixed methods approach offers an opportunity to examine the multifaceted issues around proximal drivers of access to nutritious food from different perspectives, increasing the rigour of the findings.(13, 53, 54)

The overall approach also had limitations. While the quantitative studies used nationally representative samples which enabled comparison of results between urban and rural areas, the qualitative research was only performed in urban areas. This meant drivers of food and nutrition security in rural areas such as differing access to home produced commodities were not studied.

Each of the four empirical studies were cross-sectional, with data collected at one point in time only, meaning they would not have accounted for differences over time, for instance seasonal food availability. The HIES dataset for Chapter 6 partially accounted for this as it included year-round data, but this was collected from different areas. Analysis of large national level datasets which adopted a longitudinal study design and which collected data with a consistent methodology over several years may have allowed for the study of food consumption over time, which could have strengthened some of the conclusions, for instance the effect of urban poverty on diets as urban migration progressed over time, and the impact of natural disasters. However, such longitudinal datasets are not currently available. Despite this, the research approaches were useful in addressing the thesis objectives – for the quantitative studies I was able to study and account for the effect of multiple variables on food acquisition and consumption using robust methods for statistical analysis; and for the qualitative research I was able to gain deep insights and direct proximal-level perspectives about food consumption behaviour.
The focus of global nutrition research on women of childbearing age, as was done in this thesis (Chapters 4, 5, and 7) has been described by some commentators as a limitation as it means nutrition research in men is not as commonly studied. However, women are currently more vulnerable than men to food and nutrition insecurity and the health consequences outlined in Chapter 2, which is a sound justification for this research focus.

The overall approach of the studies was on measuring proximal factors which affect diet, not health outcomes of diet. However during the very early planning phase for this thesis, I planned to study some physical markers of diet-associated health outcomes, such as Body Mass Index (BMI). As my research progressed, it became obvious that the research focus on drivers of diet was highly justifiable given the existing and ever-increasing evidence for the link between specific types of foods and health outcomes discussed in subsection 8.2 above, and in Chapter 2; and the need for methodological development in this area.

A broad consideration around the overall approach of this thesis is that the research looked only at dietary drivers of markers of nutritional status (e.g. obesity, stunting), however there are several non-dietary factors which contribute to health states that are studied as a consequence of malnutrition in this thesis, as illustrated in Figure 2.3. For example, genetic predisposition to dietary obesity and NCDs such as diabetes for Pacific Islanders is also likely to play a role in their cause. This is a complex area and the main conclusions of research in this arena are that the role of the food environment in preventing obesity is more important than genetics, and prevention of obesity should be the focus of research efforts (rather than focus on “near perfect” understanding of the aetiology). Another example of the complex aetiology of markers of nutritional status is that there is evidence from Papua New Guinea that low rates of exclusive breastfeeding and diarrhoea caused by unsafe drinking water and lack of sanitation are key contributors to child stunting rates.

8.3.2 Realist review
The first piece of analysis performed was the realist systematic review, which is presented in Chapter 3. Overall, this was a very useful starting point for the thesis as it allowed me to identify a critical research gap in food security research in the Pacific region; consolidated for me the issue that food security is not just about preventing hunger in terms of number of calories but that type of food is vital in preventing the double burden of malnutrition; and introduced me to the spectrum of approaches to measuring food security which fed into the study design for the qualitative research. The broad focus of the review on LMICs instead of on the Pacific region specifically also demonstrated that there are many commonalities in themes around food access that are not region-specific.

In terms of the technical process of performing the review, I found guidance from Wong and colleagues’ and Pawson and colleagues’ publications, (60, 61) and from one of the co-authors, Seye Abimbola, who had experience using realist review methodology. My interpretation of the realist review best practice "rules" was to use established appraisal tools, and the tools I used were the UK National Institute for Health and Care Excellence (NICE)(62) and Critical Appraisal Skills Programme (CASP) guidelines.(63) I found both of these easy and clear to apply. Using these guidelines also made it straightforward for me to engage another of the co-authors, Neha Faruqui, to run the appraisal analysis in parallel with me, and to discuss our conclusions objectively. This was a productive process which added to the rigour of the appraisal conclusions.

The review methods presented two main process challenges. The iterative process of identifying the most appropriate theories and frameworks to apply in the analysis was probably the most challenging aspect of the review. Once these theories and frameworks had been identified however, using them to systematically work through the analysis significantly added to the depth and robustness of the analysis. The second challenge was running the review and keeping records of my research while simultaneously focussing on the content of the papers identified and refining the review topic. Due to these complexities, I performed the literature search twice in the end, and only used the results of the second search. The benefit of this was that
because on the second search I had more clearly defined decision criteria for inclusion, I could focus on recording the results at each step in the search process, including those that had been identified by reference list screening of shortlisted articles.

8.3.3 Quantitative research
The key strength of the quantitative analysis in this thesis was that it adopted established methods for multivariate analysis to objectively determine the most important drivers of food acquisition and consumption. This provided new perspectives on data which had not been analysed in this way previously.

The quantitative analysis also had limitations. It did not provide a comprehensive picture of consumption of all food groups, which would be challenging to achieve this in just two studies. The research was also limited to what was allowed by the primary data collection methodology used by each survey. The data in the Samoa DHS was collected through food consumption surveys with less detailed questions than the food diary data collection methodology in the Solomon Islands HIES. A key strength of the Samoa study was that it analysed a range of food groups from the DHS dataset. However, this study was limited by the broad food categories which were not always mutually exclusive in the DHS dataset. Conversely, characteristics of the Solomon Islands HIES dataset allowed for analysis to a far greater level of granularity than the DHS dataset allowed, but because of this depth of detail, the study only focussed on one food group (fruit and non-starchy vegetables).

The key challenge of the quantitative studies was the detailed technical skillset and experience with datasets needed to perform the data analysis. I had studied biostatistics and multiple regression and statistical computing at a postgraduate level but had not had the opportunity to consolidate these skills before starting work on this thesis. Although I was not working as part of an established team throughout my PhD process, I built connections which helped considerably with this. The two key collaborators and co-authors on the quantitative data analysis were Mamaru Awoke, an expert in quantitative data analysis in public health research; and Michael Sharp,
who works at Pacific Community (SPC) Noumea, which works closely with the Solomon Islands Government on national data collection. The Samoa DHS dataset was supplied in the form of multiple files in a format that was not compatible with the statistical package SPSS and Mamaru merged the numerous DHS datasets provided – a technically complex task. Michael has several years’ experience with HIES data analysis and his in-depth knowledge of the dataset considerably enhanced the depth of analysis which could be performed. For example, he added edible portion conversion factor data, which was developed as part of a different project, to the original HIES dataset. This would not have been possible without this collaboration.

Another challenge was that I was reliant on the Samoan and Solomon Islands governments to access each dataset. Access to the Samoa dataset was somewhat serendipitous: Justin Richards, a key co-author for that paper (Chapter 4) had a connection with the Bureau of Statistics and suggested I apply for access to the dataset, and this was successful relatively quickly on the proviso that our team provided a training course on SPSS analysis of the dataset. Providing the workshop was also a very effective way for me to upskill in data analysis skills before teaching them to the Bureau of Statistics staff. This was a steep learning curve but ultimately very rewarding. The workbook I produced as part of the workshop was also very useful when performing the detailed multivariate analysis in Chapter 4. Access to the Solomon Islands dataset was a longer process. I met with the Government Statistician on my initial fieldtrip, but it took around 18 months to receive access to the dataset.

Despite these challenges, the resultant two pieces of analysis add rigorous and much-needed insight to start to address the research gap on drivers of healthy and unhealthy food consumption in the Pacific region.

8.3.4 Qualitative research
Development of survey tool
The qualitative research presented in this thesis uses methodologically novel approaches to start to address the need for more data on food security and food consumption behaviour which has been discussed in Chapter 2 and is encompassed in Aim 2, Objectives 4 and 5 in Table 2.2.

Again, collaborating with others with expertise in the field strengthened the research considerably. One key collaborator was Nicola Hawley from Yale School of Public Health. Nicola shared a FFQ with me that had been used in published research by her team in Samoa and which had been used to produce research by her team. (2, 34) Nicola provided reflections on what could be improved based on the field experience of her team, and discussed with me what should be included in a shortened FFQ. This was pivotal in designing the FFQ.

I also had the opportunity to develop and workshop in detail the open ended questions with my auxiliary supervisor Anne Marie Thow. This enabled me to discuss the study aim and objectives and ensure the questions asked would capture the data intended. One outcome of this was including an approach to questioning that asked participants to talk through what they ate on a typical day, as well as where the food came from for each meal or snack. This part of the data collection tool led to some important insights, including the reliance on convenience foods purchased during the day.

**Application of the survey tool**

As with any methodology, using a FFQ to assess diet intake has advantages and disadvantages. The FFQ is a less quantifiably precise approach than the 24 hour diet recall, but has the advantage of being less resource intensive. (64) Regardless, it is a well-established methodology which is used widely. (5, 10) As the key focus of the research in this thesis was on diet patterns as opposed to exact quantities, and because the FFQ was one part of a multi-component survey instrument that was designed to run for less than one hour per participant in total, it was an effective and appropriate approach in this research context. Further method-specific strengths and limitations such as approach to recruitment are discussed in Chapters 5 and 7.
Discussion

The FFQ was the most time consuming component of the survey. In general the questions were well understood by participants and we were able to get a solid impression of diet patterns in each survey, but I had the impression it became a little tedious towards the end for some participants. One way this could have been improved could have been to collect the FFQ in a written survey as opposed to as part of an interview, but this would require a minimum level of literacy and writing skills amongst the participants.

A key focus of the qualitative data collection tool was accurately measuring food security. When I was designing the qualitative data collection tool, there was no validated measure of food security that I was aware had been used in the study countries in the peer reviewed literature. This presented both an opportunity for my research to start to address an important research gap, and a methodological challenge as there was no baseline information on which would be an effective tool to use.

As mentioned above, the realist review (Chapter 3) revealed to me the breadth of food security measurement tools that are presented in the literature. I was surprised to learn that methods to measure food security ranged from asking just one question, to extensively validated tools with a series of questions. This strengthened my resolve to use the best available food security measurement tool in my own study design. I decided to use the Radimer/Cornell food security measurement tool because of: i. its widespread use globally, (65) ii. validation of a very similar version, the Core Food Security Module, in Pacific populations living in Hawai‘i, (66) and iii. the findings of Shoae and colleagues’ study (65) which tested and comprehensively validated the Radimer/Cornell tool for use in urban Iran and found that despite the fact that the tool was initially designed for Western cultures, it was interpreted effectively in the Iranian context and relatively minor changes were needed.

The food security component of this research did not grade severity of food security, which may be seen as a limitation. It is possible to formally design food security
measurement tools similar to the one I used to grade food security status as food secure, food insecure, moderate hunger, severe hunger as was done by Derrickson and colleagues in their Hawai‘i study. The reason I did not do this was because the small sample size may have meant descriptively quantifying more detailed analysis beyond what was done would likely have had led to unmeaningful categories with very low numbers. I also wanted to balance the depth of questioning of participants required given the detail of the rest of the questions in the qualitative tool.

Another food security measurement tool, the FIES, which has been adopted and thus validated in most regions globally to report insecurity, has been developed in the very recent years since I designed the qualitative studies. It is quite similar to the food security measurement approach I used, with a key difference being the grading of level of food insecurity – although this key information around uncertainty about food, lack of choice (indicators of moderate food insecurity in the FIES) and day/s without food (indicators of severe food insecurity in the FIES) was still gathered in the studies in this thesis. If this tool was available when I commenced work on this thesis, I would have used it instead as it is essentially a more globally accepted version of the tool I used.

There is the potential for food security measurement questions to be interpreted differently by different cultures. I adapted some questions related to food items commonly consumed locally by people with limited access to resources based on discussions and small pilot studies with the local research partner for each country. These were the SPC NCD Warrior team in Solomon Islands and Faculty of Education staff and students at the National University of Samoa. The main adaptation I made was that for both studies, the question “Due to lack of money and enough food, I only eat bread” was changed to “Due to lack of money and enough food, I only eat bread or rice, crackers/instant noodles (or any other low quality energy food)” – and the same change was made for the similar child hunger question. There was also a discussion with my Samoan research partner Suzie Schuster about the way meals are viewed in Samoan culture, and that it might not
necessarily be expected to eat three meals per day, but we decided together to keep this question and it was understood well by the study participants.

Despite my expectations, it did not seem that people were reluctant or embarrassed to express their level of food insecurity, even in relation to child hunger. The use of a private room to interview the participants is likely to have helped with this. A similar observation to this was made by Shoae and colleagues in their food security study in Iran, which was also performed in a confidential environment.(65)

The practicalities of running the individual interviews were at times challenging. The second survey (the one in Samoa) ran more efficiently than the one in Solomon Islands as I had refined my system for the study logistics including recording participants and having consent forms signed, and ensuring data was efficiently recorded using scanning of paper survey materials. The engagement of research assistants in both countries worked well and was especially useful for arranging interview times with the participants, and language translation. In both countries, the participants generally had solid English language skills and the surveys were conducted in English, but the research assistants were very useful in translating some words and phrases as needed. One of the co-authors, Pavle Vizintin, helped with the data transcription from written interview transcripts to Excel files for analysis and this saved a lot of time and also helped with validation of the data.

One important limitation of the open ended question component was that it should have asked about how the kitchen storage facilities available to the participant, not just the cooking facilities, influenced their and their household’s diet.

The sample size of the qualitative studies was small, and while the strength of the qualitative research was in gaining deep insights about food access, the breadth of the research was limited, meaning any conclusions are far from nationally or regionally representative. There is likely to be diversity in food security experiences across the Pacific region,(14) and a significant amount of further research is needed across the region in this area.
8.3.5 In-country impacts of the research process

As mentioned above, the custodians of the Samoa DHS dataset, the Samoa Government Bureau of Statistics, requested a workshop on analysing DHS data using the statistical package SPSS in exchange for providing the DHS dataset for the research in this thesis, which I delivered with two staff members of the Sydney School of Public Health who had solid experience in this area. The workshop allowed me to build good connections with the Bureau of Statistics staff, two of whom were co-authors in the publication in Chapter 4. This considerably enhanced the quality of this analysis as these co-authors were involved in the DHS data collection and were able to give important insights into the utility and limitations of the dataset, which were important in the study design.

As well as the direct capacity building from the workshop, the Bureau of Statistics team also sought my advice on the limitations of the 2014 DHS dataset when designing the subsequent DHS in 2018, thus my research was able to support improvement of future data collection.

For the qualitative research, I partnered with the National University of Samoa and SPC in Solomon Islands. These in-country partnerships provided an opportunity for the co-authors, and the research assistant teams they provided, to build their research skills and experience.

The qualitative research from Samoa has had some recent traction in the local media (see Appendix (9.2), and has been shared across Twitter, so has contributed to advocacy efforts for policy change to improve urban food environments in the region.

8.4 Policy priorities

Although policy development was not studied empirically in this thesis, the intention of the research has been for it to be useful for decision makers when designing programs and policies. Objective 1 of this thesis, as presented in Chapter 2, was to
“provide much needed information and insights about factors which affect people’s access to healthy and nutritious food and which are directly applicable to policy and program design in the case study countries and the region”. In this section I reflect on policy directions that the insights gained from the research in this thesis suggest should be prioritised.

There are some principles of diet policy making that are arguably more important to consider than any particular policy. First, no one policy is likely to be effective if implemented alone, but rather, diet policies should mutually reinforce each other. Modelling can help to identify the most effective combination of policies in particular contexts. Policy making should take into account the local behavioural, socioeconomic, and demographic factors in the environment in which the policy will be implemented – in other words, information like the information presented in this thesis should be built into policy making. Policies should be carefully assessed as the policy is implemented, and changed or steered if needed. A vital concept is that sustained country-level political commitment is critical. The factors that drive political commitment in food policy are complex and include effective nutrition actor networks, strong leadership, and data systems and evidence.

8.4.1 Improve affordability of healthy foods
As discussed above, the most important determinant of healthy food consumption identified in this thesis was affordability of a healthy diet compared with other available options. This means interventions that increase relative affordability of healthy and nutritious options compared with less healthy options are likely to increase their consumption. Avenues to increase food affordability include taxes on unhealthy foods, subsidies of healthy foods, and broader, indirect approaches like stimulating the economy and increasing incomes – and ensuring equality of incomes between and within households. In Hawkes and colleagues’ paper Smart food policies for obesity prevention, removing economic barriers to healthy food access including shifting income inequalities are presented as an important component of “Policy actions that overcome barriers to the expression of healthy preferences” – a key mechanism through which food policies can work. (67) Global modelling on fruit
and vegetable consumption published in 2019 showed that fruit and vegetable consumption would increase in lower income regions with advances in economic development. (69)

**Taxes on unhealthy foods**

Government regulation of pricing via taxes on specific foods such as food and drinks high in refined sugar or fatty meats is a key strategy that warrants continued support. (22, 70) In terms of which type of food or beverage to tax, most evidence focusses on sugar sweetened beverage consumption – as examples taxes of 10% and 18% (raised from 13%) in Mexico and Chile respectively, have each reportedly decreased sugar sweetened beverage consumption by around 7%.  
(46, 71, 72)

In Samoa, soft drinks have been taxed since 1984 and as of 2016 are currently taxed at about US$0.19 per litre. There are also 5% to 8% excise taxes on a range of unhealthy foods including refined sugar, and some energy dense, low nutrient foods such as biscuits and instant noodles. (73) Solomon Islands does not have a sugar sweetened beverage tax, (74) but the government is in the process of developing one. (75) A large global systematic analysis showed that taxes on unhealthy foods of 10% reduce consumption by 3% to 7%. (76) In terms of lowering refined sugar consumption, the findings from both Samoa and Solomon Islands presented in this thesis show that snack foods high in refined sugar such as panikeke, as well as hot beverages with added sugar, are very commonly consumed – so these taxes and planned taxes are a promising step in reducing their consumption by some degree.

Globally, there is discussion amongst the public health nutrition community about which food or beverage items to tax for the greatest health benefits. A 2018 paper on fiscal policy to improve diets emphasised the likely higher benefits of a broad approach where energy-dense, nutrient poor foods are taxed, compared with taxing based on specific nutrients such as sugar, on preventing overweight and obesity. (46) Another approach that warrants attention is taxing according to NOVA...
Discussion

classification,(51) given the increasing evidence for the poor health effects of consuming ultra-processed foods discussed above.

Subsidies on healthy foods
Revenue from taxes can be used to subsidise nutritious foods, or for other pursuits of public benefit, such as other areas of health, or education. This has been done elsewhere, for example revenue from the United Kingdom sugar tax is reported to be channelled towards funding childhood obesity prevention programs.(77)

Evidence from Chapters 4-7 showed that fruit and vegetable consumption needs to be increased, and that affordability is a key determinant of their consumption. One example of a form of government subsidised support for nutritious food consumption is social welfare benefits to offer specific support for fruit and vegetable consumption.(3) There is evidence that such approaches increase consumption.(46) For example a recent systematic review from the United States suggested that fruit and vegetable subsidies of 20% would increase intake by 10%. (78)

8.4.2 Support national and regional food systems to import, and sustainably produce, healthy food
In line with previous research, this research has highlighted the contribution of unhealthy food imports to diets in the study countries.(35, 79, 80) Improving the food environment in PICTs will need to include consideration of improvements in the accuracy and ease of interpretation of labelling of packaged foods, which are usually imported, as well as the potential to restrict imports of unhealthy foods.(35, 81) However, labelling requirements and restrictions on imports are trade policy issues.(3, 82) Cross-sectoral action where the health sector has input on economic policy decisions is crucial in order to ensure trade agreements are aligned with national nutrition priorities.(3, 83)

Ensuring local agriculture aligns with health priorities health is also critical. There is worldwide evidence that investment in local agriculture has strong potential to increase food security and adequate fruit and vegetable consumption in areas where production is insufficient, such as the Pacific region, and also has potential economic
benefits by increasing incomes.(69) In PICTs, production of foods for domestic consumption faces tough economic competition from the prospect of producing commodities for export. Progress reporting in 2019 on SDG 2 shows a downwards global trend for spending on agriculture in relation to its contribution to national economies (share of government expenditure to agriculture divided by the share of GDP from agriculture) between 2011 and 2017, however this actually rose in the Pacific region, albeit from an at least 50% lower base than any other region.(84) Despite this very recent indicator of some progress, there is an ongoing strong need for local agriculture to align with nutrition in PICTs.(38) Advocacy and cross-sectoral action is needed to build this area of government support, and an important part of advocating for governments to act will be showing the health and economic impact of poor diets.

Reliance on food imports, especially starchy staples such as rice, can be counteracted by financially supporting local production of, and applied research to improve the disease resilience and yield potential of, local staple root crops.(27) These include taro, potato, banana, and yam.(27) There is the potential for government (or other, for example philanthropic) funding of farmers to be financially incentivised to produce products that support the health and nutrition of the domestic population. This is a complex issue and funding needs to be sustainable.(27)

Climate change brings further challenges to local food production.(28) Agricultural systems and climate change are interlinked: some forms of agriculture are contributing to climate change, while climate change is likely to lead to lower crop yields in tropical areas, and to produce with lower nutrient content.(23) A 2019 review on the effect of climate change on food and nutrition security and diet related NCDs in the Pacific region warns that climate change may threaten local food production, thus exacerbating reliance on imported, energy dense nutrient poor food. Conversely, the potential climate resilience of Pacific staple crops and farming practices offers an additional argument to the value of strengthening these practices and increase consumption of these foods in the face of climate change.(85) Sweet potato is one crop which is being cultivated for climate change resilience and further
agro-ecological research is needed in this area. (86) Recent research from Tuvalu stresses the need to understand the local sociocultural situation and work in partnership with the community when deciding how to strengthen food security under the threat of climate change. (19)

8.4.3 Create healthy local food environments

Transport and storage of fresh domestically produced products to and at markets, especially in urban areas, is another significant challenge which needs to be addressed. (22, 27, 87) Solutions such as subsidies need to ensure locally produced food is competitive with imported food in terms of price. (27) Food waste and food losses lead to decreased fruit and vegetable consumption directly, and by increasing prices. (69)

Urban gardens also have the potential to support urban food security and for those living in urban areas. These gardens have huge potential to increase the healthfulness of urban diets including in reducing diabetes risk and can promote traditional foods, political will permitting. (88-90) One promising example is gardens in schools. (89, 91) Another is the Kustom Gaden Association based in Honiara, Solomon Islands, which I visited during my fieldwork. The association provides tools and training to people in Honiara and other more areas and equips people with the skills required for house yard and smallholder food production. (92)

Noting the findings from the quantitative research in Samoa that the younger age group appeared to be more likely to have unhealthy eating patterns, and the unhealthy food environment observed around schools in the qualitative research, the recent junk food bans at some schools in Samoa (93) and Solomon Islands (94) are promising. It is likely that a multi-faceted approach to food policy around schools will be needed, for instance restriction of selling of some foods at schools does not stop students bringing junk foods to school from home. (67) Advertising and marketing of junk foods to children and youth is another very important area in need of policy attention.
The results of the research in this thesis point to a concerning trend towards the consumption of inexpensive processed convenience foods especially in urban environments. Another area that thus needs support in the form of policies and programs is support for people to reduce reliance on unhealthy convenience foods because they are cheaper and more physically available than healthier options. This support may be in the form of subsidising more efficient cooking facilities for households, food storage facilities near or in workplaces such as refrigeration, and education about healthy meal preparation. Investment in the form of preparation time and higher cost of fresh ingredients has the potential to save time and money in the long run by preventing diseases and disabilities, and research to show the differences in time and cost in the long and short term of eating fresh compared with processed food is needed.(51)

8.4.4 Additional priority areas
One issue that was recurrent in this thesis was the influence of gender and importance of women in household food environments. Gender equality is an imperative cross-cutting issue which requires sustained policy focus. The 2019 SOFI report suggests that addressing gender gaps in employment and education opportunities show promise in improving food insecurity for women.(39) Interventions to improve women’s economic empowerment should be locally appropriate and designed with care, and take into account the complexities of women’s status in society. An example illustrating these complexities is research from Melanesia which has shown that increasing women’s paid work may increase the risk of domestic violence.(95)

Another potential approach to consider is to encourage legume consumption where fruit and vegetables are difficult to access due to economic or physical access, or storage or transport challenges. Legumes are high in phytochemicals and fibre. In one large prospective cohort study on fruit, vegetable, and legume consumption in over 100,000 individuals from 18 countries worldwide were shown to significantly reduce mortality risk.(10) As noted earlier, legumes are categorised as a vegetable
by some but not all national dietary guidelines. Increasing legume consumption is an area deserving of further attention.

8.5 Conclusions: how the thesis findings inform future research

The research presented in this thesis provides insights about a region that is at risk of being left behind as the world works towards progress on SDG 2.

Effective food policy should account for “people’s preferences, behaviours, socioeconomic and demographic characteristics, and the problems they face in eating healthy diets”(67) and this thesis provides information for local policy makers to start to do this. The findings are also of global value in understanding the complexities of the nutrition transition and malnutrition in all its forms currently occurring throughout the world; while also contributing to global understanding about food environment research methods.

Future research which seeks to understand the way people interact with their food environment needs to exceed the momentum of the regionally and globally very significant issue of rising malnutrition, both in the form of obesity and undernutrition. Further research is needed in several disciplinary streams, including in the areas of:

- Addressing the food security research gap in the Pacific region
- Methodological development in food environment research in LMICs, including in understanding how mixed methods research can be most effective
- Encouraging action embedded research

8.5.1 Food security research gap in the Pacific region

As mentioned previously, there is insufficient national level food security data in the Pacific region to allow for global tracking of progress on SDG 2. This is a missed opportunity and is in need of urgent attention.

There are two recent examples of frameworks and systems for regional reporting and accountability that show promise. The first is the Regional Pacific Food Security Cluster, which met for the first time in 2017 and included Samoa and Solomon
Islands. (96) The second is the Pacific Monitoring Alliance for NCD Action (MANA), which has a ‘Dashboard for Action’ for tracking progress on NCD prevention policies, including food policy. (97)

Urban food insecurity was a key issue identified in this thesis. There are learnings from other LMICs globally which can be leveraged for investigation in the Pacific region. For instance, of potential relevance to countries with rapid rural-to-urban migration rates including many in the Pacific region, is the findings of a 2018 study from peri-urban Peru which showed that households in recently-formed communities were especially vulnerable to food insecurity because of a lack of social capital, even when household size, education status and income were accounted for. (98)

8.5.2 Continue to support and strengthen food environment research approaches

The differing results between the two case study countries, including the differences in socio-demographic patterns of diets between Samoa and Solomon Islands; and the rapid changes in demographics occurring over time, for example the rapid urban migration rates in Solomon Islands in particular (99) highlight the need for ongoing context-specific food environment research.

Mixed methods approaches to assessing the food and nutrition situation in a particular setting have the potential to be mutually supportive. (13) For instance, recruitment for qualitative research, which typically takes an in-depth perspective on a small number of participants, should focus on those most vulnerable and who may lack power in the food system. These subsets of the population can be identified using quantitative analysis of national datasets, as well as by studying the existing literature at a global and regional level. This approach was useful in identifying the increased vulnerability of women compared with men to food access issues when planning the research in this thesis.

The fact that food affordability was the most important lever of access to nutritious food identified in this thesis suggests that if research resources are limited in terms
of time and capacity, instead of examining food consumption patterns across a comprehensive range of socio-demographic groups as performed in Chapters 4 and 6, or measuring food access and diet patterns using multiple approaches as performed in Chapters 5 and 7 in this thesis, there may be value in more straightforward research models involving mapping of what people eat compared with their financial circumstances. For example research in Iran has shown that consumption of starchy foods including rice is inversely associated with income.(65) However due to the complexities in the relationships between food insecurity, socio-demographic determinants of food access, the “stage” of the nutrition transition a country is at, and context-specific diet options available, this approach risks missing the full picture.

8.5.3 Action embedded research
Practically focussed, action embedded research, or research with a view to directly inform policy action warrants focus. This approach could be used to test interventions with proven success in other settings to improve access and availability to healthy food. For example there is evidence from a low-income area of the United States of America that mobile fruit and vegetable markets combined with an education program significantly increased consumption.(3) A similar intervention could be trialled in either of the case study countries, and fruit and non-starchy vegetable consumption measured before and after the intervention.

Similarly, food environment improvements such as the recently implemented recent junk food bans in some schools each of the study countries(93, 94) mentioned above should be monitored for impact. Monitoring and evaluation for impact should be built into any policy or program discussed above, as this provides an opportunity for learning at the local, regional, and global levels.

References


22. Anne Marie Thow and Wendy Snowdon. The effect of trade and trade policy on diet and health in the Pacific Islands. In: Hawkes C, Blouin, Chantal, Henson,


57. Brandkvist M, Bjørngaard JH, Ødegård RA, Åsvold BO, Sund ER, Vie GÅ. Quantifying the impact of genes on body mass index during the obesity epidemic: longitudinal findings from the HUNT Study. Bmj. 2019;366:l4067.


75. Action-oriented research to support evidence-informed food policy-making in the Solomon Islands. Food Governance Conference; 2019; The University of Sydney: Erica Reeve and Gary Sacks.

Discussion


Appendix A. Oral presentations

Appendix B. Samoa Observer article

By Sapeer Mayron, 07/09/2019

Tax fatty foods, subsidise vegetables, new research urges

Panikeke - cheap, convenient, but not healthy. (Photo: Polynesian Cultural Centre)
Access to healthy, convenient and cheap food is contributing to Samoa’s non-communicable diseases crisis, and it affects women most.

Researchers Dr. Penny Farrell, Anne Marie Thow, Suzie Schuster, Pavle Vizintin and Joel Negin looked at the behaviour that contributes to diet in Samoa, to inform food and health policies, and their results were published in April.

The team found food insecurity – where people do not have access to nutritious food – was as high as 85 per cent in their study of 41 women, which led them to making poorer food choices.

Dr. Penny Farrell, researcher in public health for over a decade, came to Samoa to investigate how low income countries are affected by food insecurity – “the most important public health issue of our time” she said.

“People in low income countries are disproportionately affected. It’s part of a global food crisis and we need urgent change.”

Dr. Farrell said understanding diet and access to food should lead to better prevention of non-communicable diseases like obesity and diabetes, and improve food security.

“We’re not just talking about how many fruit and vegetables people need to eat, we are talking about lowering people’s chances of an early death.

“We are talking about whether grandparents get to meet their grandchildren or not.”

The research was primarily done through surveys, and researchers asked the women about their diet and access to healthy eating. Dr Farrell said it is clear that the participants have a basic understanding of what healthy eating looks like, even if they don’t do it.

Some suggested a healthy meal meant eating a salad, even though that did not include protein or energy foods. Others who reported enjoying a slice of cake each day wanted help to know how to improve their diet.

Participants reported finding cost a barrier to eating green leafy vegetables, and fresh fruit and vegetables more broadly. They also were heavily influenced by their social life, and would eat unhealthily if it was around them.

“They were definitely influenced by the cost of that food as well.

“Panikeke is the most desirable, probably one of the cheapest types of food in their immediate environment so that is what they were eating.”

The study found hardly any of the women packed food to eat during their day, and relied on their environment to have something available. Often, that meant cheap, greasy fast food.

Dr Farrell said convenience, low price and taste dominate food priorities, and currently healthy food doesn’t meet any of those requirements.

“There is a real need for price comparable healthy foods, in particular fresh fruit and vegetables,” she said.
“Part of the solution needs to be foods that are culturally desirable, taste good but also are satisfying for people, and that are not contributing to the NCD’s crisis.”

The research intends to inform policy, and one useful policy could be to tax unhealthy foods and subsidise healthy foods, the research suggests.

Dr Farrell said the two should work hand in hand, where the tax goes straight towards making the subsidy possible, and not adding strain to the national budget.

But fatty meats like turkey tails and mutton flaps are beyond taxes and should not be sold at all, she said.

“But then there are other things, like refined white sugar and flour.

“They are basic staple foods that can’t be taken off shelves people are buying what is cheap and what will fill their families – white rice and white bread,” she said.

“We don’t want to take them off the shelves, we want to switch the focus.”

Read the full research online at:
www.tandfonline.com/doi/full/10.1080/03670244.2019.1582528
Appendix C. Qualitative survey tool
Understanding the socio-demographic determinants of access to healthy food in Urban Apia

SURVEY INSTRUMENT FOR INDIVIDUAL INTERVIEWS

CONFIDENTIAL

<table>
<thead>
<tr>
<th>Interviewer name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>School at which interview conducted</td>
<td></td>
</tr>
<tr>
<td>Participant ID</td>
<td></td>
</tr>
</tbody>
</table>

1. Participant consent
   1.01 Information sheet given and verbally explained?
   1.02 Consent form given and signed?

2. Introduction

Thank you for agreeing to participate in this survey. We are Penny Farrell and ...... and ..... from The University of Sydney in Australia; and National University of Samoa here in Apia.

We will ask a series of questions about your diet and the interview will go for around an hour.

Your participation is confidential and will not be linked to your child in any way. We will not share the answers with anyone including your child’s school.

You can interrupt the interview at any point to ask questions, voice concerns or end the interview if you wish.
There are contact details for our research team on the participant information sheet which is yours to keep.

3. **General information about participant**
   
   3.01 Age (in years, as at last birthday): _____
   
   3.02 Sex: _____
   
   3.03 Village & district live in: Village: ________________ District: ________________
   
   3.04 Could you tell me the final class you graduated from at school or in your education? Circle one of: Did not finish primary school, finished primary school, finished high school, has university degree)
   
   3.05 Please briefly explain what you do (e.g. study, type of employment, unemployed, care for family at home) ______________
   
   3.06 Number of adults including yourself (18 and over) in household (max, min, average) ______________
   
   3.07 Number of children (18 and under) in household (max, min, average) ______________
   
   3.08 Did you grow up in Apia, if not where did you live as a child? ______________
   
   3.09 How long have you been living in Apia? ______________
   
   3.10 Do you mainly live in Apia? ______________

4. **Food frequency questionnaire**

   We will now work through a list of food items and ask how often (never, <1/month, few times a month, 1/week, 2-4/week, 1/day, 2-3/day, >4/day) you consume one serve of each item. [Refer to printed card]

**How often do you eat one serve of:**

*MEAT*
- Beef in soy sauce
- Beef curry
- Tinned Corned beef
- Salt beef
- BBQ chicken
- Fried chicken
- Chicken curry with coconut cream
Chicken in soy sauce
Chicken baked in umu with cabbage (if Y, what cut?)
Turkey (if yes, what cut and how is it prepared?)
Roasted pork (if Y, what cut – or do you eat the whole pig?)
Pork baked in earth oven (if Y, what cut – or do you eat the whole pig?)
Fried fish
Boiled fish in coconut cream
Tinned fish
Fish prepared in any other ways – how often
Other seafood (ask to list)
BBQ lamb chop
Mutton in any other form (if yes, what cut and how is it prepared?)
BBQ sausage
Tinned vienna sausages
Other meat (if yes, what cut and how is it prepared?)
Eggs

STAPLE/ENERGY
Taro
Potato
Sweet potato
White bread
Wholemeal bread
Cassava
White rice
Green/cooking banana; If yes, how is it prepared
Coco yam
Yam
Cereal; If any, what type
Taamu (cousin of the taro)
Breadfruit

FRUIT & VEG
How often do you eat 1 serve of fruit? [reiterate serve: half a pawpaw or whole guava, eating banana]
How often do you eat 1 serve of vegetables? [reiterate serve: fistful]

DRINKS
Fruit juice (packaged)
Fruit juice (fresh)
Cordial drink e.g. Tang e.g. raro or sprim
Soda can
Tea or coffee WITH milk
Tea or coffee WITH sugar
Young drinking coconut
Milo
3 in 1 coffee sachets
SNACKS/TREATS
Lollies loli saina
Ice cream
Nuts (e.g. peanuts, ngali nuts)
Fried snacks
Pizza
Beef burger
Meat pie
Packaged potato chips
Twisties
Hot potato chips
Instant dried noodle
Pancakes
Donuts
Cake
Cream biscuits
Keke saina
Cabin crackers
Masi saina
Sausage roll
Moon pie
German bun
Cream bun
Coconut bun

5. Summary of commonly eaten foods

5.01 With the most commonly eaten item in each of the 5 categories in the previous question, why do you eat them – what influences your food choices (if need prompting, rank the most important reasons (affordability, availability, advertising, taste, convenience, habit, healthiness, or culture) for eating these foods?

5.02 [Show flip card of food pyramid.] This is the guideline for the healthy amounts of each food type you should eat. What would help you to eat your meals in these proportions?

5.03 Do you think your overall diet is different to what your grandparents ate when they were your age? Why?

6. Ways of preparing food

6.01 Which main type of cooking oil do you use and why?

6.02 How often do you cook with coconut?

6.03 Which are the main foods you cook in coconut?
6.04 How often do you fry foods in oil?
6.05 Which are the main foods you cook in oil?
6.06 How often do you prepare (or eat) soup?
6.07 Which are the main foods you prepare in soups?
6.08 List the type of cooking equipment you have at home: (E.g. open fire, small gas burner, umu oven, palagi oven etc. Do the cooking facilities in your home influence the food you cook?) How?

7. Food consumption and living situation

7.01 During a typical week day, what do you eat, and where do you get it from? Why do you choose this food? For example, in the morning after you wake up and before you leave home, what do you eat and why? [Continue to prompt until participant has explained source of all foods typically eaten in a day – will ask this open-ended question via interpreter]

7.02 What is their role in food purchasing in their household?
7.03 Who decides how money is spent on food in your household? (Participant, joint decision [with whom]) or someone else’s decision [who])
7.04 What is your household income, including remittances? What proportion of your household income is from remittances?
7.05 What is your personal income?

7.06 Can you estimate how much money you spend on food each week for yourself?
7.07 Can you estimate how much money you spend on food each week for your family?
7.08 Can you describe what is a healthy meal?

7.09 Can you list ways to make a meal healthier and balanced?

7.10 Please point to the body shape you think looks attractive for men [Show flash card]
7.11 Please point to the body shape you think looks most attractive for women [Show flash card]

7.12 Please point to the body shape you think looks most healthy for men [Show flash card]
7.13 Repeat for most healthy for men and most healthy for women [Show flash card]

8. Food security

Participants will be asked to answer the following questions in relation to the past 12 months: (Remind of confidentiality)
<table>
<thead>
<tr>
<th>Household questions</th>
<th>Often true/Sometimes true/Not true</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I have been worried that our food will run out</td>
<td></td>
</tr>
<tr>
<td>2. I have been thinking that I wish I had more money and I could buy more food</td>
<td></td>
</tr>
<tr>
<td>3. When I want to make a meal, the materials needed for making it have run out and it’s hard for me to get more</td>
<td></td>
</tr>
<tr>
<td>4. I can’t prepare meals that I think are healthy for my family, because the materials needed to make it have run out, and I don’t have money to buy them again</td>
<td></td>
</tr>
<tr>
<td>5. We eat the same food for several days in a row, because we don’t have enough money to buy different kinds of food</td>
<td></td>
</tr>
<tr>
<td>6. I only prepare a few kinds of cheap food and can’t make different food because I don’t have enough money</td>
<td></td>
</tr>
</tbody>
</table>

**Individual adult items – how often are these true for you?**

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. How often are these true for you:</td>
<td></td>
</tr>
<tr>
<td>(a) I have one meal per day</td>
<td></td>
</tr>
<tr>
<td>(b) I have 2 meals per day</td>
<td></td>
</tr>
<tr>
<td>(c) I have 3 meals per day</td>
<td></td>
</tr>
<tr>
<td>8. I can’t eat nutritious food because I don’t have money to buy it</td>
<td></td>
</tr>
<tr>
<td>9. Due to lack of money and enough food, I only eat bread, rice or noodles</td>
<td></td>
</tr>
<tr>
<td>10. Sometimes I don’t eat all day</td>
<td></td>
</tr>
<tr>
<td>11. I can’t feed my child/children nutritious food because I don’t have money</td>
<td></td>
</tr>
</tbody>
</table>

**Individual child items how often are these true for the children in your care**

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. Sometimes my child/children only have bread or rice because I don’t have money to buy more of other foods</td>
<td></td>
</tr>
<tr>
<td>13. I know that my child/children sometimes is/are hungry but I don’t have money to buy more food</td>
<td></td>
</tr>
<tr>
<td>14. My child/children have their meal sizes cut because I don’t have enough money to buy food</td>
<td></td>
</tr>
<tr>
<td>15. Sometimes my child/children don’t eat all day</td>
<td></td>
</tr>
</tbody>
</table>
Household secure: Answered ‘not true’ to all questions

Household insecure: Answered ‘sometimes true’ or ‘always true’ to one or more question related to household food insecurity (Q’s 1-6).

Individual adult insecure: Answered ‘sometimes true’ or ‘often true’ in one or more adult-level items (Q7 – Q11).

Child hunger: answered ‘sometimes true’ or ‘often true’ in one or more child-level items (Q12 – Q15).

Adapted from Shoae et al. 2007: Is the adapted Radimer/Cornell questionnaire valid to measure food insecurity of urban households in Tehran, Iran?; Public Health Nutrition: 10(8), 855–861; and Derrickson et al. The core food security module scale measure is valid and reliable when used with Asians and Pacific Islanders; The Journal of Nutrition; Nov 2000; 130, 11.

9. Health information

9.01 How frequently do you do exercise where your heart rate is fast for 30 minutes or more?
   < 1 X a week   1-3 X a week   >3 X a week

9.02 Are you pregnant? If pregnant, how many months (number of completed months if known)

9.03 Have you ever been diagnosed with diabetes? (Y/N)

9.04 Have you ever been diagnosed with heart disease or high blood pressure? (Y/N)

9.05 Alcohol consumption (Y/N)

9.06 If Y: How many times a week do you drink, how many drinks do you have on average when you drink? how many drinks per week on average (1-3; 4-7; 8+)

9.07 Do you smoke? (Y/N)
Appendix D. Supplementary analysis of Body Mass Index data for Chapter 4

Supplementary Table 1: Best-fit logistic regression for association between socio-demographic & diet factors and Obese/overweight vs. Normal BMI

<table>
<thead>
<tr>
<th>Socio-demographic factor (Referent category in brackets)</th>
<th>Odds Ratio (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aged 30 - 49 (15 – 29)</td>
<td>2.881 (2.260 to 3.674)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Rich and richest wealth quintile (Poorest, poor, middle)</td>
<td>1.331 (1.079 to 1.642)</td>
<td>0.009</td>
</tr>
<tr>
<td>Participates in physical activity (Does not participate)</td>
<td>1.245 (1.071 to 1.448)</td>
<td>0.006</td>
</tr>
<tr>
<td>Has had children (Has not had children)</td>
<td>1.542 (1.131 to 2.101)</td>
<td>0.008</td>
</tr>
<tr>
<td>Lives with partner (Does not live with partner)</td>
<td>1.853 (1.403 to 2.449)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Household size 7 to 33 people (1 to 6 people)</td>
<td>[0.781 (0.609 to 1.003)]</td>
<td>[0.053]</td>
</tr>
<tr>
<td>Smokes (Does not smoke)</td>
<td>[0.998 (0.644 to 1.546)]</td>
<td>[0.992]</td>
</tr>
<tr>
<td>Vegetable consumption (7 or more serves vs. 0 to 6 serves)</td>
<td>[1.170 (0.956 to 1.433)]</td>
<td>[0.123]</td>
</tr>
<tr>
<td>High-sugar drinks (2 or more times per week vs. 0 to 1 times per week)</td>
<td>[1.071 (0.872 to 1.316)]</td>
<td>[0.498]</td>
</tr>
<tr>
<td>High-sugar food (2 or more times per week vs. 0 to 1 times per week)</td>
<td>[0.811 (0.643 to 1.024)]</td>
<td>[0.076]</td>
</tr>
<tr>
<td>Seafood (2 or more times per week vs. 0 to 1 times per week)</td>
<td>[1.075 (0.877 to 1.3218)]</td>
<td>[0.472]</td>
</tr>
</tbody>
</table>

^ Results for Urban/rural residence, Education, Alcohol consumption, Fruit consumption (7 or more serves vs. 0 to 6 serves per week), High-salt food, and high-fat food consumption are not presented here because they returned P values of more than 0.05 in the bivariate analysis step (Step 1 in explanation of multivariate analysis steps in Methods). Results in square brackets indicate results that returned P values greater than 0.05 in Step 2. These were not included in Step 3 (the best fit model), the results of which are presented in **bold** above.
Supplementary Table 1A: Supplementary Table 1 results when all missing BMI values were included in the underweight/normal category

<table>
<thead>
<tr>
<th></th>
<th>Odds Ratio (95% Confidence Interval)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aged 30 - 49</td>
<td>1.374 (1.197 to 1.576)</td>
<td>P&lt; 0.001</td>
</tr>
<tr>
<td>Rich and richest wealth quintile</td>
<td>0.791 (0.694 to 0.900)</td>
<td>P= 0.001</td>
</tr>
<tr>
<td>Has had children</td>
<td>1.735 (1.445 to 2.083)</td>
<td>P&lt; 0.001</td>
</tr>
<tr>
<td>Participates in physical activity</td>
<td>1.175 (1.044 to 1.323)</td>
<td>P= 0.009</td>
</tr>
<tr>
<td>Lives with partner</td>
<td>1.445 (1.158 to 1.804)</td>
<td>P= 0.002</td>
</tr>
</tbody>
</table>

Supplementary Table 1B: Supplementary Table 1 results when all missing BMI values were included in the overweight/obese category

<table>
<thead>
<tr>
<th></th>
<th>Odds Ratio (95% Confidence Interval)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aged 30 - 49</td>
<td>2.853 (2.239 to 3.636)</td>
<td>P&lt; 0.001</td>
</tr>
<tr>
<td>Rich and richest wealth quintile</td>
<td>1.524 (1.254 to 1.851)</td>
<td>P&lt; 0.001</td>
</tr>
<tr>
<td>Has had children</td>
<td>1.299 (0.979 to 1.723)</td>
<td>P= 0.069</td>
</tr>
<tr>
<td>Participates in physical activity</td>
<td>1.164 (1.013 to 1.338)</td>
<td>P= 0.033</td>
</tr>
<tr>
<td>Lives with partner</td>
<td>1.730 (1.338 to 2.236)</td>
<td>P&lt; 0.001</td>
</tr>
</tbody>
</table>