School of Public Health

Using population surveillance data to identify factors influencing the dietary behaviours of Western Australians

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Human Ethics

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number #HR81/2015

Publications used in the thesis with co-authors

I contributed to conceptualising ideas, the data analysis, interpreting findings and reviewing drafts of the two publications used in this thesis. My co-authors on the two papers were Christina Mary Pollard, Deborah A Kerr, Colin W Binns and M Phillips:

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> "When eating bamboo sprouts, remember the man who planted them." — Chinese Proverb

This quote seemed appropriate somehow. The subject of my thesis is food; previous research and the surveys provided the seeds of my investigation; my supervisors gave me food for thought; my statistical advisor helped me harvest my findings; and my family and friends were the earth upon which the whole depended.

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Abstract

Abstract

Context and setting

With a strong evidence base linking healthy eating to better health outcomes, the finding that most Australians did not adhere to the 2013 Australian Dietary Guidelines (ADG) and that there was increased obesity and overall weight since 2002 indicated a need for further evidence on the way that people make decisions about diet. This thesis addresses how diet-related intentions, attitudes, knowledge, beliefs and behaviours interact and how the interactions are associated with food choices in Western Australia (WA). The ultimate aim is to inform development of public health interventions designed to move the population towards better diet by using more sophisticated statistical techniques than usually applied to survey data. The relative benefits of these new applications in terms of accuracy and usefulness will further add to the knowledge base and have the capacity to inform policy, planning and resource allocation in an evidence-based targeted approach for nutrition interventions at a population level.

Methods

Using two sequential cross sectional datasets, conducted as computer assisted telephone interviews over a period of years, five investigations were made: evaluation of self-reported behaviours related to breastfeeding; analysis of trends over time using daily fruit and vegetable consumption, weekly fast food consumption and BMI; development of healthful eating indicators using validated short dietary questions and the ADG; analysis of influences on eating patterns using the healthful eating indicators and a wide range of possible predictors; and evaluation of dietary quality indicators using running out of food at least once in the previous year as the outcome. Weighted means and prevalence estimates, factor analyses, structural equation modeling, time series, Granger causality, regressions (poisson,

logistic and linear), spearman correlations and propensity scoring were used as the statistical procedures in these investigations.

Results

The benefits, difficulties and enablers of breastfeeding, the usual method of feeding new born infants in Western Australia, is differentially seen by males and females. Results indicated that males are more likely to need information about the difficulties of breastfeeding while working and/or managing other children while females are more likely to need information about the process of breastfeeding and accessing support. For adults aged sixteen years and over, a time series analysis of daily fruit and vegetables consumption from 2002 to 2013 showed a downward trend which was forecast to continue over the next five years. In the same time period the weekly consumption of fast food also decreased while BMI showed a general upward trend. Granger causality tests suggested that changes in costs and multi strategy health promotion campaigns appeared to have a causal relationship for fruit and vegetable consumption. A temporal association existed between fast food consumption and BMI. Two independent eating patterns were identified; compliance with recommended food guidelines (RF_HEI) and compliance with guidelines for discretionary foods (DF_HEI). Less than ten percent of the sampled adult population aged eighteen to sixty-four ate well on both the RF_HEI and the DF_HEI while two thirds did not eat well on either. The risk of having low RF_HEI scores was quadrupled by living alone and doubled if male. Low DF_HEI scores increased with living in areas of social disadvantage and if male. People who did not think about health aspects of their diet were sixty percent more likely to report not having enough to eat the previous year. A path analysis to running out of food at least once in the previous year indicated that eating fast food and not eating vegetables were consequences of running out of food.

Discussion and conclusion

The guidelines for daily consumption of foods recommended by the ADG was not well adhered to. The findings indicated that there was a need to address differences in how males and females perceive breastfeeding. Development of indicators of adherence to the ADG identified a previously unknown pattern in Western Australia; people eat differently according to what they are eating. There were generally different predictors of the two healthy eating indicators, the RF_HEI and the DF_HEI, but they did have one important predictor in common; the attitude towards the health aspect of their diet. For both indicators higher scores were predicted by people who reported that they paid a lot of attention to the health aspects of their diet and conversely lower scores were associated with not giving any thought to the health aspects of diet. This finding suggested that the benefits of a healthy diet may need to be made more salient. Running out of food was associated with a poorer diet which was associated with social disadvantage on a number of levels. The finding that this already disadvantaged group ate more fast food and stopped eating vegetables indicated that there was a need for public health interventions to address probable misconceptions about costs related to fast foods and vegetables.

The monitoring of changes over time of dietary factors and behaviours that are detrimental to health depend on appropriate analysis of valid, reliable, consistent sequential data collected at a population level. This thesis demonstrated that with such data and the use of statistical techniques recently developed for application to these data, it was possible to identify a clearer picture of influences to food choices and behaviours in WA. While the findings herein are directly applicable to adults in WA, the methods offer the possibility of wider public health application.

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Glossary of common terms

Australian Bureau of Statistics (ABS)

Australian Dietary Guidelines (ADG)

Australian Health Eating Index (Aust-HEI)

Australian Health Survey (AHS)

Australian Recommended Food Score (ARFS)

Australian Dietary Guideline Index (DGI)

Estimated Resident Population (ERP)

Food Frequency Questionnaire (FFQ)

Principal Component Analysis (PCA)

The Nutrition Monitoring Survey Series (NMSS)

The Health and Wellbeing Surveillance System (HWSS)

Iterative Proportional Fitting (IPF)

Randomised Controlled Trials (RCT)

Socio-Economic Indexes for Areas (SEIFA)

Structural Equation Modelling (SEM)

United States (US)

Western Australia(n) WA

1 INTRODUCTION

> "Epidemiology represents a method of studying a health problem … (the) methodology is continually changing as it is adapted to a greater range of health problems and more techniques are borrowed and adapted from other disciplines such as mathematics and statistics" (Detels, 2009, p 2).

1.1 STATEMENT OF THE PROBLEM

Global trends of dietary patterns showed that for high income countries, of which Australia is one (The World Bank, 2012, p 19), consumption of both healthy and unhealthy food items increased between 1990 and 2010 (Imamura et al., 2015). In a recent comparison of twenty-one regions across the globe, Australian consumption of key food groups known to have an impact on non communicable disease was less than recommended (Micha et al., 2015). The first release of results from the most recent Australian National Nutrition survey, conducted in 2011-2012, indicated that the majority of people were not eating a diet consistent with the Dietary Guidelines (Australian Bureau of Statistics, 2014a). At the same time, evidence is increasing that the need to eat well as early in life as possible is inextricably linked to attainment and maintenance of a healthy weight and overall good health (Burdge, Hoile, & Lillycrop, 2012; Desai, Jellyman, & Ross, 2015; National Health and Medical Research Council, 2013c; Vaiserman, 2014; World Health Organization, 2011). A diet suboptimal in nutrient content contributes to many of the leading causes of premature death. In 2004, it was estimated that in a high income country like Australia, low fruit and vegetable consumption alone is responsible for 2.5% of all deaths and is ranked as the tenth leading risk factor cause of Disability Adjusted Life Years (World Health Organization, 2009). Conversely, improving diet by eating more fruit and vegetables, unprocessed food, less fat and salt will decrease the risk of developing many potentially preventable diseases (World Health Organization, 2011). Evidence suggests that same dietary pattern can result in less excess weight in adolescent females (Bailey et al., 2015), males

(Assmann, Lassale, Galan, Hercberg, & Kesse-Guyot, 2014) and, combined with physical activity, in adults of both genders (Klassen, Garrett-Mayer, Houts, Shankar, & Torio, 2008).

There is also evidence that greater compliance with food recommendations is associated with metabolic health independent of weight (Camhi, Whitney Evans, Hayman, Lichtenstein, & Must, 2015; Phillips et al., 2013). For Australia, Body Mass Index (BMI) is the leading modifiable risk factor in terms of Disability Adjusted Life Years (Forouzanfar et al., 2015). BMI has been associated with a number of increased health risks including heart disease and diabetes (Australian Institute of Health and Welfare & National Heart Foundation of Australia, 2004; Hruby & Hu, 2015; National Health and Medical Research Council, 2013c). Heart disease and diabetes are two of leading causes of Years of Life Lost in Australia (GBD 2013 Mortality and Causes of Death Collaborators, 2015) and are linked to diets that do not meet recommended guidelines (National Health and Medical Research Council, 2013b) . BMI is predicted to rise in Australia and result in increased costs related to treatment and management (Access Economics Diabetes Australia, 2008; Organisation for Economic Co-operation and Development, 2009) as well as an increased need for special equipment (Department of Health Western Australia Perth: Health Networks Branch, 2008). These costs will start an exponential increase over the next few years as the obese cohort of children become obese adults and already obese adults become older. Improving the dietary habits of people, both in terms of increasing adherence to the dietary guidelines and decreasing overweight and obesity are a priority.

There is a body of literature investigating specific settings and issues related to dietary patterns such as how family habits interact with external environment (Bergea et al., 2013; Larson, Laska, Story, & Neumark-Sztainer, 2012), how dieting affects weight over time in the adolescent population (Neumark-Sztainer, Wall, Story, & Standish, 2012) and in other specific venues such as schools (Garnett, Baur, & Cowell, 2011). At a population level nutrition surveys have been used to identify many association in regard to diet and food choices including: patterns and trends of attitudes, beliefs, intentions and behaviours (McArthur & Pawlak, 2011; Meng, Daly, Pollard, & Binns, 2013; Pollard, Miller, Woodman, Meng, & Binns, 2009; Satia, Kristal, Curry, & Trudeau, 2001; Sealy & Farmer, 2011; Traill, Chambers, & Butler, 2012); changing dietary habits (Arabshahi, Lahmann, Williams, Marks, & van der Pols, 2011; Zheng, Tumin, & Qian, 2013), success of community based interventions (Guerra, Nobrec, Silveirad, & Taddeid, 2014; Pollard, Miller, et al., 2008); childhood obesity and the environment (Broilo, Louzada, Drachler Mde, Stenzel, & Vitolo, 2013; Cetateanua & Jones, 2014; Green et al., 2015) and perceptions around breastfeeding (Daly, Pollard, Phillips, & Binns, 2014; Scott et al., 2015). Most of these studies are descriptive although there are some studies that use more inferential methods such as identifying the interaction between socioeconomic indicators with the cost of food and diet quality (Beydoun & Wang, 2007) or identifying the factors and interactions that are the drivers of nutritional risk in seniors (Keller, 2006).

There is limited evidence identifying how food choices are made in relation to dietary guidelines, particularly the direction of choices. There is even less evidence about the relative importance of knowledge, beliefs, attitudes, perceptions and intentions along the pathway to these choices. With increasing recognition of the role of epidemiology in public health (Detels, 2009), this research uses an epidemiological approach to investigate the way in which intentions, attitudes, knowledge, beliefs and behaviours concerning diet and nutrition interact in the adult population of WA; and explores the way in which these interactions are associated food choices made in relation to dietary guidelines.

Australia has had dietary guidelines since 1991 (National Health and Medical Research Council, 1991) with the most recent update in 2013 (National Health and Medical Research Council, 2013a). The Australian Dietary Guidelines (ADG) are consistent with international dietary recommendations (World Health Organization, 2003) and outline healthy eating patterns which place an emphasis on eating a variety of nutritious foods while limiting foods high in saturated fat, added sugars, salt and alcohol with recommendations about breastfeeding, food safety, and maintenance of a healthy weight (National Health and Medical Research Council, 2013d)

WA holds a unique set of population based survey datasets. These surveys contain data about a wide range of issues related to health and health outcomes which are not fully utilised. Two of these datasets provide the data for the investigations in this research. The first is the Nutrition Monitoring Survey Series (NMSS), a series of population based surveys conducted approximately every three years since 1995. The NMSS contains questions about nutrition-related intentions, attitudes, beliefs and behaviours developed to assess what the population thinks are barriers and enablers to eating as recommended by the dietary guidelines. The second is the Health and Wellbeing Survey Series (HWSS), a continuous population based survey which has been running since April 2002. The HWSS contains some food intake measures as well as measures of health and wellbeing. These datasets provide the basis for a comprehensive examination of nutrition related associations and interactions. Using two datasets separately and in tandem in staged analyses, guided by the work of statisticians who have shown how statistics designed for other purposes can be used with cross sectional data, the power of identification and interaction has been increased (Beran & Violato, 2010; Sauerbrei, Abrahamowicz, Altman, le Cessie, & Carpenter, 2014; Tu, 2009). To date, no studies have been found in the published literature that used this intention or perspective.

1.1.1 Significance of the research

How people make decisions and choices about the food they eat are complex, not only because such decisions are intrinsically different from making decisions about using substances such as tobacco or alcohol, which are voluntary, but also because of the number of possible choices available (Cadmus-Bertram & Patterson, 2012). The richness of the data collected at a population level in WA will allow for exploration from a number of perspectives, including personal, social and environmental, simultaneously making the data analyses and the outcomes unique. The relative benefits of these new applications in terms of accuracy and usefulness will further add to the knowledge base. It is anticipated that the results from this research can inform policy, planning and resource allocation in an evidence-based targeted approach for nutrition interventions at a population level and address the gap identified by policy makers and planners between data collections and information that is easy to access. The more thorough analysis will produce accessible information for health promotion interventions with more accurate targeting by identifying when, where and with whom to intervene. If public health campaigns and interventions are better informed through the more effective use of present data sources there is a potential for savings, both in terms of cost and effectiveness. This approach has the potential to be used by population health research in general.

1.2 OBJECTIVES AND HYPOTHESES

Traditionally, the value of survey-based cross sectional data collected at a population level is to describe groups and identify trends when surveys are conducted over time. Descriptive information, while very useful, is not the only way in which survey data can be used and other valuable information often remains un-extracted within existing survey collections. The purpose of this thesis is to address this gap using nutrition based monitoring and surveillance data as a platform. The data will be examined using specific statistical techniques to answer research questions about a population’s attitudes and behaviour around dietary guidelines; elucidate and augment the knowledge base about nutrition related attitudes and behaviour; and identify areas where further research would be beneficial.

Specifically, the objectives of this research are to demonstrate how approaching the analysis of cross sectional surveillance and monitoring data with more specific research questions and sophisticated statistical techniques can elucidate what the WA adult population thinks and does in relation to Australian dietary guidelines (ADG) and to find pathways to support development of interventions designed to shift the distribution of the population (Rose, 1985) in the direction of food choices consistent with dietary recommendations. The uptake of dietary recommendations, with their links to evidence for better health outcomes, by definition should lead to a healthier population. How this shift takes place is dependent on knowledge of how people approach food choices. Food choices depend on the whole milieu surrounding food from how food preferences are developed through family and social norms filtered through perceived barriers and enablers to eating a healthy diet (Bleich, Jones-Smith, Wolfson, Zhu, & Story, 2015; Hawkes et al., 2015).

There are two main assumptions in the approach taken in this research that differ from other population based investigations using sequential cross sectional data. The first is that information contained within population based surveys has more capacity to explain and elucidate behaviour and health related outcomes at a population level than has yet been reported (Campostrini, McQueen, Taylor, & Daly, 2015). With increasing numbers of research papers from the statistical world showing how application of statistical methods originally developed for other purposes can be used with observational and cross sectional data (Cox, 2013; D'Agostino, 2007; Granger, 2003; Reio & Shuck, 2015; Sauerbrei et al., 2014; Stuart, 2010), there is an opportunity to explore how these can enrich understanding of the complex interactions that lead to behaviour change (Friel, Hattersley, Ford, & O'Rourke, 2015).

The second assumption is that there is potential to use different surveys with common questions in tandem to provide a more complete understanding of decisions about food choices and patterns over time. The investigations under each objective will show the contribution to the knowledge base from the analysis and offer recommendations for translation into new policy or support for existing policy.

1.2.1 Objective one

Identify barriers and enablers to dietary change.

The first food that a human eats is determined by their primary care giver(s) and is either breast milk alone or with other foods; or some form of infant formula alone or with other foods. The evidence around the benefits for breastfeeding for both mothers and babies is well known (National Health and Medical Research Council, 2012b) and there is emerging evidence that what a baby is fed has an effect on food choices in later life (Robinson & Fall, 2012). In 2010, about half of WA females breastfed for six months but used supplements of some kind, and less than one in five report that they exclusively breastfed for six months (Davis & Joyce, 2011). These figures are similar to breastfeeding rates found in other specialist surveys of Australian females with new babies (Baxter, 2012; Forde & Miller, 2010), and with national surveys such as the 2004-2005 the National Health Survey (Australian Bureau of Statistics, 2007) and the 2010 National Infant Feeding Survey (Australian Institute of Health and Welfare, 2011a).

The Nutrition Monitoring Survey Series 1995-2012 contains questions about perceptions of the benefits, barriers and enablers of breastfeeding. These questions will be reduced to more manageable information in order to identify population attitudes to breastfeeding.

1.2.2 Objective two

Explore trends in recommended dietary behaviours and the factors influencing or driving these changes.

The use of forecasting is common in the economic world (Granger & Newbold, 1986; Jones, Nielsen, & Popiel, 2014) and in public health areas such as exposure to chemicals, alcohol and mortality (Jiang, Livingston, & Room, 2015; Wang, McPherson, Marsh, Gortmaker, & Brown, 2011; Zeger, Irizarry, & Peng, 2006), environmental impacts (Lal, Ikeda, French, Baker, & Hales, 2013; Moineddin, Nie, Domb, Leong, & Upshur, 2008) or risk factors and outcomes (Helgason, Tomasson, & Zoega, 2004; Taylor, Campostrini, & Beilby, 2013) Less often it is used to investigate the impact of long term compared to immediate interventions (Battersby et al., 2014; Brimblecombe et al., 2010); or to assess whether or not changing trajectories of study variables over time matter (Pachucki, 2012; Zheng et al., 2013). There is a gap in the literature with regard to investigations of the long-term impact of health promotion campaigns, particularly in modelling the campaigns with other environmental influences occurring simultaneously, such as the global financial crisis or the cost of living (outlined in Chapter three, section 3.3). Some monitoring and forecasting has been done with BMI but the resource of the HWSS, a continuous data collection with records for twelve years, lends itself to more accurate monitoring and forecasting of BMI and foods.

1.2.3 Objective three

Develop a method to measure changing dietary patterns.

There are established indicators of diet which are based on dietary records collected with food frequency questionnaires, with diet diaries or with both (Aggarwal, Monsivais, Cook, & Drewnowski, 2014; Kant, 2004) as well as scales developed to assess adherence to a set of dietary guidelines (Australian Institute of Health and Welfare, 2007; Chiuve et al., 2012; McNaughton, Ball, Crawford, & Mishra, 2008). These indicators and scales depend on the collection of the necessary data about diet with ability to assess nutrient intake. In Australia, dietary records and food frequency surveys have been infrequent. The most recent collection was in 2011-2012 (Australian Bureau of Statistics, 2014a) and prior to that 1995 (Australian Bureau of Statistics, 1998). There are no other types of measures for assessing how a population is behaving with regard to food choices in the interim between measured dietary intake surveys. This gap will be addressed in this research. Healthy eating indicators will be created using estimations of what the adult population aged eighteen to sixty-four years ate the previous day consistent with ADG, as measured by the 2012 NMSS, and conducting confirmatory factor analysis and structural equation modelling.

1.2.4 Objective four

Define the key factors that influence specific dietary behaviours and their interactions.

There are many studies in the nutrition and diet literature that explore how beliefs (Franchi, 2012; Pettigrew, Donovan, Jalleh, & Pescud, 2014), perceptions (Buckton, Lean, & Combet, 2015; Pollard, Daly, & Binns, 2008; Velazquez, Pasch, Ranjit, Mirchandani, & Hoelscher, 2011), attitudes (Baiocchi-Wagner & Talley, 2012; Howe, Mandic, Parnell, & Skidmore, 2012) and socioeconomic indicators (Bonaccio et al., 2014; Green, Brown, & Ohri-Vachaspati, 2015) are associated with diet and dietary behaviours. Some investigations have used risk factors and socioeconomic indicators to model pathways to dietary behaviour (Beydoun & Wang, 2007; Wang, Worsley, & Hunter, 2012) and obesity (Beydoun & Wang, 2010). There is a gap in investigations that model them simultaneously or order them in importance in decisions about food choices. In this research, using the 2012 NMSS, applications of a variety of statistical procedures will be used to evaluate and synthesise information about perceptions, intentions, knowledge and enablers leading to food choices.

1.2.5 Objective five

Improve the characterisation and thus prediction of those likely to undertake certain dietary behaviours.

The terms food security and food insecurity have been used interchangeably in the literature. They refer to a state where there has either been no food or insufficient food with no money to buy more. These states are often combined with additional measures of food adequacy (Barrett, 2010; Bastian & Coveney, 2012). In Australia, questions about running out of food, and going without food, with no money to buy more are used as two high level indicators of food security (Australian Bureau of Statistics, 2014b). In this thesis, the term food insecurity will be used to indicate either running out of food or having insufficient food and not being able to afford more. Food insecurity is a problem with consequences for health and wellbeing even in high income countries such as Australia (Australian Bureau of Statistics, 2012; King et al., 2012). To address objective five two methods to describe associations with food insecurity will be presented. The first method will use both the NMSS and the HWSS, two cross sectional data sets, to describe a range of associations, both socioeconomic and attitudinal, that are linked with food insecurity. Studies that use more than one data source to investigate health-related risk factors are generally examining different methods of data collection (Atkinson, Billing, Desmond, Gold, & Tournas-Hardt, 2007; Barker et al., 2009; Daly, Parsons, Wood, Gill, & Taylor, 2010) or the use of both a qualitative and quantitative data source (Edmunds, Stephenson, & Clow, 2013; Pettigrew et al., 2014). The use of two different cross sectional studies is less frequent (Campostrini, Holtzman, McQueen, & Boaretto, 2006) and will represent a new approach to a common measure in different surveys. The second method will use one of the datasets, the HWSS, to create a path to food insecurity. The path will identify the relative importance of variables associated with food insecurity with whether they are likely antecedents or consequences.

2 LITERATURE REVIEW

2.1 SEARCH STRATEGY

There has been a major increase in peer-reviewed research in the area of diet and health since 1999 with about 70% of all publications about diet and health in humans occurring since that time. In 2012, three searches using only keywords of diet and health were conducted using 1) Medline 2) Pub Med and 3) Global Health. These searches showed that between 69-78% of all journal articles with these search terms were reported from January 2000 to September 2012. The large number of articles and the increasing interest in diet and health outcomes reflected by this information underlines the importance of identifying population eating habits and the drivers of these. The breadth of the literature review in this chapter underlines the complexity of the area and the potential influences to decisions about what to eat and why. A brief literature review is also provided at the beginning of each specific investigation addressing an objective. Multiple database searches were conducted for three separate purposes. The first search was conducted in 2012 to identify seminal and systematic review publications in the areas which needed to be covered for the objectives of the research; then an ongoing search of the literature over the course of the research was conducted for the specific areas being investigated; and finally a search just before the research was submitted was conducted to ensure that the most up-to-date information was included in relation to each research objective.

The first search, which was the basis of the literature review, did not limit the dates as many of the areas being studied were based on health effects, theories or statistical procedures which had their roots in seminal publications as early as the 1930s. The second search concentrated on the most recent relevant research in the areas under investigation although no date filter was put on the search. The third search concentrated only on the research conducted from 2010 to 2016. All identified documents were briefly scanned for relevance; articles that seemed relevant were more closely examined and those that actually were relevant were retrieved for inclusion in the review. The PRISMA list was used to determine quality, relevance and coverage of reference and the ones meeting these criteria were selected for the literature review when there were many. If there were few, the most relevant were used. Reference lists of retrieved documents were used to identify additional publications necessary to understand the paper being reviewed and/or providing additional necessary information relevant to the objectives of the research. Some of the areas such as the types of data and their uses and statistical methods were primarily researched using books rather than journal articles. Journals were searched for use of the types of data and/or statistics in relation to diet or health behaviours. For areas that have particularly large numbers of papers, such as the relation of diet and nutrition to morbidity and mortality, systematic reviews were selected as the reference source. A summary of the database searches that were performed during the process of conducting the review is shown in Appendix one.

2.2 The Importance of Diet to Health and Wellbeing

> "...In some way we really are what we eat. And our health is deeply linked to what we have for breakfast, lunch and dinner every single day..." *(Bonaccio, Iacoviello, & Gaetano, 2012, p 402)*

The objectives of this research are to show how cross sectional population based data can be used to contribute to the evidence around dietary behaviour in relation to the ADG. In Australia, the first dietary guidelines produced in 1982 (National Health and Medical Research Council, 2003b) were based on the amount and variety of nutrients necessary for optimal health (Cashel & Jefferson, 1994). The 1991 recommendations have been based on the research conducted to identify these (National Health and Medical Research Council, 1999a, 2003a, 2003c). The most recent set of guidelines released in 2013 builds on previous evidence strengthening the basis for the dietary guidelines for Australians. The recommendations and guidelines are very similar between 2003 and 2013 but the 2013 summary provides more definition and detail. More examples of foods within the major food groups have been provided and there is a whole new section on not only what foods should be limited but also what substitutions should be made, such as substituting high fat food with low fat alternatives (National Health and Medical Research Council, 2013d).

Increasing evidence is showing that decisions about what you eat are important. These decisions will result in eating habits that either contribute to health and wellbeing or are detrimental to health and wellbeing. Decisions that result in less than optimal eating habits have the potential to be changed to healthier ones thereby contributing to better health and wellbeing (Hawkes et al., 2015). Until relatively recently the study of the effects of diet on health either focused on the consumption of a single food component such as vegetables, fruit, fat, fibre, and sugar or it focused on the to increasing risk of contracting a particular disease or having a condition such as cardiovascular disease, bone disease, various forms of cancer and obesity. The major contributions of these studies were to demonstrate that diet was important to health and to identify how much or little of a nutrient or nutrient group was necessary to produce an effect. More recent studies show that the pattern of eating over the life cycle as well as the diet quality of what is eaten makes the most difference to overall health and chronic disease prevention (Liese et al., 2015; M. L. McCullough, 2014).

2.2.1 Breastfeeding and health

The strength of evidence to support the promotion of breastfeeding is growing particularly as breastfeeding benefits both the baby and the mother (National Health and Medical Research Council, 2012b). Apart from breast milk being the ideal food for optimal infant growth and development (Butte, Lopex-Alarcon, & Garza, 2001), there are additional long-term benefits for the infant. There is convincing evidence of a lower risk of becoming obese (Owen, Martin, Whincup, Smith, & Cook, 2005) or developing high cholesterol or high blood pressure (Owen et al., 2008) later in life. Breastfeeding is also associated with lower rates of mortality and morbidity from gastrointestinal infections for the baby (Anderson, Malley, & Snell, 2009; Kramer & Kakuma, 2009) and reduced risk of coeliac disease (Akobeng, Ramanan, Buchan, & Heller, 2006) and asthma (Ip et al., 2007; Oddy, 2009). There is some evidence that breastfed babies have improved cognitive development (Horta, Bahl, Martines, & Victora, 2007; Kramer et al., 2008) and increased bonding with the mother (Moore, Anderson, & Bergman, 2009). Benefits for the mother include a reduced risk of ovarian cancer, quicker recovery after birth, and a possible reduced risk of breast cancer and type II diabetes (National Health and Medical Research Council, 2012a). There is also evidence that breastfeeding is associated with a lower risk of Sudden Infant Death syndrome (Ip et al., 2007). Evidence to date shows no counter-indications for exclusive breastfeeding to around six months for healthy full-term babies (Becker, Remmington, & Remmington, 2011; National Health and Medical Research Council, 2012b). In Australia, guidelines for infant feeding recommend that females exclusively breastfeed until six months of age and to continue breastfeeding until 12 months and beyond which are in line with global recommendations (Mass, 2011; National Health and Medical Research Council, 2013a; World Health Organization, 2008a).

Identifying the ways in which the WA adult population perceives breastfeeding as well as what they consider to be barriers and enablers of breastfeeding will be explored under objective one.

2.2.2 Diet and Obesity

The increase in the prevalence of obesity as well as the increasing overall mean weight is closely related to an unhealthy diet in the Australian population (Australian Institute of Health and Welfare, 2011b). In WA alone, self-reported mean BMI has risen from 26.9 in 2002 to 27.7 in 2011 and the prevalence of obese people in the same time period has risen from 21.0 to 26.3 (Thomlin, Joyce, & Patterson, 2012). Strong links have been found for obesity in childhood and adolescence being associated with premature adult mortality particularly in association with cardiovascular disease and also other diseases (Reilly & Kelly, 2011; Song et al., 2012) but these adult risks may be attenuated when adult BMI is considered (Park, Falconer, Viner, & Kinra, 2012). Obesity is also associated with a variety of chronic health conditions including hypertension, diabetes, obstructive sleep apnea, increased risk of cardiovascular disease, and asthma in both adults

(Australian Institute of Health and Welfare & National Heart Foundation of Australia, 2004; Department of Health Western Australia Perth: Health Networks Branch, 2008) and children (Van Cleave, Gortmaker, & Perrin, 2010). Evidence suggests that preventing obesity can increase life expectancy (Franks et al., 2010), improve quality of life (Kushner & Foster, 2000) and decrease the resource burden on health systems. The need for intervention is reflected in a new set of clinical guidelines for the management of overweight and obesity (National Health and Medical Research Council, 2013c).

Barriers to healthy eating and excess weight are determined by both external and internal perceptions (Dixon et al., 2015; Porter, Bean, Gerke, & Stern, 2010). The evidence confirms that obesity is complex and therefore more complex approaches may be needed to deal with it (Morris, Beilharz, Maniam, Reichelt, & Westbrook, 2015). These new approaches may be some way off but increasingly there is awareness that interventions are required to start early and over a wide range of areas where decisions about food choices are being made.

Quantifying the trend of BMI over time and identifying some of the temporal influences will be illustrated under objective two.

2.2.3 Nutrition, morbidity and mortality

There is a large body of evidence for the influence of diet on health. In recent years the evidence is growing that it is diet quality and diet patterns rather than the component parts that may be the most influential to overall health and wellbeing, both physical (Belin et al., 2011; M. Bonaccio et al., 2012; Engelfriet et al., 2010; Erickson et al., 2012; Henriquez Sanchez et al., 2012; Jodkowska, Oblacińska, Tabak, & Radiukiewicz, 2011; Sofi, Abbate, Gensini, & Casini, 2010) and mental (Davison & Kaplan, 2012; Henriquez Sanchez et al., 2012; Jacka, Mykletun, Berk, Bjelland, & Tell, 2011; Oddy et al., 2009). This section summarises evidence from reviews about diet and health and also cites studies that have been seminal in the exploration of dietary patterns on health outcomes.

2.2.4 Summary of dietary patterns and health

One of the first major studies investigating the effects of diet on health was the retrospective study of mortality rates of elderly Greek people following a Mediterranean diet. The diet, characterised by being high in monounsaturated fat, complex carbohydrates and fibre, dairy mostly from cheese, relatively low consumption of meats and moderately high in consumption of fish, was statistically significantly dose related (Trichopoulou et al., 1995). The Mediterranean diet was also shown to be protective for Greek adults of all ages in a prospective study (Trichopoulou, Costacou, Bamia, & Trichopoulos, 2003). The components of the diet that have been shown to contribute most were the high consumption of fruits, vegetables, nuts and legumes, relatively higher consumption of monounsaturated fats compared with saturated, with lesser contributions from cereals, dairy products and meat or fish. A prospective study of females in the US (Kant, Schatzkin, Graubard, & Schairer, 2000) and of males in Sweden (Kaluza, Hakansson, Brzozowska, & Wolk, 2009) showed similar patterns. Similar results were also found when Principal Component Analysis (PCA) was used to identify patterns of eating as defined by the data collected rather than by an identified grouping of foods related to diet such as the Mediterranean diet. PCA was used to examine the relationship between reduced risk of dying and plant based dietary patterns relatively high in fruit, vegetable legume and nut consumption. These patterns showed the most reduced risk of mortality in a number of European populations (Bamia et al., 2007).

Systematic reviews have generally confirmed the results of these retrospective studies. Using a modified version of the Bradford Hills Guidelines for Causality, which is a recognized and frequently used set of criteria for determining the quality of research results, a systematic review found strong causal relationships between cardiovascular disease and diets high in fruit, vegetables, nuts and monounsaturated fatty acids (the components of the Mediterranean Diet). Moderate associations were identified between cardiovascular disease and fish, folate, grains and fibre while weak associations were identified between cardiovascular disease and eggs, milk and saturated fatty (Mente, de Koning, Shannon, & Anand, 2009).

A systematic review of dietary patterns and diabetes concluded that some research showed diets such as the Mediterranean diet showed glycemic improvement but the results were variable and no definite conclusions could be drawn. Similarly there was no single micronutrients ratio that was related to a reduced risk of diabetes. When each individual component was studied the overall results were suggestive but inconclusive leading the authors to suggest different approaches to measuring the effects of nutrition on endocrine functions (Wheeler et al., 2012). Although other studies have found that diet may reduce those at risk of diabetes (Esposito, Kastorini, Panagiotakos, & Giugliano, 2010; He et al., 2015), translation of lifestyle interventions, including diet and physical activity, to improving outcomes in relation to risk found that the only consistent gain was the weight loss associated with the lifestyle changes (Cardona-Morrell, Rychetnik, Morrell, Espinel, & Bauman, 2010). There is some evidence that physical activity plus a diet with a low glycemic index produced reductions in compensatory hyperinsulinemia (Solomon et al., 2010).

Davies et al (2011) found that there were observational studies to support the role of diet in reducing the risk of various cancers but that the higher level evidence was lacking which was consistent with an earlier systematic review (Kant, 2004). They argued that the connection between diet, physical activity, body weight and the combination of these to reduced risk of cancer was more convincing than diet alone (Davies, Batehup, & Thomas, 2011). Frequency of eating has been implicated in colon cancer from some case control studies but the link was not found in a prospective cohort study (Mekary et al., 2012). In a prospective study the Dietary Approaches to Stop Hypertension (DASH diet) was related to reduced colorectal cancer risk in both males and females (Miller et al., 2013). Vegetarian diets have been shown to reduce the risk of cancer (Huang et al., 2012) and cardiovascular disease (Marsh, Zeuschner, & Saunders, 2012).

A series of studies assessing the health effects associated with diet quality showed that, independent of the ways in which diet quality was assessed, lower risk of mortality was associated with diet quality, specifically: lower all cause mortality was associated in a linear fashion with better diet quality in the general population (Liese et al., 2015); decreased risk for all-cause, cardiovascular disease, and cancer mortality was associated with diet quality among older adults (Reedy et al., 2014) and adult populations from different ethnic groups (Harmon et al., 2015). The project also found that eating within dietary guidelines had a lower risk of death from chronic disease for post menopausal females (George et al., 2014).

2.3 SPECIFIC FOODS AND HEALTH

As well as research based on dietary patterns and quality, specific food groups have been associated with health (Murray & Lopez, 2013; Trichopoulou, Bamia, & Trichopoulos, 2009) and form the basis of the ADG food recommendations for Australia (National Health and Medical Research Council, 2013b).

2.3.1 Fruit and vegetables

A systematic review of a series of meta analyses of diet and cardiovascular conditions and fruit and vegetable consumption found convincing evidence that a high daily intake is associated with reduced risk of cardiovascular disease, stroke and hypertension with less convincing evidence for the link with a variety of other health conditions (Boeing et al., 2012). There was also a linear relationship between fruit intake and total fruit and vegetable intake and risk of death (Wang et al., 2014).

2.3.2 Dietary fat

The role of dietary fats, particularly saturated fats, in relation to increased risk of coronary heart disease has been well researched and the different effects of types of fat on risk of heart disease identified (Mozaffarian, Katan, Ascherio, Stampfer, & Willett, 2006; Willett, 2012). A systematic review of the effects of high stearic acid soya bean oil versus trans fatty acid in a solid form included an overview of the relationship between saturated fatty acids and the risk of cardiovascular disease. Thirteen of the twenty-one studies reviewed found that there was an increased risk of cardiovascular disease with relative risks ranging from 1.19-1.29 depending on the unit intake of total saturated fatty acids. The eight studies which did not show this association had some confounding variables such as lack of health history and/or lack of differentiation of the fat types but the evidence for substitution of high stearic acid soya bean oil for trans fatty acids was clearly associated with reduced low density lipoprotein (LDL) cholesterol (Hunter, Zhang, & Kris-Etherton, 2010). A more recent review found evidence of reduced risk in groups using marine Omega 3 fatty acids, particularly in groups with an already elevated risk of cardiovascular disease (Delgado-Lista, Perez-Martinez, Lopez-Miranda, & Perez-Jimenez, 2012).

A review of dietary recommendations for fat intake showed that while most reviewed dietary guidelines were comparable with regard to total, saturated and trans fats, there were gaps such as intake of cholesterol and not every guideline had recommendations on the ratio of n-6 to n-3 fatty acid intake (Aranceta & Pérez-Rodrigo, 2012). Australian guidelines recommend reducing consumption of saturated fats as well as keeping overall fat intake low which is in line with research findings.

2.3.3 Added sugars and sugar sweetened beverages

There has been considerable research on the effects of sugar in diet with inconclusive results (Louie & Tapsell, 2015). A recent systematic review and meta analysis of the effect of added sugar on ectopic fat concluded that under conditions of a hypercaloric diet conditions were likely to increase ectopic fat deposits but that there was insufficient evidence to compare the different sources of added sugar with intakes of other nutrients (Ma et al., 2015). A systematic review of twenty-two cross sectional and/or prospective studies found a negative association between the added sugar and diet quality (Louie & Tapsell, 2015). A systematic review and meta analysis of the effect of sugar sweetened beverages on weight gain in children and adults concluded sugar sweetened beverages were associated with weight gain in both (Malik, Pan, Willett, & Hu, 2013). Although this finding was supported in the results of a longitudinal study of children aged from seven to eleven years , this study also found that any sweetened beverage, sweetened artificially or with added sugar was associated with increased adiposity at age eleven (Laverty, Magee, Monteiro, Saxena, & Millett, 2015).

In Australia, a comparative descriptive study of adults in WA and South Australia found that there was an increased likelihood of obese and overweight consuming and sugar sweetened beverages and drinking a larger amount of these compared with healthy weight adults (Pollard et al., 2015). In the same study WA adults who didn't think about the health aspects of their diet were over four times as likely to drink sugar sweetened beverages compared with those who gave it some thought.

2.3.4 Fibre

A systematic review of the literature on breast cancer and dietary fibre concluded that as consumption of dietary fibre increased the risk of breast cancer decreased but the effect was not large (0.93 [0.89-0.98]). Individual food based fibre intake was not statistically significantly associated with decreased risk of cancer (Aune et al., 2012). Although dietary fibre is recommended as protection against diverticulitis, the evidence is generally based on cohort or population based studies and the case control studies have yielded inconsistent results (Ünlü, Daniels, Vrouenraets, & Boermeester, 2012). The case for a protective effect from fibre in relation to colorectal cancer is stronger with dietary fibre, whole grains and cereal grains all showing a dose related reduced risk although vegetable, fruit and legume fibres did not show this effect (Dagfinn Aune et al., 2011).

2.3.5 Summary

This body of evidence underlines the strong links of diet with health and highlights the importance of discovering how people make choices about the foods they eat in ways that will allow for effective education and intervention at a population level. The development of healthy eating indicators under objective three will use proxy measures of the food types discussed in Sections 2.3.1 to 2.3.4 and the investigation of the interaction between perceived barriers and enablers under objective four will help to clarify some of the important drivers of these healthy eating indicators from a population perspective. Examples of such associations are those found between drinking sugar sweetened beverages and attitudes toward the health aspects of diet described briefly in section 2.3.3.

2.4 DIET AND WELLBEING

Diet may contribute to, or ameliorate emotional states which in turn may contribute to or ameliorate health conditions or the path may be in the opposite direction. Under objective five, the health and wellbeing of people who ran out of food at least once in the previous year and did not have the money to buy more is investigated. Self reported measures of mental wellbeing include the reporting of a doctor diagnosed mental health condition such as depression or anxiety as well a score on the Kessler 10, a measure of psychological distress (Kessler et al., 2002). This section provides a brief overview of the relationship between diet and mental health.

Links have been found between mental health and diet internationally (Bamber, Stokes, & Stephen, 2007; Karampola, Papandreou, & Makedou, 2011; Lai et al., 2014; Low Dog, 2011) and here in Australia (Porter & Evans, 2008). Adults in the United States who followed American Dietary Guidelines were less likely to be depressed (Kuczmarski et al., 2010) as were those following a Mediterranean dietary pattern (Sánchez-Villegas, Henríquez, Bes-Rastrollo, & Doreste, 2006). Prospective studies of adolescents found a relationship between depression and diet (Jacka et al., 2011; Skinner, Haines, Austin, & Field, 2012) and general mental health problems (Oddy et al., 2009).

People who had some chronic condition and who had an unhealthy diet were more likely to be depressed (Beydoun & Wang, 2010; Exebio, Zarini, Exebio, & Huffman, 2011); Latinos at risk of diabetes who had a poor quality diet had depressive symptoms (Pagoto et al., 2009); females with breast cancer who had a poor quality diet were more likely to be depressed (Tangney, Young, Murtaugh, Cobleigh, & Oleske, 2002), or report a poorer quality of life (Wayne et al., 2006); females in a weight loss clinic and diagnosed with depression had an overall poorer quality of diet (Appelhans et al., 2012); quality of diet and the level of nutrient intake was associated with mood disorders (Davison & Kaplan, 2012); a relationship was found between quality of diet and risk of chronic conditions associated with cognitive functioning in older people (Shatenstein et al., 2012); higher quality of life and functioning over time was found to be associated with higher diet quality scores (Germain et al., 2013; Gopinath, Russell, Flood, Burlutsky, & Mitchell, 2014; Ruano et al., 2013); and changed eating patterns with increased caloric intake over time associated with stress (Harding et al., 2014; Isasi et al., 2015).

2.4.1 Summary

There is a general consistency that diet and mental health are associated but how it is associated has not been determined. It may be that a quality such as optimism acts as a mediator in decisions about what we eat which in turn affects our diet quality and our physical and mental wellbeing (Soliah, 2011). It could be that some of the key components of a dietary pattern have an effect on mental health functions (Sánchez-Villegas et al., 2006) or it may be that eating a healthy diet is a latent indicator of a general state of mind about health (Gopinath et al., 2014). Under objective five, in the exploration of the path to having insufficient food at least once in a year, self reported indicators of mental wellbeing are explored as well as the more usual sociodemographic indicators.

2.5 MEASURES OF DIET PATTERNS AND QUALITY

Regular monitoring of adherence to dietary guidelines requires regular assessment of what a population knows about the guidelines as well as some indication of diet. Such measures can also be used to examine relationships between eating patterns and health, the environment, family members eating patterns, education and health promotion activities and interventions. Measures are usually described in terms of diet patterns, diet density or diet quality.

2.5.1 Measuring food consumption

Selecting the way in which to measure food consumption depends on the purpose of the research and the way in which the data is collected and analysed. Typical use and method of collection can be put into a matrix showing which measure of food intake can be analysed in terms of nutrients or total dietary pattern (Thompson & Subar, 2012). There are four methods most often used to collect dietary information. A brief description of each follows with a summary table (Table 2.1) showing strengths and weaknesses of each. This summary was made based on the information provided by the review of methods of assessing diet for research (Thompson & Subar, 2012).

2.5.2 Dietary records

Information about diet can be collected as a record of what and how much has been eaten over a specified consecutive period of time of between one and seven days. Dietary records can be collected as open-ended versions as well as checklists similar to the FFQ. They are used to identify measures and scales of food patterns, food quality and food density.

2.5.3 Food Frequency Questionnaire (FFQ)

The FFQs use country-specific foods or food groups and ask respondents how many times they have been consumed within a specified period of time with some also asking how much of the food was eaten. The time period can be quite large such as six months or a year but it can also be as little as a week. The questionnaire is generally in the form of a checklist of foods with times/amounts consumed as the response category. The results from FFQ are often the basis of food quality or food density scales and was one of the measures used in the 1995 Australian National Nutrition survey (Australian Bureau of Statistics, 1998) used by all three of the Australian dietary scores developed to assess diet quality (sections 2.5.10 to 2.5.12).

2.5.4 Twenty-four hour recall

As the name implies, this method of dietary data collects detailed information about what has been eaten in the previous twenty-four hour period. It requires specially trained interviewers to conduct as a main feature of the method is to probe about food types, preparation and amounts so that the most accurate picture can be obtained. They can be used in population based surveys as they don’t take long to administer and are relatively easy for respondents. This type of measure was also a part of the three dietary quality assessment measures developed in Australia.

2.5.5 Brief Dietary Assessment

This method uses a series of short questions to estimate consumption of particular foods or food groups. They are designed for use in population based surveys and focus on the key food groups rather than the total diet. They are very useful in identifying compliance with particular food guidelines such as fruit and vegetable consumption. In this research, under objectives three and four, validated brief dietary assessment questions provide the basis for the development of the healthy eating indicators. A description of the questions and methods are found in Chapter **Error! Reference source ot found.**.

2.5.6 Summary of methods

As Table 2.1 shows, there are limitations and advantages to each method outlined in this section. The purpose of the research needs to guide the method used to collect the data (Thompson & Subar, 2012). In general, the longer the time needed to collect the information or to recall consumption the lower the reliability and validity of the data. However, the longer and more in-depth explorations of dietary behaviour and food choices are the only way that a complete picture of a person's diet can be obtained. The use of more than one measure such as a dietary recall measure and a food frequency measure has allowed more complete picture of the entire diet, including episodic food consumption (Carroll et al., 2012).

In countries with limited financial resources, using multiple measures to collect dietary information may not be feasible, particularly in assessing diet at a population level which involves large samples. Other research has shown that as long as the questions comprising the assessment of diet or dietary behaviour are using validated questions they can be assumed to provide useful information (Marks, Webb, Rutishauser, & Riley, 2001; Subar et al., 2015).

Table 2.1 Summary of food measure characteristics based on the Thompson and Subar review of dietary assessment methods

Measures	Reliability tested	Validity tested	Main collection methods	What is collected	Possible outputs	Main use(s)	Major advantages	Major Weaknesses
24 Hour Recall	Yes	Yes	Telephone, self-administered via mail or internet	Total intake over 24 period	Nutrient assessment, total diet and amounts	As a method of assessing diet quality	Quick to administer and minimal recall bias; low response burden	Only assesses a 24 hour period and may not provide enough information about the entire diet
Dietary Record (3-7 days)	Yes	Yes	Telephone, self-administered via mail, internet or smart telephone	Total intake over 3 to 7 days	Nutrient assessment, total diet and amounts	As a method of assessing diet quality, density and pattern; As an intervention to improve eating habits	Gives a reasonable overall picture of diet	Recording errors although these can be controlled by careful precoding and computer based coding
FFQ (anywhere from 1 wk to 1 yr)	Yes	Yes	Telephone, self-administered via mail or internet	Frequency of consuming foods over a period of time and/or amounts consumed	Nutrient assessment, total diet and frequency	As a method of determining diet patterns, quality and density	Provides information about a wide variety of foods	Recall bias and response burden with poor reliability and validity
Brief Dietary Assessment (daily intake)	Yes	Yes	Telephone, face-to-face	Daily amount consumed of particular foods or food groups	Amount of particular food or food groups eaten within a specified period or frequency	As a method of determining population compliance with consumption of specific food or food groups	Easy to administer; can give information about compliance with dietary guidelines for food groups	Cannot be used as indicator of total diet; the application of results will depend on the quality of the data collection and sampling
Combination of methods – usually dietary record and FFQ	Yes	Yes	Telephone	Intake, frequency and amounts over a recommended 4-6 collection points	Nutrient assessment, total diet and frequency	As a method of assessing entire diet. As an intervention to improve habits	Allows for the inclusion of foods consumed episodically	Has the weakness of both methods

2.5.7 Methods to measure diet patterns

There are different ways in which measures of food and nutrients are used in research. Some of the methods used that were described in Sections 2.2 and 2.3 are outlined here in more detail.

Dietary patterns are used to describe, at a population level, a grouping of foods that are then used to study outcomes such as morbidity and mortality. A diet pattern is usually operationally defined within a study as a score on a diet quality measure and often depends on patterns of eating from which nutrient quantities are measured or inferred. Scores can be a measure of diet density, or the density of nutrients within the diet; a measure of diet quality or the types of food eaten in the diet; or a dietary pattern which examines the total foods eaten.

'A priori', or evidence based investigations, define dietary patterns in accordance with some previously defined standard such as Australian Dietary Guidelines (National Health and Medical Research Council, 2003b) or an identified group of foods known to have beneficial effects on health such as the Mediterranean Diet (Trichopoulou et al., 2009).

'A posteriori', or data driven investigations, group foods into dietary patterns statistically by performing statistical analyses such as PCA on reported consumption (Markussen et al., 2015). There are merits for each approach (Ocke, 2013). The evidence based approach uses already established associations between diet and disease/mortality and explores how these are expressed within and between populations. Data driven studies contribute evidence of diet patterns that appear to reduce or increase risk of morbidity or morality as described in Sections 2.2 and 2.3 and establish links with dietary patterns and chronic disease (Jones-McLean, Shatenstein, & Whiting, 2010). Many such studies have been done using randomised control trials to establish causality (Ball et al., 2015; Esposito et al., 2010; Fewtrell, 2011; Thorne & Baldwin, 2014). The strength of the evidence driven approach in the establishment of dietary patterns is that there are known outcomes associated with the evidence base, in this case, a set of dietary guidelines allowing for specific hypotheses to be tested.

Data driven approaches explore what a population is actually doing and then seeks to relate this to health outcomes (Biesbroek et al., 2015; Zinck, de Groh, & MacFarlane, 2015) or come up with new ways to assess nutrient intake (Woolhead, Gibney, Walsh, Brennan, & Gibney, 2015). The strength of the data driven approach is that it can identify how a set of foods or nutrients are grouped within the research population. This shows what the research population is actually doing in relation to diet or nutrients. Table 2.2 shows a summary of the main differences and features of the two different methods for defining dietary patterns and shows that each contributes to the body of evidence (Moeller et al., 2007).

Table 2.2 Summary of the different ways to develop measures of dietary patterns

A priori (Evidence based) Measures
Hypothesis driven
Based on evidence already established
Generally use dietary guidelines as basis for measure
Can be single nutrient based or total diet based
Describe desirable eating pattern(s)
A posteriori (Data driven) Measures
Use data to determine relationships
Generally examine total diet patterns
Describe eating patterns at the point of measurement
Easier to statistically manipulate and control

A comparison of the outcomes related to dietary patterns found that both the evidence based dietary patterns and the data driven dietary patterns showed the same associations with health outcomes (Ruano et al., 2013). An investigation combining both approaches showed that the combined approach was not better than either alone. The conclusion drawn was that new innovative ways of developing dietary patterns were required as those already in existence were not adding new information to the knowledge base (Kant, 2010).

This research seeks to do that under objective three. The evidence based approach was used to develop a scale of amounts and types of foods eaten the previous day using short validated dietary questions based on the ADG. The data driven approach was used determine whether or not there was another latent underlying pattern within the scale.

2.5.8 Using evidence based measures to develop dietary patterns and quality scales

Commonly used measures of diet patterns and quality are evidence driven. These measures are either ones whose composition is known to be associated with health outcomes or ones which are based on an agreed set of dietary guidelines based on scientific evidence of reduced risk related to health conditions and/or mortality. Diets are scored for the presence (or absence) of the known nutrients or food groups that are associated with health outcomes (Kant, 2004; McNaughton et al., 2008). There have been forty-one scales developed for this purpose. Frequently cited measures are based on the Healthy Eating Index (HEI), the Diet Quality Index (DQI), the Recommended Food Score (RFS) which were developed in the United States (US); the Mediterranean Diet Index (MED) which was developed in Greece; the Australian Health Eating Index (Aust_HEI), the Dietary Guideline Index (GDI) and the Australian Recommended Food Score (ARFS) which were developed in Australia. All use information taken from a survey either a dietary record (DQI, HEI) or a Food Frequency Questionnaire with our without additional information from another measure.

What defines a scale is the measure against which it is constructed. In the United States (US) the measures are usually constructed with some dietary guideline recommendation whereas the European scales use a definition of a ‘Mediterranean’ diet which can vary with what is included. For example there is the original Greek version (Trichopoulou et al., 1995) of the Mediterranean diet, an Italian version (Bonaccio et al., 2012), (Martínez-González et al., 2002) a Spanish version and an alternative style Mediterranean diet (Lopez-Garcia et al., 2014). In a comparison of which scales best predict cardiovascular disease (CVD), the updated AHEI-2010 and the MED which included fish as a component were better than the original HEI, the RFS and the DQI (Fung et al., 2005). The AHEI-2010, which updated the scale based on new evidence of the foods which were associated with less risk of chronic disease, was better than the AHEI-2005 in predicting the relative risk of CVD, stroke, diabetes and cancer (Chiuve et al., 2012). The three indices developed in Australia are based on methods originally used in the US.

2.5.9 Australian Dietary Food Scores

Although the ADG are very similar to other dietary guidelines in similarly developed countries such as the United States (McGuire, 2011) and Canada (Health Canada, 2011), they are not identical. For example, in Australia the recommended daily amounts of fruit and vegetables are provided separately whereas in Canada and the United States they are combined. In order to assess how well Australians are doing against the ADG, there was a need for an Australia specific dietary food score.

Australia has had relatively few nutrition surveys. The most recent National Nutrition survey was conducted in 2011-2012 using 24-hour dietary recall of food, beverages and supplements (on two separate days), a report of usual dietary behaviours and whether or not the person was on a diet. Nutrient intake and composition was estimated using a modified version of the Agricultural Research Service of the United States Department of Agriculture Dietary Intake Data System (Australian bureau of Statistics, 2014b). To date no food scores have been developed on these data although a recent study identified three eating patterns for males and two for females (Milte & McNaughton, 2016).

The previous National Nutrition survey was conducted in 1995. The information about food consumption in this survey came from a 24-hour dietary recall of food, beverages and supplements and a FFQ with amounts recorded. The assessment of nutrient intake and composition was done using a combination of the ABS food survey coding and the Australia and New Zealand Food Authority customized nutrient composition database (Australian Bureau of Statistics, 1998). This data from this survey has been part of the three food score indices developed in Australia.

2.5.10 Australian Health Eating Index (Aust-HEI)

The Australian Health Eating Index (Aust-HEI) was developed for use in population based surveys and used seven measures covering fruit and vegetable consumption, dietary fat consumption and diet variety (Australian Institute of Health and Welfare, 2007). The Aust_HEI assesses variety and choice using a FFQ and amount and type by using a short dietary questionnaire. The total score ranges from 0 to 60. The Aust-HEI has had limited use within Australia to date and the questionnaires and surveys on which its score is based have not been repeated in the recent past.

2.5.11 Australian Recommended Food Score (ARFS)

The development of the Australian Recommended Food Score (ARFS) used a FFQ as the basis but scored consumption as zero if the food was eaten less than once a week and one if the food was eaten at least once a week. Then additional points were awarded for evidence that the diet was in line with recommended guidelines such as eating two serves of fruit daily. The maximum score is seventy-four and includes adjustments for alcohol consumption and for missing values (Collins, Young, & Hodge, 2008). Estimates of nutrients within the diet were also calculated and a subset of females who had plausible reported eating patterns was compared with the full sample with few statistically different results. The ARFS was constructed using data from females aged between forty-five to fifty years of age taken from the Australian Longitudinal Study of Females' Health. Females who scored in the upper two quintiles of the ARFS were associated with better self-reported health, fewer visits to health professionals and fewer self-reported depression symptoms. They were also better educated, less likely to smoke and more likely to do adequate physical activity. The direction of change for all statistically significant results was linear over the quintiles. Recent evidence suggests that the ARFS produces reliable and valid measures of nutrient intake and the dietary quality (Collins et al., 2015).

2.5.12 Dietary Guideline Index (DGI)

The Australian Dietary Guideline Index (DGI) was developed using a variety of measures taken from the 1995 National Nutrition Survey (McNaughton et al., 2008). There were three measures within that survey, a FFQ, a Food Habit and Attitudes Questionnaire (FHQ) and a 24 hour dietary recall (not used in the DGI). Most of the scale used the FFQ and a method similar to that used in the United Stated Health Eating Index (HEI-f) scale construction (McCullough et al., 2000) but the Recommended Food Score (RFS) method was adapted for assessing the amount of fruit and vegetables consumed to avoid any over-reporting of fruit and vegetables by respondents, which has been found to be the case in analyses of studies using a FFQ (Cade, Thompson, Burley, & Warm, 2002). For the DGI, the Food Habit Questionnaire (FHQ) was the basis of the assessment of adequate fruit and vegetable consumption as it had been shown to be a valid measure in Australia (Riley, Rutishauser, & Webb, 2001). The DGI is different from other scales as uses alternative guidelines where none existed in Australia at the time, such as the daily amount of water which is based on American guidelines. Higher DGI scores were statistically significantly associated with consumption of foods lower in saturated fats and added sugars, higher in protein and fibre, higher self reported health and lower blood pressure (McNaughton et al., 2008). The composition of this DGI most closely reflects the 2013 ADG recommendations and for this reason it is the used as the basis of the healthy indicators (Chapter 4).

2.5.13 Using data driven analyses to develop dietary patterns and quality scales

Measures of dietary patterns, quality and density can also be developed by using statistical procedures to group items from measures such as a FFQ or a SDQ. The most commonly used statistical procedures are Cluster Analysis (Fransen et al., 2014; Kimokoti et al., 2012), Factor Analysis (Barbaresko et al., 2014; Boggs, Ban, Palmer, & Rosenberg, 2015; Knudsen et al., 2014) and Reduced-Rank Regression (Barbaresko et al., 2014; Kimokoti et al., 2012; Wosje et al., 2010). These statistical methods focus on explaining the variation in food intake and the resulting grouping of dietary patterns need not be associated with health outcomes. The number of dietary variables is reduced by finding factors that are composed of correlated dietary variables. Measures developed using these methods are investigating dietary patterns from the perspective of how a population is behaving at that time. For example cluster analysis was used in a study of 1,114 Australian girls aged six to nine years, to identify dietary patterns and of the four identified, the one with the healthiest food intake pattern was only followed by about one-third of the girls (Grieger, Scott, & Cobiac, 2012). Other studies try to associate patterns of eating with known information about food and its relationship with health outcomes. Data from the Malmo study of Finland of 4999 people aged forty-five to sixty-eight years identified six food pattern clusters and found that the clusters related to reduced risk of cardiovascular disease were followed by less than half of the population (Hlebowicz et al., 2011). More recently reduced-rank regression is being used to identify dietary patterns that are more directly related to health outcomes. An example of this approach has been used to identify what components of a diet were related to bone mass and fat mass in 375 children aged between four and eight over a four year period. The results showed that high intake of vegetables was associated with low fat mass and high bone mass and that a diet high in fried foods was associated with high fat mass (Wosje et al., 2010).

The overview of the way in which dietary measures are converted to dietary indices with their strong associations with health outcomes provides evidence of the necessity for having this information. The problem for Australia is that these indices depend on the collection of dietary intake data suitable for conversion to nutrient intake and diet quality/density. Such data is infrequently collected and Australia needs a way to assess how the population is behaving in relation to dietary recommendations in the interim. This gap is addressed by the basis of the development of the healthy eating indicators described in Chapter four.

2.6 THE BASIS FOR CHANGING BEHAVIOUR

An aim of this present research is to provide information about how the adult population of WA uses perceptions, beliefs, knowledge, attitudes and dietary behaviours to make choices about food and beverage consumption in order to assess adherence to dietary guidelines. As far back as the 1960s, Azjen and Fishbein provided evidence that the relationship between knowledge, attitudes, beliefs, intentions and subsequent behaviour is not straightforward (Ajzen & Fishbein, 1970). In health promotion, theories about how people make decisions form the basis for planning how to influence decisions in the direction of healthier outcomes.

One of the few systematic reviews evaluating theories and using evidence that is structured by expert developed grading found that Cognitive Behavioral Theory which is based on a combination of cognitive theories and behaviour theories to be the most tested theory in nutritional counselling and also the most effective (Spahn et al., 2010).

Figure 2.1 shows the ways in which variable mediators are theorised to influence behaviour change postulated by the major social cognitive based theories (Baranowski, Cullen, & Baranowski, 1999). The fit with any of these theories for changing behaviour in relation to nutrition is not particularly good as 1) constructs from theories are often applied without testing the complete original theory for its effectiveness (Painter, Borba, Hynes, Mays, & Glanz, 2008; Rothman, 2004); 2) theories tend to exclude at least some of the external factors known to modify behaviour (Barker & Swift, 2009); 3) shared cultural background may play a more important role in determining attitudes and beliefs than previously recognised (Dykes & Flacking, 2010; Leeman, Fischler, & Rozin, 2011) and 4) incomplete understanding about how psycho social variables act as mediators affects the prediction of dietary behaviours (Baranowski et al., 1999).

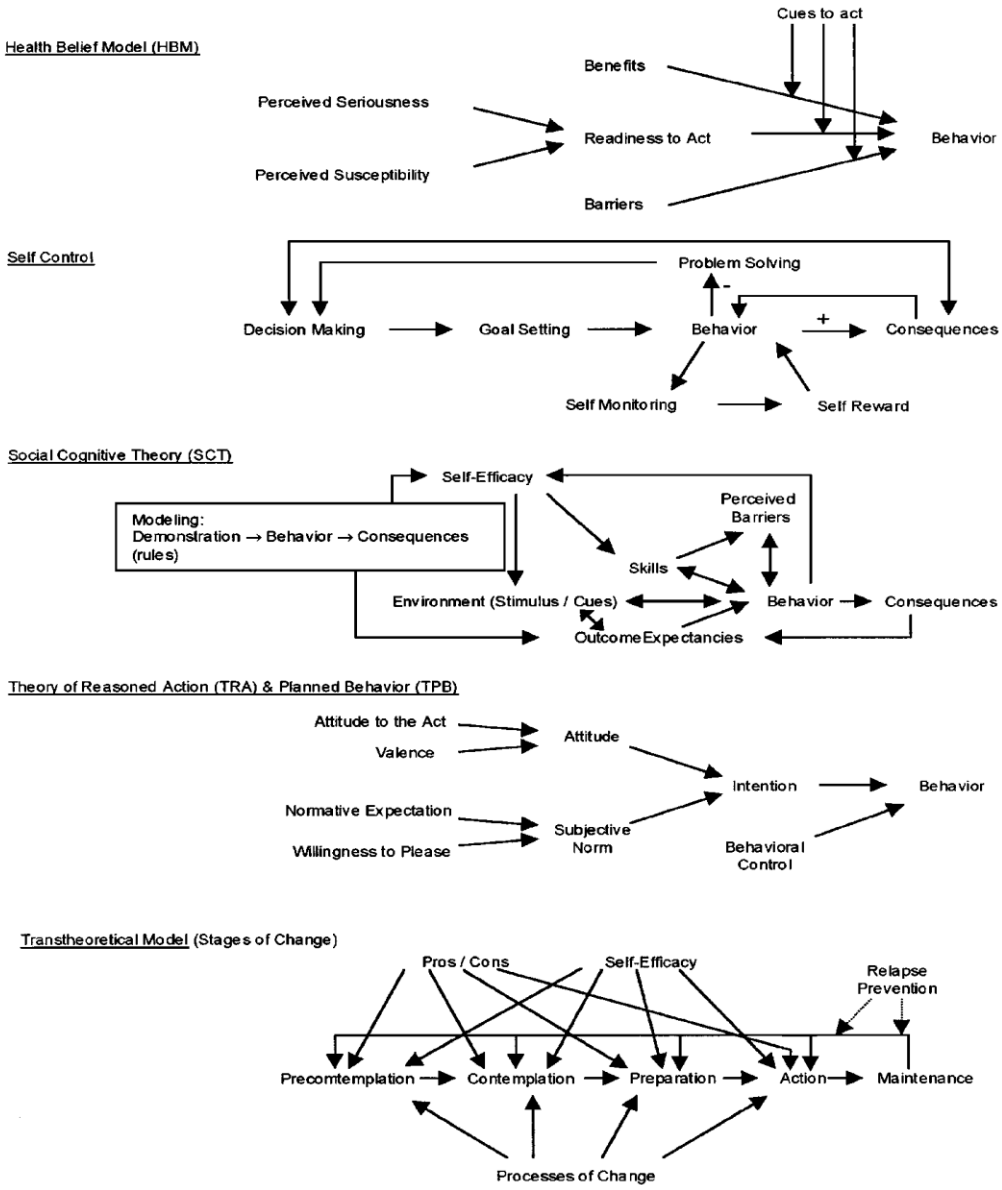

Figure 2.1 Schematic representations of major psychosocial theories, (Baranowski et al., 1999, p 20)

A multilevel study looking at the relative contribution of personal, social and environmental factors in determining fruit and vegetable intake in females from different socioeconomic backgrounds found that the personal and social factors were more important than neighbourhood store density which was the environmental measure (Ball, Crawford, & Mishra, 2006). The difficulty with limiting the environment to a single or even a group of factors such as density of stores is recognised but needs to be addressed and included in studies investigating how people make decisions (Ball, Timperio, & Crawford, 2006).

2.6.1 A taxonomy approach

When a population is the subject of an investigation, theories of behaviour change can be complex to apply. The influence of proximal variables, such as sale prices or attractive displays close to a checkout, affecting decisions about food choice are more difficult to assess from a population perspective while distal variables, such as attitudes and beliefs may be part of a larger social norm (Tarrant, Khan, & Qin, 2015) and/or cultural norm (Gallegos, Vicca, & Streiner, 2013; Scott et al., 2015; Boyd Swinburn, Egger, & Raza, 1999).

While theory should be invaluable to the health interventionist, the theory needs to be properly applied and the evidence from that application provided back to the theorist. Barker and Swift (2009) argue that creating a directory of theoretically based psychologically appropriate behaviour change techniques (a taxonomy) may be more useful to health promotion practitioners than adopting one theoretical perspective. They argue that studies adopting a taxonomy approach to behaviour change would ultimately lead to the development of a theory integrating the successful components (Barker & Swift, 2009). The taxonomy approach is the one used in the present research.

2.6.2 Systems based interventions to change behaviour

All of the theories described above have the individual's attitudes, intentions and behaviours as the focus of change. There is another and growing perspective that this focus needs to be changed to a system focus (Jayasinghe, 2015). Environments provide the context for behaviour (Bergea et al., 2013; Biglan, Flay, Embry, & Sandler, 2012; Cetateanua & Jones, 2014) and may be counter productive in supporting strategies aimed at making individuals responsible for changing to healthier behaviours (Alvaro et al., 2011). The concept of obesogenic environments has been raised with a structure for addressing these (Swinburn et al., 1999) as well as the converse of developing healthy food environments with government responsibility for the creation and evaluation of these (Swinburn et al., 2013). In Australia there is a large source of information that has the potential for use to assist in the identification of areas where a systems approach could be effective (Jorm, 2015).

Some systems based changes have shown a significant change in actions associated with healthy nutrition choices. Provision of breastfeeding rooms at a workplace along with supportive policies lead to longer breastfeeding duration (Tsai, 2013); the introduction of taxes on various food items or a ‘fat tax’ has introduced as a measure to change dietary choices at a systems level, but these have not yet been evaluated (Lee et al., 2013). Conversely, actions taken at a system level can adversely affect dietary choices unintentionally. Shorter lunch hours at schools in Wales led to less consumption of healthy foods at school (Townsend, 2015).

The systems approach to changing behaviour has been an approach used frequently in smoking (Hill, Amos, Clifford, & Platt, 2014; Sandford, 2003) and alcohol (Campostrini et al., 2006; Jiang et al., 2015; Livingston, Chikritzhs, & Room, 2007). These successes depend on political will to support policies (Martineau, Graff, Mitchell, & Lock, 2014) which in turn is dependent on the support of the population they are attempting to change (Dono, Bowden, Ettridge, Roder, & Miller, 2015). In some cases, the will of the population is in advance of the political will (and concomitantly government action), as shown in New South Wales, where a community based survey showed that the community was willing to support even stricter government measures that are currently in place with regard to smoking (Walsh, Paul, Tzelepis, Stojanovski, & Tang, 2008) and in WA, where the community has shown strong support for government control over a wide range of food related controls which are not yet in place (Pollard, Daly, Moore, & Binns, 2013). There has been a call to more rigorously evaluate population based public health strategies so that there is a better evidence base on which to assess both success of current strategies and the probability of success for future work (Lawrence, Mitrou, & Zubrick, 2011). It is likely that a combination of system based changes along with evidence based population strategies aimed at changing individual’s behaviour supported by policies aimed changing social and cultural norms are required to effect any consistent changes in dietary choices (Cohen & Swift, 1999; Freeland-Graves & Nitzke, 2013).

2.6.3 Other approaches to changing behaviour

Models specific to disciplines have been proposed which promote the role of the environment/society in overcoming major population health issues such as obesity using the ANGELO model (Swinburn et al., 1999) and the Obesity Policy Action framework (Sacks, Swinburn, & Lawrence, 2009); injury prevention using the Spectrum of (Injury) Prevention (Cohen & Swift, 1999); a Diffusion and Social Marketing approach to disseminating successful interventions in physical activity (Dearing, Maibach, & Buller, 2006); and the influences on social networks on smoking cessation (Christakis & Fowler, 2008). These models all recognised that approaching behaviour change at the individual level was unlikely to succeed unless the context (environment, society etc) within which the behaviour was embedded was changed as well. A study showing that people who did not consider future consequences had less healthy eating habits (Dassen, Houben, & Jansen, 2015), suggests that proximal factors were more influential with this group. This finding further illustrates the complexity of the role of community based health education programs. Policies and strategies based on these both need to incorporate some recognition of the role of proximal influences in decision making about food choices as well as the larger social context.

2.6.4 Application to the this research

While the development of questions used in the analysis of the investigations in the research was informed by social cognitive theory, it is most likely that the results arising from addressing the objectives of this research will be most applicable to the taxonomy and system based approaches. This is because the overall perspective is at a population level. Attitudinal, perceptual and behavioural inputs are described from that perspective across a number of areas including breastfeeding, healthy eating and running out of food. The time series investigation of food consumption and BMI are also looking across the whole of WA over a period of time. Discussions under the objectives will explore these concepts further.

2.7 COLLECTING EVIDENCE ABOUT ATTITUDES, PERCEPTIONS AND BELIEFS IN A POPULATION

In terms of using a population approach to public health interventions in nutrition, studies data about dietary knowledge, beliefs, intentions and behaviours are collected and measured by asking questions of a representative sample of the population being studied (Mehra, 1973). There are two main types of population based study paradigms. The first is the prospective research (either done as a cohort or longitudinal research) where the same sample of a population is studied over a period of time. The second is the cross sectional where a sample of the population is surveyed at a point in time and if the survey is repeated the sample changes to reflect the population at the time of the survey. The baseline data from cohort studies can be used as cross sectional study samples which has the advantage of identifying the population characteristics at baseline, independent of follow up analyses (Gallegos-Carrillo et al., 2009; Schluter, Turner, & Benefer, 2012). They also don’t have the problem of sample loss, a problem with cohort studies, but they cannot be used to identify temporal lags between variables of interest such as obesity and outcomes such as stroke. They offer challenges when surveys conducted at different time periods are pooled for data analyses but there are statistical methods that can be used to identify differences between years and adjust for these (Bersamin, Stafford, & Winkleby, 2009).

Cross sectional survey data can be the basis on which a subsample is extracted for further investigation as targeted population groups can be identified in the primary survey (Daly et al., 2010). Cross sectional studies offer the advantage of showing the population characteristics as they are at the time of the study and are useful when trends are being studied (Pollard, Miller, et al., 2009). A comparison of a cohort sample with three cross sectional studies on breast cancer showed little difference in the results between the two data collection methods (Caplan, Lane, & Grimson, 1995).

2.7.1 Use of dietary variables in cross sectional studies

In investigations studies of how a particular component of diet is associated with the risk of a particular disease (Delgado-Lista et al., 2012) or studies attempting to related a total pattern to reduced risk of mortality (Sherzai, Heim, Boothby, & Sherzai, 2012), accurate measures of diet are necessary. In population based measures of dietary choices, the quality and accuracy of the measures can be selected based on the purpose of the study (Thompson & Subar, 2012) and the research questions being asked (Kerr et al., 2012). As long as the data are collected using best practice survey principles then application of appropriate statistical procedures can deal with limitations associated with the data collection method (Campostrini et al., 2015; de Leeuw, Hox, & Dillman, 2008).

Translational research is research that uses results from the evidence base and applies it with aim of reducing disease (Boushey, 2012). The outcomes of this present research have the potential to be used as translational research and to bring an evidence base about population patterns to inform a variety of public health interventions that can be used both by future researchers.

2.7.2 What constitutes evidence in health promotion

There is some debate about what constitutes evidence and how is it collected particularly in the field of health promotion (Green, 2014; McQueen, 2001; McQueen, 2002). The randomised controlled trial (RCT) is considered to be only truly ‘objective’ (and therefore the best) method of collecting data. This tight definition is wise for studies with variables that can be precisely quantified, such as drugs or treatment regimens and where outcomes may be associated with risks of mortality or detriments to health. Not all evidence is amenable to RCT studies and RCT designs are neither necessary nor applicable to all circumstances (Campostrini et al., 2006). Arguably, for studies where variables are quantified from a personal perspective, such as recording attitudes or beliefs, limiting evidence to RCT methodology is neither possible nor functional (Green, 2014). In these types of studies, outcomes are stated as probabilities and/or relative risks in the likelihood of occurrence and are referring to processes and behaviours often at a population level rather than physical interventions involving individuals. If a study reveals "…an effect large enough to swamp the effects of any additional confounding then such study designs must be regarded as on a par with RCTs" (Howick, Glasziou, & Aronson, 2009, p 192). Broadening the way in which evidence is evaluated, presented to policy makers, used in policy making and then explained after policy should reflect the strength of the evidence base (MacDonald et al., 2006).

In terms of a 'level of evidence' survey data does not have any rating in either the National Health and Medical Research Council's Levels of Evidence (National Health and Medical Research Council, 1999b), the Brownson and Jones set of criteria (Brownson & Jones, 2009) or adaptations of the Bradford Hills set of criteria (Cadmus-Bertram & Patterson, 2012) which makes assessment of scientific 'worth' of survey based information difficult. Books and papers have been written about how to conduct surveys (de Leeuw et al., 2008; Dillman et al., 2009); how to sample for surveys (Battaglia, Izrael, Hoaglin, & Frankel, 2009); how to weight survey data (Bergmann, 2011; Deville, Sarndal, & Sautory, 1993), how to report surveys (Bennett et al., 2011) and possible uses for surveys (Stefano Campostrini et al., 2015). As yet been it appears that there are no papers or books written on how to assess the worth of survey based information, a gap that this research may start to fill.

2.7.3 How evidence from cross sectional data can indicate causal relationships

The basis of the levels of evidence criteria are designed to determine causality which is appropriate for establishing direct connections between nutrients and disease (Mente et al., 2009). However, there has long been the view that a legitimate and necessary branch of research seeks to identify the larger population perspective using an epidemiological approach (Colditz, 1985). Different types of evidence call for different assessments of what would be necessary for attributing a causal or probable causal relationship shown in Figure 2.2 (Howick et al., 2009).

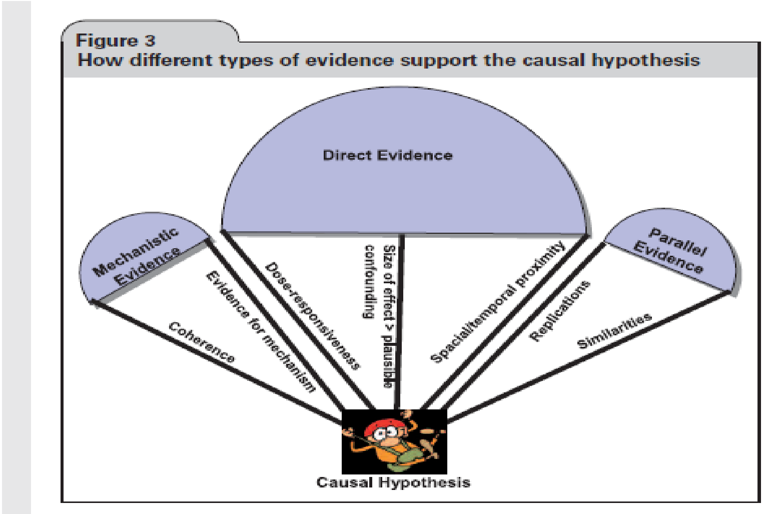

Figure 2.2 Model for decisions about attribution based on type of evidence (Howick et al., 2009, p 192)

Another approach to attribution of causality in cross sectional and observational data is to use the criteria as inferences to the best explanation thereby avoiding either inductive or deductive inferences (Ward, 2009). Table 2.3 shows how survey data characteristics can be matched to criteria necessary to attribute causality.

Table 2.3 Linking survey data characteristics to causality criteria, adapted from (Cadmus-Bertram & Patterson, 2012, p 116)

Criteria	Comments in relation to cross sectional survey data (not part of the Cadmus Bertram criteria)
Strength of association	As with other types of data, the strength of the association is a key indicator of a 'true' association rather one arising from an unknown confounding variable or set of variables.
Consistency	Reliability as well as validation against other measures or populations is another key indicator of the likelihood that association identified are 'true'.
Specificity	Specificity refers to the level of prediction or frequency where which one factor predicts the frequency or magnitude of effect. In cross sectional data, multiple causes and outcomes are likely, particularly when evidence is being assessed against psychosocial concepts. Here parallel results would offer support for specificity and would need to be incorporated into the evaluation of the cross sectional evidence.
Time Sequence	In public health terms, the estimates of change revealed by surveys needs to be temporally viable when trying to assess the effects of campaigns or interventions. However, longer time periods may be necessary to demonstrate behaviour change that is consistent and enduring, as was shown in the smoking campaigns and legislation effects.
Dose-response	Increased risk associated with exposure is translated in surveys to mean the increase relative risk in relation to known associates of that risk.
Credibility	For surveys, credibility is demonstrated by the plausibility of identified associations.

The results from the analysis of the cross sectional data used in this research show many of these characteristics and the use of statistical procedures such as the Granger Causality test (section 3.2) and propensity scoring (Section 3.2) adds support to the strength of identified associations. These techniques are used in the analyses described in Chapter five (addressing objective two) and in Chapter eight (addressing objective five).

2.7.4 What complex analyses can reveal

Interventions designed to assist people in changing their behaviour to reduce their risk of developing a health condition require evidence that accurately reflects the population. The benefit of the kinds of analyses alluded to above is that they can identify populations where an intervention strategy has either been unnecessary or unsuccessful; partly successful or not at all successful. This allows for population based strategies to be developed for each segment of the population rather than assuming that one strategy will be enough to promote change across a whole population. While the argument that moving the population risk even a small bit to lesser risk[1] makes a difference across all segments, other research shows that already marginalised groups become more marginalised (Glasgow, Vogt, & Boles, 1999). The investigations outlined in chapters four to eight show applications of the analytical techniques described in Chapter three, Section 3.2 to achieve more specific description of populations in relation to dietary behaviours and decisions.

2.8 TRANSLATING POLICY TO ACTION

The World Health Organization (WHO) encourages governments to undertake research to inform policy and intervention development and evaluation (World Health Organization, 2008b). Information from WA based population based nutrition surveys is sporadic and mostly based on fruit and vegetable consumption but what has been produced has had recognition from the international literature (Pollard, Miller, et al., 2009; Pollard,

[1] In population terms this is known as moving the 'curve' to the left which refers to the normal bell shaped curve that is typical of most variables being changed so that the mean now reflects a lower proportion or number at risk and therefore a net gain will have been made.

Nicholson, Pulker, & Binns, 2009) and influenced health promotion activities in WA (Pollard, 2006). There is international recognition that data translation is a crucial step in persuading health professionals of the value of population survey data to support the setting of priorities in terms of resources, policies, strategies, interventions and evaluations (Choi, Anil, & Brian, 2009; Choi et al., 2005) and that good quality data needs to underpin this (Des Jarlais, Lyles, Crepaz, & Group, 2004). While policies rarely have a theoretical base (Breton & De Leeuw, 2011) many have some evidence base (Mason et al., 2014).

2.8.1 What is required for policy makers to take action

The policy maker, usually under a politically driven time constraint, will have to make do with either intuition, previous work or a 'best guess' if relevant, easily accessible and understandable information is available (Marston & Watts, 2003). They argue that all evidence-based discussion has four key elements but the way in which these interact changes with the perspective of both the researcher and the policy maker. Figure 2.3 shows these four elements and the way in which they are assumed to operate.

$$\frac{\text{Question(s)+Evidence=Knowledge/Claim(s)}}{\text{Assumption(s)}}$$

Figure 2.3 Elements of evidence-based discussions (Marston & Watts, 2003, p 151)

Two points are not reflected in the equation shown in the previous page: being in a position with the authority to speak the 'truth' can be as important as speaking the truth, and "a wide array of external vested interests may be committed to a predetermined outcome irrespective of the evidence" (Marston & Watts, 2003, p 146). The equation above could be modified to include the status of the discussants as shown on Figure 2.4.

$$\frac{\text{Question(s)+Evidence=Knowledge/Claim(s)/Assumptions(s)*Status}}{\text{Vested interests and (or) Political agenda}}$$

Figure 2.4 Modified model of elements of evidence-based discussions

Table 2.4 presents the present researcher's summary of reviews of what policy or decision makers want from research information undertaken by Innvær et al. (2002) and Orton et al. (2011).

Table 2.4 Summary of review of facilitator and barriers to use of evidence in policy and decision making in public health with comments

Facilitators	Barriers	Comments on Criterion which are ranked by number of studies where it was a finding
Personal contact between researchers & policy makers	No personal contact between researchers & policy makers	This may be the most under-rated criterion and also the least followed in research circles.
Timeliness and relevance	Lack of timeliness or relevance	Relevance is more easily addressed than timeliness as many analyses are time consuming to perform and often no money is allocated to this side of the research.
Readily available	Not easily accessible	Making information accessible along with timeliness and relevance are key criteria for ensuring it is used in policy and/or decisions
Inclusion of a summary and recommendations		In some areas, it is seen as outside the expertise of the researcher to make recommendations. This perception needs to be addressed and changed.
Confirmation of current policy or in alignment with future policy		While this criterion is logical and not unexpected, it is also limiting from a research perspective.
Level of demand		While relevant to both, being 'told' what to research isn't always well received. This needs to be changed if researchers want to influence policy.
Good quality, methodologically sound and if possible peer-reviewed	Poor quality	This really should be nearer the top but it does show that for policy makers, it may be less important than personal or political issues.
Assessment of effectiveness		Being able to demonstrate that the information leads to effective outcomes is one of the most important outcomes.
Easily incorporated into common parlance		People making policy or decisions need to be able to translate their evidential base into language that can be understood by the public.
	Mistrust	Lack of trust between researchers and policy makers is seen as a major barrier and needs to be addressed by both groups.
Easily incorporated into common parlance	Power/budget issues	Resourcing and who has the 'power' at any given time can influence use of information. Sustainable funding is necessary

Facilitators	Barriers	Comments on Criterion which are ranked by number of studies where it was a finding
	Poor quality	This would seem to be an obvious barrier but it is not seen as important as personal contact.
	Data needed at micro level	This is a barrier for the researcher as often this requirement is not able to be met, either because no data exists or because the numbers the evidence is based on are too few.
	Political issues	The political arena is the milieu of policy makers. Appreciation of the power of the political area by researchers is needed.

2.8.2 Models of how research and policy interact

A model of how policy and research interact and influence each other has been conceptualised by Lawrence and Yeatman (2008) who see policy practice as an influential factor affecting environmental and cognitive-personal determinants. These in turn influence behaviour which influences public health. Behavioural research identifies and helps to understand behaviour using the behaviour observed and there is a feedback cyclical loop between behavioural research and policy practice. The relationship between the two is shown in Figure 2.5.

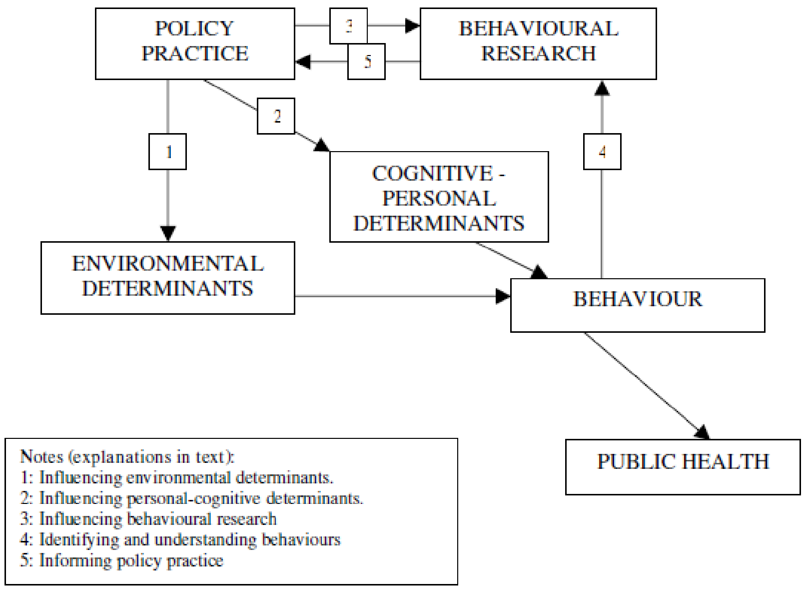

Figure 2.5 Conceptual model of the policy practice and behavioural research relationship (M. A. Lawrence & Yeatman, 2008, p 2)

The model was evaluated using the New South Wales (NSW) school-based intervention 'Fresh Tastes Healthy Canteen Strategy'. Within that strategy the model appears to work adequately but what it is describing is what has happened, not what could happen, that is, it doesn't predict the relationships, it just describes how they might be operating. The authors of that study recognised the need to be evaluated in a wider context as evaluations within specific situations make it less useful to the health promotion community trying to promote evidence based programs and evaluation. (Rychetnik, 2003).

Another view of the way diet and health are related uses an ecological approach showing the levels at which research can influence policy and which approach be most likely to hve an effect. At the macro level food labelling would be the approach whereas at the local community level it might be school policy to limit availability of less healthy foods and at the individual level the taxing unhealthy foods or food additives (Bleich et al., 2015). A framework showing areas that need to be addressed when trying to understand the influences on decisions about food choices is shown in Figure 2.6.

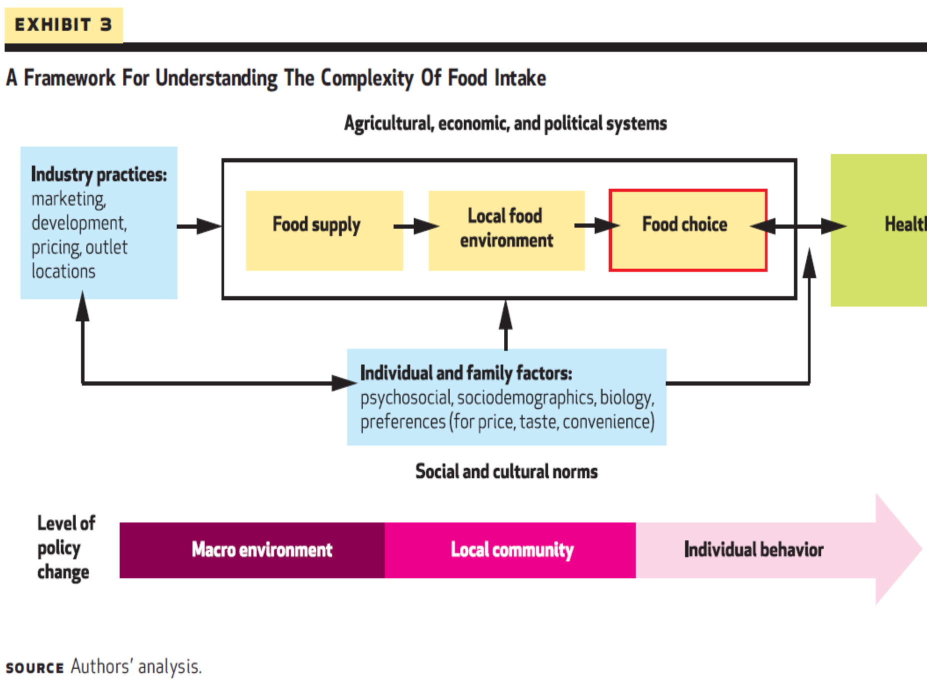

Figure 2.6 An ecological framework showing levels to be addressed to influence health-related food decisions (Bleich et al., 2015, p 1816)

A similar approach proposes a theory of change with directions and actions related to improving diet and thereby reducing obesity. This approach shows an individual perspective of how change might occur with the individual and their food preferences the start of the path with influences from the social, information and food environments an intervening set of variables on the path to food choices and the associated outcomes of BMI and health. The hypothesis is that food preferences are learned early in life primarily from parents and caregivers and these can be modified over time through influences from the three environment levels (Hawkes et al., 2015). Figure 2.7 presents the framework for their theory of change.

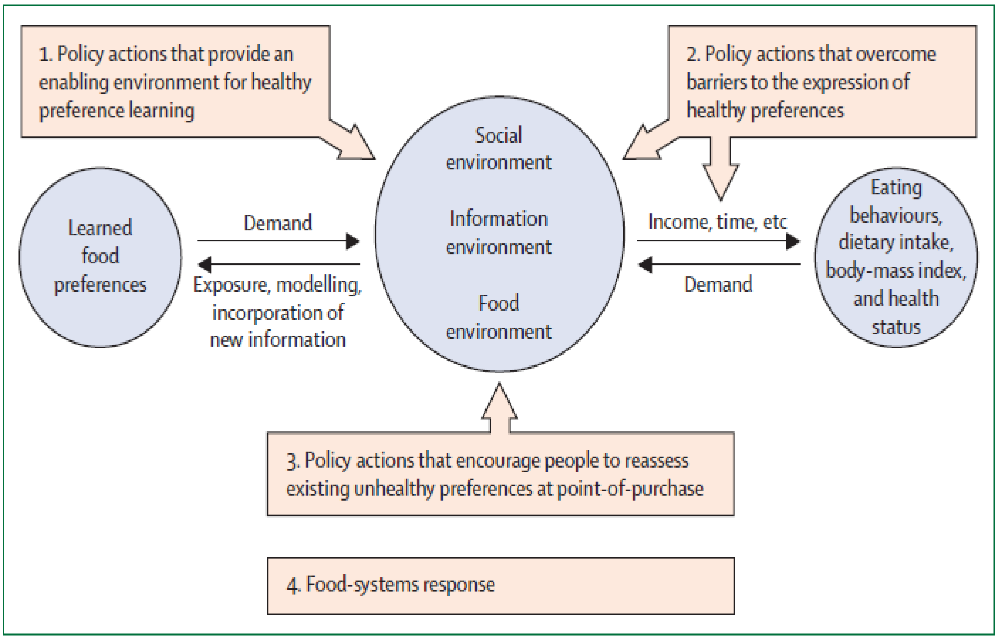

Figure: Framework of the theory of change and the four mechanisms through which food-policy actions could be expected to work

Figure 2.7 A framework for the theory of change (Hawkes et al., 2015, p 2411)

Both of these approaches advocate the use of levels of policies aimed at influencing the path to food choices within all levels and contexts. Understanding how barriers and incentives to healthy eating work within populations will assist in the development of strategies and policies that are likely to resonate with the target population and encourage change to a healthier eating pattern (Bleich et al., 2015). This may be more successfully done if policies are based on targeting the development of food preferences so that "…policies … extend beyond making healthy choices the easy choices to making healthy choices the preferred choices" (Hawkes et al., 2015, p 2417).

In Australia, a recent review found that across the country there 259 community based initiatives around the reducing obesity and increasing physical activity but relatively few (14.2%) used a multilevel strategy (Whelan et al., 2015). These results suggest that there is a need to educate those running such initiatives of the increased likelihood of positive outcomes if more than one strategy is used simultaneously. Under objective two of this research, supporting evidence for this position is presented.

2.9 PRESENTING THE EVIDENCE

At this point in time, evidence is still presented in traditional ways with tables, figures and graphs. These methods are in themselves good but unless what they are showing is clear to the reader, then they not useful. Data from complex systems or analyses present particular challenges to the researcher in how best to present the outcomes. With few exceptions, this is an area where there has been little work done to date. Methods for analysis involving numbers which have relatively precise meanings give rise to models which can be quantified and presented in figures such as nomograms, graphs and representation of models. What is appealing about a pictorial representation is that it can summarise a very large amount of background data into a relatively brief summary. To a researcher or clinician who is not an epidemiologist or health trained statistician some pictorial representations may look interesting but the interpretation may be challenging, as illustrated by Figure 2.8. To a lay person, even one well educated in aspects of health, interpretation would be either difficult or the output have so many caveats that what is really being shown becomes obscure. In many cases the information which is relevant and important becomes lost in scientific notations or in a level of precision that is un-necessary for broad policy directions. Results like these are necessary to get papers published in peer review journals, but the challenge remains to translate such complex outcomes into information that policy and decision makers can access and use easily.

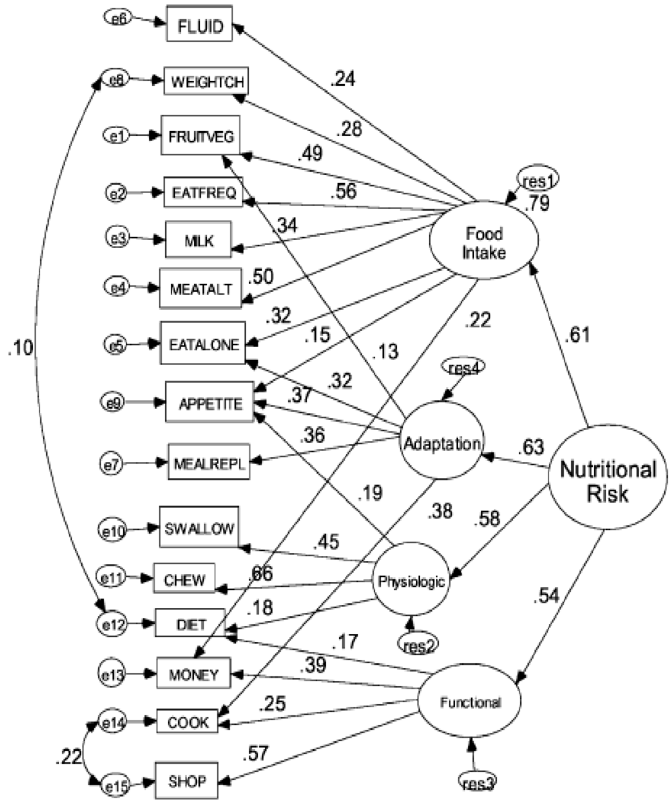

Fig. 1. Final four-factor structural equation model for nutritional risk in seniors. *Abbreviations:* e, error term; res, residual covariance. For item abbrevi tions, see Appendix.

Figure 2.8 Example of structural equation model, (Keller, 2006, p 839)

The challenge is to find analytical tools and pictorial output to translate self-reported responses from individuals who are embedded in cultural, environmental, social and political settings into accessible output. This present research aims to find pathways from the starting point of a perspective (personal, population sub-group or population) to an end point (a desired or predicted outcome) and then to provide results that can be used to represent the outcome in a way that ‘speaks’ to policy and decision makers.

2.9.1 Differing perspectives on aspects related to policy and decision making

> “It is often necessary to make a decision on the basis of information sufficient for action but insufficient to satisfy the intellect —Immanuel Kant” (Brownson & Jones, 2009, p 313)

Even if the research is compelling and the policy makers interested in the results and the political will in alignment with both, there is still a major area of difference in approach. Communication styles and how decisions are made change in relation to organisation and position within that. The differences are summarised in Table 2.5. The key difference to note for policy makers is that for people occupying positions which are intrinsically less secure and more directly dependent on the public, the dependence on science and empirical evidence is less than the dependence on public perception of an issue. While not directly addressed by Brownson and Jones (2009), the table implies that for evidence to be influential on decisions about policy, it must also be influential with the public.

Table 2.5 Differences in perspectives and communication styles for decision making (Brownson & Jones, 2009, p 314)

Characteristic	Executive branch, public health administrator	Legislative branch, elected official	Legislative branch, staff member
Time in Position	Longer	Shorter	Shorter
Accountability	Prime Minister, Minister for health, Department of Health CEO	Constituents by whom they are elected, political party	Elected legislator, committee chair
Personal connection to constituents	Moderate	High	High to moderate
Knowledge span	Deeper knowledge on health issues	Less depth, wider breadth	Less depth, wider breadth
Decision making based on external factors (aside from research)	Low to moderate	High	High
Time spent on a particular issue	Longer	Shorter	Shorter
Type of evidence relied on	Science, empirical studies, experience from the field, personal experience	Science, media, 'real world' stories, constituents, lobbyists, party priorities	Science, media, 'real world' stories, constituents, lobbyists, party priorities

The other key variable to consider is determining what research is necessary from the perspective of a policy maker. Greenlick et al (2005) suggest that the capacity to frame a research question in a way that is relevant yesterday but also will be relevant in five years may be more valuable than the results section of an article. They maintain that researchers rarely ask policy makers or legislators what they need and even more rarely evaluate any outcomes of their research (Greenlick, Goldberg, Lopes, & Tallon, 2005) There is a school of thought that knowledge of what is important to decision makers and policy makers should be driving not only what is being communicated but also what is being researched, applied and evaluated (Briss, Brownson, Fielding, & Zaza, 2004).

2.9.2 How this relates to decisions about eating

These issues are key to the success of translating nutrition evidence to policy. If the evidence about the role of food in health is to be translated into useful policy, then recognition and adherence to the processes outlined in the section above may make messages and interventions more effective. It has been suggested that an intermediary function, those who can bridge the research/policy gap, may be necessary in this process (Campostrini et al., 2015). Translation of the analytical pathways can be put into context and used with illustrations about successful interventions related to the evidence.

At this point in time, there is evidence about what some of the precursors of food choice decisions are but the evidence is generally quite specific to a group, such as weight in adolescents (Jodkowska et al., 2011) and food choices in food insecure families (Bauer et al., 2015). Less is known about how to effectively and permanently change food choice decisions to choices consistent with dietary patterns associated with good health and wellbeing. The phenomena of delay discounting, which is the amount of delay a person is willing to tolerate to obtain a particular outcome, and probability discounting which is the degree of uncertainty a person is willing to tolerate to obtain a particular outcome, are starting to provide valuable information about how decisions are made about food. (Rasmussen, Lawyer, & Reilly, 2010) Incorporating the newly emerging evidence about the relationship between food, gender and environment means that a more comprehensive perspective is needed in the approach to finding interventions likely to succeed. It may be that combining the results from this study with the evidence of how choices are made by people who are obese as described in (Pachucki, 2012) will lead to an added outcome. The possibility is that not only can population based interventions be better informed but also group specific interventions. While the main focus of this research remains epidemiological, the results may also inform plans for interventions that are targeting more specific problems in nutrition. Groups such as obese males and females who are at risk of cardiovascular disease and other chronic conditions affecting their quality of life and who also have the added risk factor of unhealthy eating would be a group that would be a high priority for behaviour change. To this end, a guide using rigorous methodology on how best to design community based interventions is available. This guide advocates systematic reviews for evidence that the proposed intervention works, subject/issue based models of the intervention plan and dissemination strategies (Briss et al., 2004). Work has also been done on evaluating interventions and reporting on these using TREND (Des Jarlais et al., 2004), a framework similar to CONSORT which was designed for the reporting of randomized control trials (Begg, Cho, Eastwood, & et al., 1996) and STROBE for observational studies (Vandenbroucke et al., 2007).

2.10 SUMMARY

This literature review has highlighted the importance of eating a healthy and balanced diet over the course of life so that there is reduced risk of premature disease, chronic conditions and mortality. The review outlined a number of theories about how behaviour may be changed. From this review, given the number and complexity of factors which influence food choices and the focus of this research, two theoretical frameworks for how behaviour occurs and/or is changed appeared to offer the best explanatory power for the results from the investigations arising from the research. The first is the taxonomy approach of grouping information according to shared qualities so that outcomes can inform theorists as well as theorists offering back some further information that may provide explanatory context for any results found. The second is the systems approach which produces its influence at the system level, such as passing legislation to tax unhealthy food or introducing policies to affect large institutions such as not providing unhealthy foods in a school canteen or providing facilities in a workplace that support and encourage breastfeeding. The investigations from this thesis could offer information for both approaches by providing evidence to suggest and support relevant policies; policies that have the power to be translated into action.

As the basis of this thesis is data from two cross sectional data from two surveys, the review found that while such surveys were common in the nutrition field, the use of the information was generally at the descriptive level with few going further. The evidence suggested that there was an opportunity to provide some information about how better use could be made of these types of data by employing well known but, in this field, underutilised statistical methods. Evidence from the review suggested that how these results will be applied depends on intersectoral collaboration at a number of levels, the political, the food environment, the community and those who work in the field of public health. The review further suggests that there is a whole body of evidence that does not influence policy and while there may be political barriers driving some of this, it is equally likely that the evidence was either untimely; inaccessible to the policy maker both in terms of physical access and also in terms of interpretive access, and/or not relevant to current policies and directions for public health.

While this thesis does not address the direct application of the results to policy, it does suggest how they may be applied. In addition, each objective addressed in this thesis also includes a brief literature overview of information relevant to the investigation which is used to inform the analysis and assist in the interpretation of the results. Key findings from each of the five investigations will be highlighted with suggestions for further research informed by both the larger and the more specific literature reviews.

3 METHODS-DESCRIBING THE DATASETS

This chapter contains descriptions of the two datasets used in this research as well as a description of the measures and the analysis undertaken for each of the five objectives. The measures for analysis are taken from two WA Department of Health population-based cross sectional survey series. Both are monitoring systems conducted over time. These two datasets investigate different issues but have in common a number of questions which allows for the exploration of context in some instances. A brief description of the each of the datasets relevant to this research is provided below. Ethics approval for the use of the data in the NMSS and HWSS for this research was granted in 2012 by both the Department of Health (DOHWA Ethics Project 2011/65), and Curtin University (HR81/2012).

3.1 THE HEALTH AND WELLBEING SURVEILLANCE SYSTEM (HWSS)

The HWSS was designed to collect information on the health and wellbeing of the residents of all ages residing in WA. Data were collected on a wide range of areas which included: measures for lifestyle risk factors including smoking, physical activity, alcohol consumption, nutrition, height and weight, doctor diagnosed hypertension, high cholesterol cardiovascular disease, diabetes, asthma, COPD, quality of life using the Medical Outcomes Short Form 8 developed for population based used (Ware, Kosinski, Dewey, & Gandek, 2001) and measures of psychological distress using the Kessler 10 scale (Kessler et al., 2002) along with key socio demographics measures including the SEIFA for WA. SEIFA is an index of relative social advantage and disadvantage produced for every collector district within Australia (Australian Bureau of Statistics, 2013d).

In March 2002, the HWSS was piloted with a questionnaire, developed for use with adults aged 25-64 years and in April questionnaires for young adults aged 18-24 years and older adults aged 64 and above were piloted. Over the years the questionnaires were combined and refined as new information was available. By 2005, the questionnaires were stable and, with minor changes, were still in use in 2015. A full description of the survey development and questions has been published as a Department of Health report (Daly, 2005).

The survey follows in all particulars the principles of continuous data collection (Campostrini et al., 2015). The aims and objectives of the HWSS

The HWSS was set up to with the following aims:

1. To provide timely high quality information to inform policy, planning, purchasing and provision of services

2. To provide information at local health region level, with the eventual goal of making small area data available (Statistical Local Area level or better

3. To provide information that is used for population performance indicators

4. To provide information that can be used to evaluate long-term effects of programs and interventions

5. To provide information about trends over time as well as seasonality

6. To provide a robust set of baseline health status and lifestyle information for health service managers

7. To provide quality data to researchers and health professionals that can be used to support programs, interventions and future initiatives.

These aims had the broader objectives of:

1. Monitoring the health and wellbeing of Western Australians using validated reliable indicators

2. Identifying health status and lifestyle trends over time

3. Identifying emerging and salient issues in a timely manner

4. Identify and report on health-enhancing behaviours as well as risk factor behaviours

5. Ensuring that the data collected reflects the need for information within a particular age group.

3.1.1 HWSS sampling and data collection methods

Since its inception the WA Health and Wellbeing Surveillance System (HWSS) interviews up to 6600 people of all ages by telephone each year. Up to 2005, when interviews were conducted every month of the year, there were gaps of up to two months while funding was secured to continue the interviewing. This occurred because of the funding cycle in place at the Department of Health in WA at the time. In 2005 the funding became recurrent and interviews were conducted every month of the year and on almost every day of the year.

Stratified random samples were drawn using the most current version of the Electronic White Pages for Western Australia which had been coded according to area of residence. Up to 2008, the strata were the ten health service areas for the Department of Health. In 2008, the ten strata were reduced to three areas, metropolitan Perth, the Kimberley and Pilbara and the rest of the State as these areas were the ones which were most likely to show differences in prevalence estimates of key variable. The ten health service areas were used to identify the three strata making sampling fractions over the years roughly comparable. All sample households with an address in the EWP were sent a Primary Approach Letter (PAL) explaining the purpose the survey, how the sample was selected, who would be asked to do the survey and about how long it would take. In addition, two brochures were included in the PAL. The first further illustrated the purpose of the survey and provided some results from the survey so respondents could see how the data were used; the second explained how the data would be linked to hospital and death data if permission were given to do that during the survey. Telephone numbers were provided for verification of the authenticity of the survey, for any concerns related to questions in the survey and for further information on data linkage. For every household in the initial sample up to ten calls had to be made with no response before the number was coded as a non contact. Contacted numbers were eliminated if they were not a household or if there was no person in the household capable of providing an interview. If there was an adult who fulfilled the requirements of the survey the household was selected. Households with more than one adult were asked which adult had the most recent birthday and that adult was selected for interview. No substitutes were permitted. At least ten call backs were made to achieve an interview. Respondents gave verbal permission to continue and were informed of their right to discontinue the interview or to refuse to answer questions. Interviews were conducted in all months of the year and at various times during the day up to 9 pm on weeknights and between 10 am - 6 pm on weekends unless the respondent requested an evening call. A raw response rate of not less than 70% was required based on households contacted whether or not an interview is achieved. The response rates were calculated using a modified version of the American Association for Public Opinion Research (AAPOR) method (The American Association for Public Opinion Research, 2000). The response rates are shown in Table 3.1.

Table 3.1 Response rates for the HWSS, by year, 2003-2013

	Interviews achieved	Raw response percent (a)	Adjusted response percent (b)	Participation percent (c)
2003	5,922	70.7	76.9	82.0
2004	4,540	75.0	79.7	81.7
2005	6,600	73.5	79.4	85.2
2006	5,327	74.5	80.2	86.6
2007	6,540	73.7	81.6	89.4
2008	6,663	76.7	83.6	89.8
2009	7,881	78.8	84.6	91.7
2010	6,780	74.9	80.7	90.5
2011	6,147	74.7	82.1	89.8
2012	5,917	73.8	81.8	89.6
2013	6,486	74.2	83.9	90.0

(a) Raw response rate (completed interviews / eligible contacts + non-contacts)
(b) Adjusted response rate (completed interviews / eligible contacts)
(c) Participation rate(completed interviews / completed interviews + refusals)

The 2002 surveys were pilots and were run as four different surveys for which an overall response rate was not available. As the requirement for a raw response rate of 70% was in place and 6,309 interviews were achieved it is likely that the overall response rates were similar to those for other years. The response rates, methods of sampling and efforts to achieve an interview mean that prevalence estimates are likely to be reasonably representative (Groves, 2006).

3.1.2 Source of questions used in the HWSS

The questions for the HWSS used in this research were taken either from previous surveys conducted by the Australian Bureau of Statistics or were developed by specialist bodies such as the Strategic Inter-governmental Nutrition Alliance, the Strategic Inter-governmental Physical Activity Alliance and the Computer Assisted Telephone Interview Technical Reference Group. (University & Technology, 2002) During their tenure, they contributed questions and expert technical advice to surveys being conducted in Australia in the late 1990s and early 2000s. Questions used in the analyses in this research are provided in relevant methods sections and in Appendix two.

3.2 THE NUTRITION MONITORING SURVEY SERIES (NMSS)

The NMSS commenced in July/August 1995 to provide information to assist planning interventions promoting the Australian Dietary Guidelines for healthy eating (National Health and Medical Research Council, 1991). These guidelines have not changes much with updates (Chapter two, Section 2.2). The overall aim of the NMSS is to monitor the knowledge, attitudes and behaviours about food and nutrition related to the ADG of WA adults aged eighteen to sixty-four years. Specifically, the objectives are to:

1. Explore the personal relevance and understanding of dietary recommendations and the perceived need for dietary change
2. Assess stages of change in relation to specific dietary behaviours
3. Identify and quantify public perception of the barriers and enablers of dietary change
4. Monitor the relative importance and salience of public health nutrition initiatives
5. Identify the main sources of nutrition information and monitor community perception of that information
6. Monitor the dietary concerns of the community

7. Assess socio-demographic variations in self-reported nutrition attitudes, intentions.

3.2.1 NMSS sampling and data collection methods, 1995 to 2012

The NMSS conducted in 2009 and 2012 used identical sampling strategy and methods as described for the HWSS in Section 3.1.1 above. Prior to 2009 a variety of other methods of sampling and administration were used. Table 3.2 summarises the sampling strategy, method and response rates for the surveys from 1995 to 2012.

Table 3.2 Characteristics of the samples used, NMSS WA 1995 – 2012

Year	Original Sample Frame	Method used	Original sample	Sample Called Out	Aged 18-64	Percent Refused	Interview complete	Adjusted Rate*
1995	Telephone numbers randomly generated	Sampled by quotas for metropolitan Perth (75%) & 4 rural centres (25%)	12,842	No	63.4%	22.6%	1002	34.4%
1998	Telephone numbers randomly generated	Sampled by quotas for metropolitan Perth (75%) & 4 rural centres (25%) & sex (50% 50%)	13,005	No	27.6%	66.6%	1004	29.5%
2001	Telephone numbers randomly generated	Sampled by quotas for metropolitan Perth (75%) & 4 rural centres (25%) & sex (50% 50%)	23,728	No	14.0%	59.3%	1004	33.4%
2004	Randomly extracted using 2004 EWP	Sampled by quotas for metropolitan Perth (50%) & 4 rural centres (25%) & sex (50% 50%)	4,023	No	47.8%	30.9%	1202	66.9%
2009	Randomly extracted using 2008 EWP	Stratified random sample with metro, rural and remote	3,499	Yes	45.0%	11.4%	1284	87.8%
2012	Randomly extracted using 2008 EWP	Stratified random sample with metro, rural & remote	6,500	Yes	28.9%	9.2%	1548	90.0%

*Determined by number of completed interviews divided by completed + refusals

3.2.2 Source of questions used in the NMSS

The questionnaire included measures of the intentions, knowledge, attitudes and beliefs about a wide range of food-related areas, including eating foods recommended for daily consumption in the ADG; specific attitudes towards eating out, buying healthy food and who should run school canteens and community support for government initiatives. The questions assessing attitudes, perceptions and intentions to behave were based on the translational theory of change (Prochaska & DiClemente, 1982). Evidence has shown it is these antecedents which influence decisions about dietary behaviours, both at an individual level (Berge, Meyer, Loth, MacLehose, & Neumark-Sztainer, 2015; Dissen, Policastro, Quick, & Byrd-Bredbenner, 2011; Loth, MacLehose, Bucchianeri, Crow, & Neumark-Sztainer, 2014; Renzaho, Kumanyika, & Tucker, 2011) and at a population level (Baranowski et al., 1999; Loth, MacLehose, Fulkerson, Crow, & Neumark-Sztainer, 2013; Robinson, Thomas, Aveyard, & Higgs, 2014; Wang & Chen, 2012).

Consumption questions used short dietary questions of key food group consumption in the day prior to the survey evaluated against weighed dietary records (Marks et al., 2001; Riley et al., 2001; Rutishauser, Webb, Abraham, & Allsopp, 2001). While food consumption questions did not meet the requirements for estimation of nutrient intake (Kerr et al., 2012), they were suitable for monitoring adherence to the Australian Dietary Guidelines at a population level (Thompson & Subar, 2012).

Questions used in the analyses in this research come from the surveys conducted between 1995 and 2012 and are provided in relevant methods sections and in Appendix two.

3.3 Analytic Approaches for Population Based Cross Sectional Data

> “It is a basic tenet of intervention that it is far easier to modify the more proximate determinants of health, such as individual food choices, than it is to alter the intermediate and distal forces that affect those choices. Changing the organization of society and the core components of culture poses enormous challenge, yet there is growing recognition that only through alteration of the fundamental causes of disease … can true primary prevention be realized “ (Coreil, 2008, p 112).

With increasing numbers of research papers from the statistical world showing application of statistical methods originally developed for other purposes with observational and cross sectional data (Cox, 2013; D'Agostino, 2007; Granger, 2003; Reio & Shuck, 2015; Sauerbrei et al., 2014; Stuart, 2010), there is an opportunity to explore how these can enrich understanding of the complex interactions that lead to behaviour change (Friel et al., 2015). Theories about behaviour change all posit that decisions about health have influences. They both suggest pathways to decisions about health include influences such as knowledge, attitudes and intentions and propose their position in relation to proximate and distal influences on a decision. The relative importance of these mediating variables and the direction of their influence on decisions have not been clearly established. While theories generally suggest the direction of influence or particular components to explain behaviour, their hypothesised connections need to be tested (Barker & Swift, 2009). Possible ways to investigate the relative importance and direction of influence include the use of relatively sophisticated inferential statistical analysis including: factor analysis which then feeds into regression or mediation analysis; time series analysis which incorporates forces on the economy and/or health promotion campaigns occurring within the studied time frame; predictions using time series which include some measure of causality; and estimating possible causal paths using methods developed for different modes of administration and applying them to survey data.

3.3.1 Weighting and Iterative Proportional Fitting (IPF)

The accuracy of results from cross sectional population surveys is an outcome of both the sampling method, the coverage and the weighting used (Groves et al., 2009, pp 232-39). Weighting adjusts the data to be more representative of the population from which the sample was drawn so knowledge how the sample was extracted is an essential part of the weighting process (Mokdad & Remington, 2010). The importance of weighting to get the most representative estimates of prevalence has been acknowledged in the literature (Kalsbeek & Agans, 2009; Thomas et al., 2005) and the way in which the data are weighted can significantly affect some estimates (Kolenikov & Hammer, 2015; Mokdad et al., 2003). There are two ways in which sample weighting is done. The first way of weighting is to use a two stage process. The first stage takes into account the sample design which is often complex and adjusts for probability of selection. The second stage adjusts estimates to account for over or under representation of population subgroups (Kolenikov, 2010). The second way of weighting also adjusts for probability of selection but adopts a different mathematical method, iterative proportional fitting (IPF) for deriving the post estimation weights (Battaglia et al., 2009; S. Kolenikov, 2014). IPF is a computational technique involving marginal totals for subpopulations which are generally based on census data estimates and allows for more potentially biasing variables such as race and education to be included in the post estimation weights (Mokdad et al., 2003). The purpose of this kind of weighting is to make the sample even more representative of the population than can be achieved by the more traditional post stratifications which are typically based on only two or three variables such as residential area, age and sex. In the US the prevalence estimates for key health risk factors based on data from the Behavioral Risk Factor Surveillance System (BRFSS) changed when IPF using marginal proportions for race, education and marital were included in the weighting (Mokdad, 2009). In Australia, IPF is not usually used to weight survey data although South Australia has recently started to use it with their surveillance system (Dal Grande, Chittleborough, Campostrini, Tucker, & Taylor, 2015). Comparisons of weighting types and prevalence estimates are provided in Appendix three. The results support the decision to use a simple version of IPF for the statistical analyses in this research.

Multivariable procedures such as structural equation modelling and factor analysis do allow a sampling weight and an additional advantage of using IPF is that it combines proportional fitting of marginal totals with the probability of selection to produce a single weight. Models to describe the behaviour and/or attitudes evidenced by the sample will have more validity for assumptions about generalisation to the adult population of WA through the use of these powerful multivariable statistics. This is because there are post estimation tests for goodness of fit, meeting assumptions, assessing the effect of missing data and appropriateness of the statistics which are not available for models developed within the survey unit.

3.3.2 Factor Analysis and Principal Component Analysis

Factor analysis has been a frequent methodology for statistically identifying patterns of diet within a population with subsequent regression, often based on quintiles or tertiles (Catsburg et al., 2015; He et al., 2015; Oellingrath, Svendsen, & Hestetun, 2014). It has also been used for identifying patterns of diet against known dietary pattern indicators associated with health (Boggs et al., 2015; Marialaura Bonaccio et al., 2015) and situational variables associated with diet (Leech et al., 2014).

There are two kinds of factor analysis, exploratory and confirmatory. Exploratory factor analysis is used to identify underlying, or latent, variables based on reducing a larger set of related variables, preferably based on a theoretical construct. The concept is to identify the underlying structure in a set of variables. Confirmatory factor analysis is derived from a priori assumptions usually driven by a theory (Downey & Chang, 2013). The concept is to confirm or refine aspects of a model (Gerbing & Hamilton, 1996; Reio & Shuck, 2015). The two are commonly used together in the design and validation of scales using questionnaires (Camilleri et al., 2015; Reid, Courtney, Anderson, & Hurst, 2015; Sautron et al., 2015) as well as identifying underlying latent concepts related to theories and/or hypotheses (Downey & Chang, 2013; Grilo et al., 2010; Sotres-Alvarez, Herring, & Siega-Riz, 2010).

PCA is a data reduction technique used to group large amounts of data into more manageable components for analysis when identification of latent variables is not the aim or is not appropriate. “PCA analyzes a data table representing observations described by several dependent variables, which are, in general, inter-correlated. Its goal is to extract the important information from the data table and to express this information as a set of new orthogonal variables called principal components” (Abdi & Williams, 2010, p 433). Principal component analysis is sometimes used with exploratory factor analysis or reduced-rank regression and usually has very similar results (Barbaresko et al., 2014).

PCA has a long history of use with dietary patterns including identification by country (Fernandez-Alvira et al., 2014); in infants (Wen, Kong, Eiden, Sharma, & Xie, 2014); in children (Moschonis et al., 2014); in adolescents (Northstone, Smith, Cribb, & Emmett, 2014); in older people (Markussen et al., 2015); by biological indicators (Marklund et al., 2014); and nutrition (Wood et al., 2014).

Another similar statistical technique is cluster analysis which groups people with similar patterns rather than variables. Outcomes from factor analysis, PCA and cluster analysis have been compared (Fransen et al., 2014; Hearty & Gibney, 2013) but the data used for each are not comparable and neither are the aims of the analysis. Factor or principal component analysis uses statistical procedures to group together variables that indicate or may indicate a latent variable (for instance, a healthy diet) whereas cluster analysis groups cases to identify groups with similar characteristics. Both are valuable but for the purpose of diet patterns, factor analysis and PCA are likely to provide more explanation about dietary behaviours than cluster analysis.

This evidence led to the decision to use either factor analysis or principal component analysis for data reduction purposes in the analyses described in Chapter four (objective one) and Chapter 6 (objective three).

3.3.3 Mediation analysis and propensity scoring

> “...mediation analysis ... is a statistical procedure to test whether the effect of an independent variable ...on a dependent variable ... (it) is at least partly explained by a chain of effects of the independent variable on an intervening mediator variable ...and of the intervening variable on the dependent variable...”(Fiedler, Schott, & Meiser, 2011, p 1231).

The process of mediation "… occurs as part of a hypothesized causal chain of events…"(Coffman, 2011, p 1). It is the explanation for how a chain of events works such as those explaining how behaviour is modified by intention and intention by attitudes which is the basis for the Theory of Reasoned Action (Fishbein & Ajzen, 1975). It can also be used to assess how one variable affects the relationship between two other variables (MacKinnon, Fairchild, & Fritz, 2007), for example how stress might affect the relationship between gender and food choices. To investigate the presence of mediators and/or their effects requires the use of statistical procedures designed for this purpose with any corrections necessary depending on the type of data used (Mackinnon & Cox, 2012). Such studies most often use data collected by randomized controlled trials or use longitudinal data. A typical use of mediation analysis would be the study examining the contribution of genetic and environment to zygotic twin's eating behaviours (van den Bree, Eaves, & Dwyer, 1999). However data from observational data can be used (Caudroit, Boiche, & Stephan, 2014) including cross sectional survey data using variables such as cost of food and socio economic information (Beydoun & Wang, 2007) or paths to nutritional risk (Keller, 2006).

Propensity scoring is a statistical method which estimates how likely a specific treatment is to have caused an outcome and not some random event or other treatment. The technique was developed to address non randomized trials and observational data where unknown influences might be responsible for observed outcomes (D'Agostino, 2007; Rosenbaum & Rubin, 1983). This technique is also used in mediation analysis to assess the probability that the variables in a model are in a probable causal relationship to the outcome represented by the dependent variable rather than some other outcome (Jo, Stuart, Mackinnon, & Vinokur, 2011).

There is an assumption that what is entered into the model has a potentially logical connection, either theoretically or on the basis of a selected level of statistical significance, to the outcome and that what has been collected and selected for entry into a model is what is important to the outcome. Given these assumptions, a variable may be excluded from a model because it is not theoretically or logically connected, not statistically significant at $p<.05$ within the model or simply not part of the data collection. In all cases the outcome estimate of the model will be sensitive to that “missing” variable(s). In a randomised controlled study unobserved confounders do not bias outcomes because they are assumed to be equally randomly distributed between the treatment and non treatment groups. More recently research has shown that with the use of methods such as propensity scoring it is possible to assess probable causality for cross sectional data using statistical methods previously used in other data collection methods because the sensitivity to “missing” (unobserved) variables is being assessed statistically (Stuart, 2010). Using simulation studies to estimate the effects of unobserved variables in cross sectional data, research showed that propensity scores based on observed variables also control for bias in unobserved variables (Little & Rubin, 2000; Rosenbaum & Rubin, 1983). It has been used in cross sectional research showing that information seeking about actions that might prevent cancer was significantly associated with increased likelihood of behaving in a consistent manner such as eating fruit and vegetables (Lewis et al., 2012) and healthy lifestyle behaviours (Ramirez et al., 2013).

Propensity scoring was used in the path to having running out of food in order to identify the direction of effects (Chapter 8, Section 8.3.).

3.3.4 Time series and Granger causality tests

Time series is a type of regression carried out on a variable or variables which are collected in a strict temporal sequence, such as daily, weekly or monthly. The aim of the analysis is to both see what has happened in the past and also to predict what might happen in the future. There are two basic approaches, one which examines the data using regression techniques to come up with a structural model and then tests that (Ostrom, 1978); the other is a data driven approach which uses a statistical technique to find a model that best fits the data (Granger & Newbold, 1986). As part of a time series investigation, Granger Causality is a statistical test which is used to determine whether or not there is a causal relationship between the variable under examination and the outcome (Cox, 2013). According to Granger, causal attribution in a time series is based on a set of premises. They are that "…the cause preceded the effect and a causal series had information about the effect that was not contained in any other series according to the conditional distributions… the same causality is found under a variety of situations…"(Granger, 2003, pp 69 and 70). Searches using the term Granger Causality with health promotion found four citations; with public health found eight citations, with risk factors found four citations; and with health plus time series found nine citations. Only four citations used time series regression and were applicable to health risk factors and how these changed with economic or socio demographic factors over time. These were a study of alcohol consumption and socio demographic factors (Brinkley, 1999); a study on college students, fatality and drug use (Hingson & White, 2010); an international study looking at direction of causality between a number of health indicators and socioeconomics (Akhmat, Zaman, Shukui, Javed, & Khan, 2014) and a study which found evidence for a temporal causal relationship between heart disease and self reported dietary measures, particularly fats (Lynch, Glass, & Tran, 1988).

Having data collected consistently over twelve years (HWSS 2002 to 2103) allowed the use of Granger Causality tests to be conducted and temporal associations between health promotion campaigns and costing factors to be explored (Chapter five, section 5.5.4)

3.4 ANALYSIS PROCEDURES

Each objective for this research uses a different set of analytical procedures which are described in the methods section addressing that objective. There are some analysis methods common to all five investigations and all statistical analysis was conducted using STATA 13.1 (StataCorp, 2013). These are briefly described below.

3.4.1 Extraction of means, prevalence estimates and confidence intervals

Except where otherwise described, the method of weighting for the extraction of means and prevalence estimates was Iterative Proportional Fitting (described in Section 3.3.1 above) using age, gender and area of residence for the marginal population totals.

The Stata 13.1 Survey module (StataCorp, 2007) is used and confidence intervals are produced using robust estimates as calculated within that module. Statistical significance for mean estimates was calculated using one way analysis of variance.

3.4.2 Regression analyses

Unless otherwise stated, the regression analyses were also conducted with the IPF weighting described above. In some analyses confirmatory regression analyses were conducted outside the survey module although the IPF weight was generally included.

3.4.3 Factor analyses

All factor analysis was conducted with dichotomous variables using tetrachoric factor analysis, usually with varimax rotation unless otherwise stated (Wirth & Edwards, 2007). Factors with eigenvalues of one or more were the basis of the factor assignment.

3.4.4 Time series analysis for data collected over time

Time series analysis was conducted on the HWSS data with tests for autocorrelation (Becketti, 2013), effects of interventions and causality (Granger, 1988). Where the series was not linear Holt Winters smoothing was used to predict future trends (Becketti, 2013).

3.4.5 Structural equation modelling

Structural equation modelling was used within the survey module, with the sampling weight outside the survey model and without any weight. On the unweighted model, post estimation tests were used to assess the goodness of fit using the comparative fit index (CFI) with a value of 0.9 as the standard and Root Mean Square Error of Approximation of $p<0.05$ (Acock, 2013; Alavifar, Karimimalayer, & Anuar, 2012; Tabachnick & Fidell, 2001).

3.4.6 Path analysis

Path analysis was conducted using logistic regression and Bayesian Information Criteria to assess the direction of effect (Acock, 2013) and propensity scoring to test for strength and effect of the selected variables within the path (Coffman, 2011).

4 IDENTIFY BARRIERS AND ENABLERS TO DIETARY CHANGE: ADDRESSING OBJECTIVE ONE

The first objective is to evaluate self-reported behaviours consistent with Australian adult dietary recommendations as measured in the Nutrition Monitoring Survey Series 1995-2012 by comparing traditional methods with new and as yet unapplied robust methods. This investigation involves the reduction of large amounts of data to more manageable information to identify population attitudes in relation to breastfeeding. The method and development of these indicators was accepted for publication in February 2014. A copy of the paper follows.

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4.1 COPY OF PAPER IDENTIFYING POPULATION ATTITUDES TO BREASTFEEDING

Abstract

Objective: The objective of this research was to investigate knowledge and community perceptions of breastfeeding in Western Australia using a factor analysis approach.

Methods: Data were pooled from five Nutrition Monitoring Survey Series which included information on breastfeeding from 4,802 Western Australian adults aged 18–64 years. Tetrachoric factor analysis was conducted for data reduction and significant associations identified using logistic, ordinal and poisson regression analyses.

Results: Four factors were derived for benefits (it’s natural, good nutrition, good for the baby, and convenience), barriers (breastfeeding problems, poor community acceptability, having to go back to work, and inconvenience) and for enablers (breastfeeding education, community support, family support and not having to work). As assessed by standardized odds ratios the most important covariates across benefit factors were: importance of

breastfeeding (ORs range from 1.22–1.44), female gender (ORs range from 0.80 to 1.46), being able to give a time for how long a baby should be breastfed (ORs range from 0.96 to 1.27) and education (less than high school to university completion) (ORs range from 0.95 to 1.23); the most important covariate across barrier factors was being able to give a time for how long a baby should be breastfed (ORs range from 0.89 to 1.93); and the most important covariates across all enabling factors were education (ORs range from 1.14 to 1.32) and being able to give a time for how long a baby should be breastfed (ORs range from 1.17 to 1.42).

Conclusions: Being female, rating breastfeeding as important, believing that babies should be breastfed for a period of time and education accounted for most of the statistically significant associations. The differences between male and female perceptions require investigation particularly in relation to returning to work.

4.2 Introduction

The promotion of breastfeeding is an international public health priority and the recommendation to exclusively breastfeed until around six months of age has been adopted by many countries around the world including Australia [1,2]. The recommendation regarding the length of time to continue breastfeeding after the introduction of solid foods varies, for example, until twelve months of age and beyond in Australia [1] and the United States [3], and to continue breastfeeding to the age of two years or beyond which is the World Health Organization (WHO) recommendation that has been adopted by many developing countries as well as countries like Canada [2]. The strength of evidence to support the promotion of breastfeeding is growing and compelling, particularly as breastfeeding benefits both the baby and the mother. Apart from breast milk being the ideal food for optimal infant growth and development [4], there are additional long-term benefits for the infant. There is convincing evidence of a lower risk of becoming obese [5] or developing high cholesterol or high blood pressure [6] later in life. Breastfeeding is also associated with lower rates of mortality and morbidity from gastrointestinal infections for the baby [7,8] and reduced risk of coeliac disease [9] and asthma [10,11]. There is some evidence that breastfed babies have improved cognitive development [12,13], and increased bonding with the mother [14]. Benefits for the mother include a reduced risk of ovarian cancer, quicker recovery after birth, and a possible reduced risk of breast cancer and type II diabetes [1]. There is also evidence that breastfeeding is associated with a lower risk of Sudden Infant Death syndrome [10]. Evidence to date shows no counter-indications for exclusive breastfeeding for around six months for healthy full-term babies [15,16]. Population based surveys are able to provide specific information about areas of interest within a community. They can identify population groups considered to be at health risk due to their behaviours [17]. Although questions on breastfeeding have been included in population surveys before, respondents are generally females of child bearing age or with small babies. The topic seems to be considered less relevant to the general population [18,19]. Surveys rarely ask the public about the perceived benefits of breastfeeding or circumstances that make it easier or more difficult to breastfeed. If the general public do not know the benefits of breastfeeding, messages about the importance of breastfeeding are likely to be less compelling and effective in facilitating exclusive breastfeeding for the recommended six months. Without knowledge of the potential benefits and barriers, complying with the breastfeeding guidelines may be difficult for mothers. The Health Department of Western Australia conducts triennial population surveys of males and females aged 18 to 64 years to guide the development of interventions to increase behaviours consistent with the Australian Dietary Guidelines (Nutrition Monitoring Survey Series-NMSS). These unique surveys explore knowledge about breastfeeding recommendations, barriers and enablers of breastfeeding from females currently breastfeeding, potential mothers, their partners and the population past the childbearing age. The objective of this study was to investigate the perceptions of breastfeeding in the general community of Western Australia (WA) using a factor analysis approach. We were particularly interested in assessing perceptions of factors which may encourage or deter females from breastfeeding.

4.2.1 Ethics Statement

The NMSS were granted approval from the Western Australia Department of Health Human Research Ethics Committee (HREC) who act in accordance with the National Health and Medical Research Council (NHMRC) Ethics Committee guidelines. As part of that NHMRC ethics procedure, consent issues are addressed and specifically, our procedure for receiving verbal consent from participants was approved.

4.3 METHODS

4.3.1 Study Population

Five cross sectional computer assisted telephone surveys were conducted with over 1200 WA adults aged between 18 and 64 years during July and August in the years 1995, 1998, 2001, 2004 and 2009. A total of 5496 people were surveyed in this pooled Nutrition Monitoring Survey Series (NMSS) of which 4208 provided information on all of the variables used in the inferential analysis. All of the variables had missing values less than 1% except income (8%) and the rating of importance of breastfeeding (3%). Using computer generated random digit dialling with known area prefixes, the 1995, 1998 and 2001 samples were stratified by area and the 1998 and 2001 samples were also quota sampled by sex. Using the most recently available Electronic White Pages, the

2004 and 2009 samples were randomly selected by area and the 2004 survey quota sampled by area and sex. In 2004 and 2009 all sample households with an address were sent an approach letter explaining the purpose of the survey, how the sample was selected and how long the interview would take. In 2004 eligible respondents within a household were selected by the most recent birthday and no substitutes were accepted unless the quota had been achieved for that group. In 2009 eligible respondents within a household were selected by the most recent birthday and no substitutes were accepted. There were no partially completed interviews. The response rate ranged from 29.5% (1998) to 87.8% (2009) with an average of 50.4%.

4.3.2 Measures

The NMSS monitors population attitudes, beliefs and selected self-reported behaviours. In relation to this research the questionnaire contains questions about breastfeeding including a rating of the importance of breastfeeding and an opinion of how long a baby should be breastfed. Three multiple-response questions were asked about benefits, barriers and enablers of breastfeeding:

1) What do you think are the benefits of breastfeeding for babies?

2) What do you think makes it difficult for females to continue to breastfeed their babies for at least six months? (barriers)

3) What do you think would make it easier for females to continue to breastfeed their babies for at least six months? (enablers)

The data collection evolved over time. The initial survey questionnaire in 1995 contained open-ended questions which asked each respondent to identify as many benefits, barriers and enablers in relation to breastfeeding as they could. Interviewers were instructed to probe for as many responses as possible. The multiple responses were grouped into categories assigned by the researchers and dietitians based on focus group research conducted in Perth, Western Australia which identified perceptions of barriers and promoters at the time [20,21]. For each question a number of categories were identified. Since 1995, the same question format has been used with interviewers pre-coding responses into these identified categories. Interviewers were instructed to record verbatim any responses that didn't fit into the categories. These 'other' responses were then recoded into the existing categories where possible by an expert panel. There was an average of 3.9% on each occasion that were unable to be recoded and remained as an 'other' category. The 'other' category is not included in the analysis. For the purpose of this study, we interpret 'knowledge of breastfeeding' as knowing something about the benefits, barriers and enablers as well as rating breastfeeding as important and having an opinion that babies should be breastfed for a specific time.

4.3.3 Analysis

Due to the complex sampling designs the data were weighted using adjustments for differing sampling fractions for areas of residence (all years) and for probability of selection of the household from the number of listings in the electronic White Pages and the number of adults (ages 18–64) within the household (2009 only). Post-estimation adjustment was used to correct for under or over representation of gender, age and areas of residence using the 2011 Estimated Resident Population for WA aged 18–64 years (the year of the most recent census at the time of analysis) [22]. The plan for the analyses specified a four stage approach as follows: First we examined individual knowledge, barriers and enablers by gender; secondly, to reduce the data, tetrachoric factor analysis was conducted to identify groupings within knowledge, barriers and enablers; thirdly ordinal regression was used to examine each of the factors for statistically significant sociodemographic associations; finally the total number of responses to knowledge, barriers and enablers were examined to see if the number mentioned was statistically significantly associated with any of the sociodemographic indicators and to see whether the number of each increased or decreased over time. Descriptive statistics used estimates of prevalence with 95% confidence intervals. Logistic, poisson and ordinal regression analyses were conducted using the methods which correct for sample design and post survey weighting. Pearson chi squared tests were used to estimate p values and to determine statistical significance in the univariate tables. Logistic regression was used to investigate single benefits, barriers or enablers where there were statistically significant differences between males and females. As the benefits, difficulties and enablers were all multiple response variables and recorded as 0 = No, 1 =Yes, a tetrachoric factor analysis using varimax rotation was conducted to reduce the data and identify any underlying factors [23]. Ordinal logistic regression analyses were conducted on the factors extracted because the factor scores were based on the sum of the questions within each factor making an ordinal assumption for the scale more conservative than an assumption of an interval scale [24]. Each of the factors was entered into ordinal logistic regression analysis to identify the variables associated with each factor score. The sociodemographic variables entered into the model were gender (male compared with female), age in groups (18–24, and 25–64 in five year groups), highest level of education attained (four groups from less than year 10 schooling to a completed university degree), household income (earning less than Aus$60,000 per annum compared with earning Aus$60,000 or more), employment status (in paid employment compared with not currently in paid employment), country of birth (Australia compared with all other countries of birth) and area of residence (metropolitan Perth compared with outside that area). Two other variables were also included, rating of the importance of breastfeeding (1= not at all important to 5= very important) and not knowing how long a baby should be breastfed compared with being able to give a specific time for how long a baby should be breastfed. Dichotomous variables are coded with first category = 0 and the second category =1. The validity of the proportional odds assumption for ordinal logistic regression was tested using the adjusted Wald statistic and the assumption of linearity was tested for education using fractional polynomial transformations. Standardized odds ratios are reported to enable the relative importance of the independent variables to be assessed. To avoid inflating the overall critical p value, multiple comparisons were corrected using the method of Holm [25]. In the results section only those p values which were significant after correction are reported. Heckman selection models were used to examine the sensitivity of the results to missing values [26]. After testing for the validity of the assumption of a Poisson distribution, poisson regression analysis was conducted to identify predictors of the total number of benefits, barriers and enablers. A p value less than 0.05 was regarded as statistically significant. All analysis was conducted using the Stata statistical package (Version 12, StataCorp LP, College Station, Tx).

4.4 RESULTS

Table 4.1 describes the NMSS survey sample characteristics across the pooled dataset from 1995 to 2009. Although there were changes in the proportion of people choosing each benefit, barrier and enabler in different years there were no consistent linear trends over time for either males or females (Figure 4.1).

Table 4.1 Sample Characteristics by Socio-Demographic Groups, NMSS 1995-2009

	Sample	%
Gender	**5496**	
Male	2430	44.2
Female	3066	55.8
Age group	**5496**	
18-24 years	521	9.5
25-34 years	1124	20.5
35-44 years	1565	28.5
45-54 years	1306	23.8
55-64 years	980	17.8
Highest level of education	**5472**	
Less than Year 12	1546	28.3
Year 12 or equivalent	1188	21.7
Trade/Certificate/Diploma	940	17.2
University	1798	32.9
Household income	**5054**	
Up to $60,000	2861	56.6
Over $60,000	2193	43.4
Employment status	**5491**	
Employed	3973	72.4
Unemployed	1518	27.6
Country of birth	**5495**	
Born in Australia	3724	67.8
Born elsewhere	1771	32.2

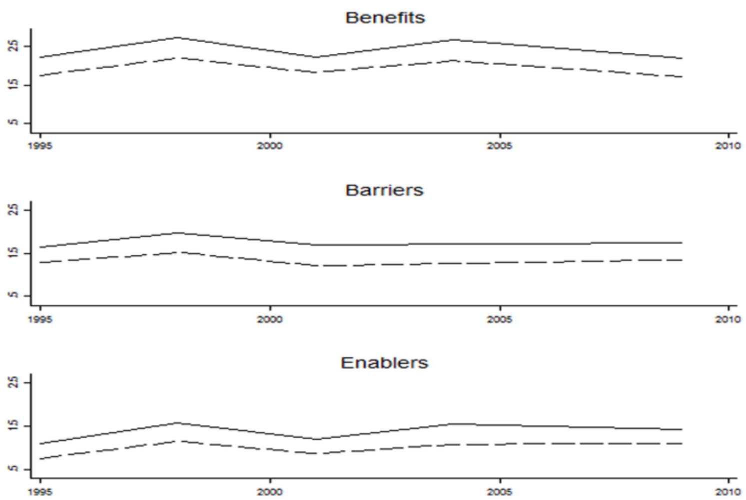

Figure 4.1 Mean number of benefits, barriers and enablers by gender and year, NMSS 1995–2009. Y axis: Mean number. X axis: Year of survey. Legend: Solid line = Females; Dashed line = Males.

Nevertheless the year of survey (1995, 1998, 2001, 2004 and 2009) was included in the inferential analyses as an interval variable to adjust for any small variation over time in the pooled dataset. Table 4.2 shows the proportion of men and women choosing each benefit, barrier and enabler with the confidence interval around each estimate

Table 4.2 Benefits, barriers and enablers of breastfeeding by gender, NMSS 1995-2009[a]

Benefits for baby of breastfeeding	Male (%)CI	Female (%)CI
Provides Immunity	**37.8 (35.7-40.0)**	**60.8 (58.7-62.9)**
Provides vitamins and minerals	39.9 (37.7- 42.2)	41.0 (38.9-43.2)
Ideal Food	23.2 (21.3-25.2)	25.3 (23.5-27.3)
Good for baby's health	29.6 (27.5-31.7)	34.8 (32.7-36.9)
Natural/No chemicals	22.3 (20.5-24.3)	17.5 (15.8-19.3)
Easy/Convenient	5.9 (5.0-7.1)	14.8 (13.2-16.4)
Encourages emotional bonding	34.5 (32.3-36.7)	45.0 (42.8-47.2)
Other	2.3 (1.7-3.1)	5.0 (4.1-6.0)
Barriers to breastfeeding	**Male (%)CI**	**Female (%)CI**
Need to work	27.2 (24.9-29.6)	48.8 (46.4-51.2)
Problems with milk supply	18.0 (16.1-20.2)	25.7 (23.6-27.8)
Soreness	26.8 (24.5-29.2)	30.8 (28.6-33.2)
Inconvenient	11.1 (9.2-12.3)	10.6 (9.2-12.3)
Not publicly acceptable	23.8 (21.6-26.2)	22.0 (20.1-24.1)
Not enough time	16.0 (14.2-18.1)	21.9 (20.0-24.0)
Don't like doing it or seeing it	1.5 (.92-2.3)	2.0 (1.4-2.8)
Other	8.2 (6.8-9.8)	13.2 (11.6-15.0)
Enablers of breastfeeding		
Not having to work	18.5 (16.8-20.3)	28.1 (26.2-30.1)
Having more time	9.8 (8.5-11.2)	14.8 (13.3-16.5)
Having more facilities	9.5 (8.2-10.9)	13.7 (12.2-15.3)
Having more education	11.9 (10.5-13.4)	18.4 (16.7-20.2)
Being better informed about the process	7.4 (6.3-8.7)	9.8 (8.6-11.2)
Having support of partner and family	7.1 (6.0-8.3)	12.8 (11.4-14.4)
Being acceptable to community	28.0 (26.0-30.2)	33.3 (31.2-35.4)
Other	3.6 (2.8-4.5)	5.2 (4.3-6.3)

[a] Multiple responses allowed.

4.4.1 Benefits of Breastfeeding for the Baby

One third of respondents (33.1% [95% CI 31.6%–34.6%]) knew at least two benefits of breastfeeding while 6.5% [95% CI 5.7%–7.3%] did not know any benefits. A logistic regression analysis found that males (OR 3.7 $p<0.0001$), people aged between 18 and 34 years (OR 1.96 $p<0.0001$), people having only school education (OR 1.88 $p<0.0001$) and those surveyed in 2001 (OR 1.64 $p<0.05$) or 2009 (OR 2.5 $p<0.0001$) were more likely to have no knowledge of the benefits of breastfeeding. About the same proportion of males and females said breastfeeding provides vitamins and minerals, or is the ideal food for babies. A significantly higher proportion of women than males reported that breastfeeding provides immunity, is easy or convenient, and encourages emotional bonding. Males were more likely than females to report that breastfeeding was natural or had no chemicals.

4.4.2 Barriers

Significantly more females said that the need to work was a breastfeeding difficulty (48.8%) compared to 27.2% of males. Females were also significantly more likely than males to report breastfeeding problems such as problems with milk supply and lack of time, as barriers to breastfeeding. About the same proportion of males and females reported inconvenience, poor public acceptability, and not having enough time as barriers to breastfeeding.

4.4.3 Enablers of Breastfeeding

Similar patterns were seen with breastfeeding enablers although having breastfeeding more accepted in the community was most often reported by both females and males (33.3% and 28% respectively) as an enabler to breastfeeding, followed by help with breastfeeding problems such as soreness and supply, work and support issues. A logistic regression analysis showed that being female (OR 1.3 $p<0.001$), having a university education (OR 1.6 $p<0.001$), being born outside Australia (OR 1.3 $p<0.001$) and being surveyed after 1995 (OR 1.04 $p<0.001$) were all associated with believing that greater community acceptance would make breastfeeding easier.

4.4.4 Underlying Factors Influencing Breastfeeding

The tetrachoric correlation based factor analyses identified four factors each for benefits, barriers and enablers to breastfeeding. Table 4.3 shows the four factors associated with them and the Eigen value and the explained variance for each.

4.4.5 Variables Associated with the Benefit Factors of Breastfeeding

Benefit factor one relates to the naturalness of breastfeeding and the fact that breast milk is free from chemicals. There is a significant association between the factor score and decreasing year of survey from 2009 (OR=0.853 p=0.013), being male (Reciprocal OR=1.25 p=0.013), having an income greater than $60,000 (OR=1.18 p=0.007) and increasing rating of the importance of breastfeeding (OR=1.29 p=0.001). Benefit factor two relates to breast milk providing nutrients for the baby and emotional bonding with the mother. There is a significant association between the factor two score and decreasing year of survey from 2009 (OR=0.857 p=0.002), being female (OR=1.09 p=0.042), increasing education level (OR=1.22 p<0.001), increasing rating of the importance of breastfeeding (OR=1.35 p<0.001) and being able to give a specific time for how long a baby should be breastfed (OR=1.19 p<0.001). Benefit factor three relates to the health effects of breastfeeding for the baby and that breast milk is an ideal food. There is a significant association between the factor score and being female (OR=1.46 p<0.001), increasing age in five year increments (OR=1.17 p=0.001), increasing education level (OR =1.23 p<0.001), increasing rating of the importance of breastfeeding (OR=1.44 p<0.001) and being able to give a specific time for how long a baby should be breastfed (OR=1.27 p<0.001). Factor four relates to the ease and convenience of breastfeeding. There is a significant association between the factor four score with being female (OR=1.18 p<0.001), increasing level of education (OR=1.11 p=0.024), increasing rating of the importance of breastfeeding (OR=1.22 p<0.001) and being able to give a specific time for how long a baby should be breastfed (OR=1.20 p=0.001).

Table 4.3 Factors[a] which underlie the benefits, barriers and enablers of breastfeeding, NMSS [b] 1995-2009

Benefits for baby of breastfeeding	**Factor One**	**Factor Two**	**Factor three**	**Factor four**
Factor Name	Natural	Nutrients & bonding	Good for baby	Convenient
Category(ies)	Natural	Vitamins/minerals & bonding	Good for baby's health & ideal food	Easy & convenient
Eigen value	1.30	1.70	1.10	0.94
Variance Explained (total 0.934)	0.38	0.27	0.19	0.1
Barriers to breastfeeding	**Factor One**	**Factor Two**	**Factor three**	**Factor four**
Factor Name	Breastfeeding problems	Unacceptable	Work	Inconvenience
Category(ies)	Supply problems and breast soreness	Dislike breastfeeding & unacceptable	Have to work	No time and breastfeeding inconvenient
Eigen value	1.50	1.30	1.10	0.97
Variance Explained (total 0.960)	0.42	0.28	0.19	0.07
Enablers of breastfeeding	**Factor One**	**Factor Two**	**Factor three**	**Factor four**
Factor Name	Education	Community support	Family support	Not having to work
Category(ies)	More education about breastfeeding generally	More facilities & public acceptance	Having more time & family support	Not having to work
Eigen value	1.70	1.44	1.16	0.82
Variance Explained (total 0.943)	0.39	0.29	0.19	0.07

As assessed by standardized odds ratios the most important covariates, across all benefit factors were: the importance of breastfeeding (ORs range from 1.22–1.44), female gender (ORs range from 0.80 to 1.46), being able to give a specific time for how long a baby should be breastfed (ORs range from 0.96 to 1.27), and increasing education level (less than high school to university completion) (ORs range from 0.95 to 1.23). Employment status, country of birth and area of residence were not associated with any breastfeeding benefit factors.

4.4.6 Variables Associated with the Barrier Factors for Breastfeeding

Barrier factor one relates to milk supply and breast soreness. There is a significant association between the factor one score and being able to give a specific time for how long a baby should be breastfed (OR=1.13 $p<0.001$). Barrier factor two relates to breastfeeding being distasteful and unaccepted by society. There is no significant association between the factor two score and any of the independent variables after correction for multiple comparisons. Barrier factor three relates to needing to work. There is a significant association between the factor three score and being female (OR=1.60 $p<0.001$), increasing age (OR=1.26 $p=0.002$), increasing education (OR=1.36 $p<0.001$), and being able to give a specific time for how long a baby should be breastfed (OR=1.16 $p=.021$). Barrier factor four relates to the inconvenience of breastfeeding. There is a significant association between this factor and being able to give a specific time for how long a baby should be breastfed (OR=1.93 $p=0.002$). As assessed by standardized odds ratios the most important covariate across all barrier factors was being able to give a specific time for how long a baby should be breastfed (ORs range from 0.89 to 1.93). There were no associations with year, employment status, household income, country of birth, area of residence and importance of breastfeeding.

4.4.7 Variables associated with the enabling factors for breastfeeding

Enabling factor one relates to the necessity of breastfeeding information and education. There is a significant association between this factor and increasing education level (OR=1.17 $p=0.003$), increasing rating of breastfeeding importance (OR=1.28 $p<0.001$) and being able to give a specific time for how long a baby should be breastfed (OR=1.26 $p<0.001$). Enabling factor two relates to community facilities and community acceptance of breastfeeding. There is a significant association between this factor and increasing levels of education (OR=1.21 $p<0.001$), increasing rating of breastfeeding importance (OR=1.24 $p<0.001$) and being able to give a specific time for how long a baby should be breastfed (OR=1.18 $p<0.001$). Enabling factor three relates to family support and having time to breastfeed. There is a significant association with this factor and being female (OR=1.25 $p<0.001$), increasing level of education (OR=1.14 $p=0.009$), and being able to give a time for how long a baby should be breastfed (OR=1.42 $p<0.001$). Enabling factor four relates to not having to work. There is a significant association with factor four and increasing year of survey (OR=1.19 p=0.003), being female (OR=1.29 $p<0.001$), increasing age (OR=1.27 $p<0.001$), increasing level of education (OR=1.32 $p<0.001$), and being able to give a specific time for how long a baby should be breastfed (OR=1.17 $p=0.003$). As assessed by standardized odds ratios the most important covariates across all enabling factors were: education (ORs range from 1.14 to 1.32) and being able to give a specific time for how long a baby should be breastfed (ORs range from 1.17 to 1.42). There were no associations with employment status, household income, country of birth and area of residence.

4.4.8 Changes over time

The ordinal regression models showed that survey year was associated with two of the reported benefit factors: factor one relating to the naturalness of breastfeeding and that breast milk is free from chemicals and factor two relating to the provision of nutrients for the baby and emotional bonding with the mother. In both cases there was a decreasing association of these factors with the year of survey. One enabling factor, factor four relating to not having to work, is also related to the year of the survey with an increasing association over time. No other associations between other factors and year of the survey were found.

4.5 VARIABLES ASSOCIATED WITH THE TOTAL NUMBER OF BENEFITS, BARRIERS AND ENABLERS

In a multivariate poisson regression analysis of the total numbers of benefits, barriers and enablers the total number of benefits of breastfeeding reported increased with being female, having a university education, and rating breastfeeding as very important (Table 4.4).

Table 4.4 Number of breastfeeding benefits, barriers and enablers mentioned[a], NMSS

Total number of benefits mentioned	**Coef**	**95% Confidence Interval**		***p* value**
Year of survey	0.01	-0.02	0.05	0.475
Age in five year groups	0.01	0.00	0.02	0.243
Female versus (vs.) male	0.14	0.11	0.18	0.004
University Education vs. less education	0.13	0.09	0.16	0.017
Income $60,000 or more v. income less than $60,000	0.04	-0.01	0.08	0.272
Born in Australia vs. born overseas	0.03	0.00	0.07	0.146
Living outside metropolitan area vs. metropolitan	-0.03	-0.07	0.01	0.530
Breastfeeding a baby very important vs. less than very important	0.28	0.23	0.34	0.000
Baby should be breastfed for specific time vs. not giving a time	0.29	-0.20	0.36	0.127
Constant	0.12	0.03	0.27	0.037
Total number of barriers mentioned				
Year of survey	0.09	0.01	0.18	0.038
Age in five year groups	0.00	-0.02	0.02	0.742
Female vs. male	0.19	0.11	0.28	0.000
University Education vs. less education	0.19	0.10	0.27	0.000
Income $60,000 or more v. income less than $60,000	0.01	-0.08	0.10	0.866
Born in Australia vs. born overseas	0.04	-0.04	0.13	0.346
Living in the metropolitan area vs outside	-0.12	-0.22	-0.03	0.011
Breastfeeding a baby very important vs. less than very important	0.08	-0.03	0.19	0.146
baby should be breastfed for specific time vs. not giving a time	0.41	0.23	0.60	0.000
Constant	-0.24	-0.56	0.09	0.159
Total number of enablers mentioned				
Year of survey	-0.02	-0.09	0.05	0.555
Age in five year groups	0.01	-0.01	0.03	0.229
Female vs. male	0.27	0.21	0.34	0.000
University Education vs. less education	0.25	0.19	0.32	0.000
Income $60,000 or more v. income less than $60,000	0.04	-0.03	0.11	0.236
Born in Australia vs. born overseas	0.10	0.03	0.17	0.004
Living in the metropolitan area vs outside	-0.11	-0.18	-0.04	0.002
Breastfeeding a baby very important vs. less than very important	0.28	0.18	0.38	0.000
baby should be breastfed for specific time vs. not giving a time	0.46	0.31	0.61	0.000
Constant	-0.78	-1.04	-0.52	0.000

[a] Multivariate poisson regression analysis, [b] Western Australian adults 18 to 64 years

The total number of barriers to breastfeeding increased with the year of the survey, being female, having a university education, living in the metropolitan area and thinking that a baby should be breastfed at least for some time. The total number of enablers to breastfeeding increased with being female, having a university education, being Australian born, living in the metropolitan area, rating breastfeeding as very important and thinking that a baby should be breastfed at least for some time. Aside from gender and education, two of the most important variables related to the total number of benefits, barriers and enablers that a respondent mentions are the rating of the importance of breastfeeding and the time given that a baby should be breastfed for (duration).

The mean number of benefits mentioned by respondents who rated breastfeeding as very important is 2.39 (CI: 2.35–2.42) compared with those who rated it as less than very important 1.69 (CI: 1.62–1.77). The mean number of benefits and enablers increased with increasing time for how long a baby should be breastfed. There was no significant association between time for how a long baby should be breastfed and the mean number of barriers identified (Figure 4.2). All regression models were checked for goodness of fit and were satisfactory with *p* values <0.05. The Heckman selection models showed that the results were not sensitive to missing values with none of the Mill’s ratio *p* values <0.05.

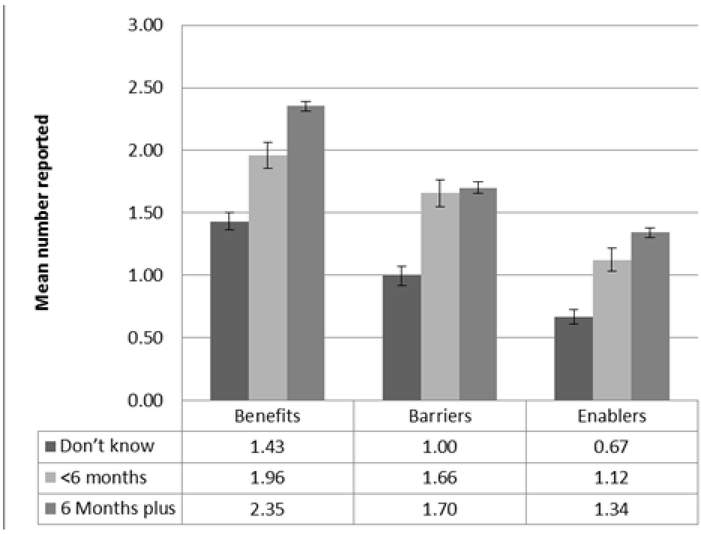

Figure 4.2 Mean number of benefits, barriers and enablers by how long a baby should be breastfed, NMSS 1995–2009

4.6 DISCUSSION

The objective of this study was to investigate the perceptions of breastfeeding in the general community of WA using a factor analysis approach in order to assess the relationships between these perceptions and knowledge about breastfeeding. We defined knowledge of breastfeeding as knowing something about the benefits, barriers and enablers as well as rating breastfeeding as important and having an opinion that babies should be breastfed for a specific time. Our results suggest that the knowledge of the benefits of breastfeeding among the general community was lower than would have been predicted from respondents' ratings of the importance of breastfeeding. The mean number of benefits reported was less than three (2.39). While believing that a baby should be breastfed for over six months increased the mean number of benefits mentioned, one in fifteen people were not able to mention any benefits of breastfeeding and a further twenty percent only mentioned one benefit. This was in spite of respondents being encouraged to think about as many breastfeeding benefits as possible which leads to the conclusion that the level of knowledge regarding breastfeeding among the WA population is not high. Females were able to report more benefits than males but less than half could name more than two benefits of breastfeeding. This underestimation of the benefits of breastfeeding has also been reported in Canada [27]. These findings support the need for ongoing community wide education regarding the benefits of breastfeeding to infants and mothers as well as support for comprehensive pre-natal education [28]. The same pattern is shown regarding barriers to breastfeeding. More barriers were reported by females but the mean number of barriers females identified was less than two. This result is somewhat surprising given that in WA, less than fifteen percent (14.8%) of mothers reported exclusively breastfeeding to six months in 2010 and less than half (43.7%) breastfed at all after six months [29]. While the perception of the community may be that there are relatively few barriers to breastfeeding, our results and the low compliance with the Infant Feeding Guideline recommendations to exclusively breastfeed until about six months suggest that they are a major determinant of breastfeeding practice. The main barrier to the continuation of breastfeeding for more than six months was the need to return to work. These findings support previous research showing that even in countries where there is support for maternity leave [30] and here in Australia where it was the second most commonly given reason for stopping breastfeeding [31]. While some Australian mothers report being able to breastfeed and work [29] our results suggest that there is a perception among the community that either mothers would not be supported to continue breastfeeding by their employing organization or would not be able to breastfeed is similar to that found in other studies [31,32]. The perceived barriers of poor social acceptability, lack of time and needing to return to work may be amenable to change however a comprehensive range of intersectoral interventions, including health system level to support health professionals who support mothers would be required [33–35]. For mothers themselves, our results suggest support from family and partners would be beneficial. This is consistent with previous research in Australia [36]. Government policies supporting family based parental leave, including paternity leave, may help to assist mothers of new born babies address the difficulty of breastfeeding when there were other young children in the family as well as encourage emotional connection with the infant. Australians have access to a 52 week job-protected family leave, and more recently a paid parental leave scheme which enables eligible working parents up to 18 weeks paid minimum wage parental leave or two weeks 'dad and partner pay' [37]. A comparison of fathers' patterns of statutory paternity leave taking across 24 countries between 2003 and 2007 found that taking leave was more likely with at least 50% of income replacement and of greater than fourteen days allowance [38]. The current study findings also support the need for policies to assist the acceptability and feasibility of breastfeeding at work including employer provision of facilities and breaks for females to breastfeed when feasible and practical [39]. Education campaigns regarding the benefits of breastfeeding may also assist as support for such policies is likely to be based on knowledge of the benefits of breastfeeding [2, 39]. Health workers are well placed to assist mothers and families to address the breastfeeding problems. The NHMRC Infant Feeding Guidelines for Health Workers acknowledges that they can provide invaluable factual information and empathetic support, demonstrate practical skills and discuss strategies for problem solving [1]. It is important that health workers are trained and encouraged to enable this to happen. While these results are specific to Western Australia, the findings are consistent with the breastfeeding literature and make them likely to be applicable to females in countries with a similar demographic structure. The data in this study are cross sectional and all results in this survey relate to associations rather than causality. Cross sectional surveys such as the NMSS are consistent with the World Health Assembly resolution to monitor non-communicable diseases and their determinants, and strengthen surveillance systems to provide the foundation for advocacy and policy development, as well as providing a tool to evaluate the effectiveness of interventions and progress made [40]. The main limitation of this study was that the data collection method changed over time and with it the response rates. The lower response rates for years prior to 2009 were mainly due to the Random Digit Dialling method which, particularly for the earlier years, was done without any matching to existing known operational numbers. The quota sampling in years prior to 2009 also contributed to difficulties in making the population groups comparable. Weighting as described in the methods section was used to adjust for these sampling differences. Mobile telephones were not included in the sample frames prior to 2009. Any bias from this source should be minimal as in 2004, the time of the previous survey, Australia still relied predominantly on land lines. The data is self-reported and therefore may be vulnerable to social desirability bias. Further research is needed in translating these results into policy and practice. The findings of this research identify knowledge gaps in the length of time a baby should be breastfed and the benefits of breastfeeding for the mother and baby. It is likely that including specific information about the benefits of breastfeeding for mother and babies in community wide education campaigns would be beneficial. Differences between male and female perceptions of breastfeeding benefits, barriers and enablers need to be investigated further so that ways that males can more effectively understand and support breastfeeding mothers are identified.

4.7 CONCLUSIONS

Being female, rating breastfeeding as important, having a belief that babies should be breastfed at least for some time and education accounted for most of the statistically significant associations in breastfeeding perceptions. Knowledge of the specific benefits of breastfeeding is relatively low. The barriers that people report are not related to any socio demographic variables so there is a high degree of uniformity about the perception of barriers to breastfeeding within the community. A number of enabling factors were identified and these should be taken into consideration when planning interventions to increase the knowledge regarding breastfeeding and the length of time that Australian females should be encouraged to breastfeed. The differences between male and female perceptions require investigation particularly in relation to returning to work.

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Author Contributions

Analyzed the data: AD MP. Contributed reagents/materials/analysis tools: AD MP. Involved in conceiving the Nutrition Monitoring Survey Series (NMSS): CMP AD. Involved in developing the NMSS survey instruments: CMP AD. Worked with the Department of Health in Western Australia to oversee the surveys being conducted: CMP. Wrote the first draft of the paper: AD CMP. Contributed to writing the manuscript: AD CMP MP CWB. Meet the ICMJE criteria for authorship: AD CMP MP CWB. Agree with manuscript results and conclusions: AD CMP MP CWB.

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4.8 ADDITIONAL INFORMATION ABOUT THE STUDY

The description of how the questions about beliefs, difficulties and enablers of breastfeeding were asked and recorded was necessarily brief in the paper. To address this, a fuller description is provided below.

In 2009, the NMSS questionnaire used the following three questions as worded below.

1. What do you think are the benefits of breast-feeding for babies? Try to think of all the possible benefits (Interviewer note: After first responses, PROBE Anything else?)

2. What do you think make it difficult for women to continue to breast-feed their babies for at least six months? Try to think of all the things that might make it difficult. (Interviewer note: After first responses, PROBE Anything else?)

3. What do you think would make it easier for women to continue to breast-feed their babies for at least six months? Try to think of all the things that might make it easier. (Interviewer note: After first responses, PROBE Anything else?)

Multiple responses were encouraged and the interviewers prompted for additional responses until the respondent said they didn't know any more. The interviewers had been previously trained in placing, where possible, each of the responses given by the respondent into one of a large number of pre-coded categories. These pre-coded categories had been developed by an expert panel from responses given in the previous four surveys. If the interviewer was unsure of what code a response should be given they were instructed to record the answer from the respondent verbatim. They also did this for any responses that were clearly not one of the pre-coded categories.

As described in the paper above under section 4.3.2, all the 'other' responses were either put into one of the existing codes, or a new code was created (if twenty or more respondents mentioned it) or it was kept as an ‘other’ response. The coding of the ‘other’ responses in this manner was done by an expert panel in the area.

4.8.1 Tables associated with regression results described in text

Tables 4.5 and 4.6 are the full logistic regression results for summary results in the text presented in section 4.4. Table 4.5 presents the logistic regression results for respondents who were unable to think of any benefits of breastfeeding compared with respondents who knew at least one benefit. The comparison group for year of survey was 1995; males were compared with females; respondents aged 18 to 34 years were compared with those aged 35 to 64 years; and those having less than 12 years of education were compared with those having 12 or more years of education.

Table 4.5 Associations from logistic regression for those who do not know any benefits of breastfeeding

Don't know any benefits	OR	95% CI		*p value*
Year of survey -1998	1.09	0.70	1.68	0.711
Year of survey -2001	1.64	1.10	2.44	0.016
Year of survey -2004	1.32	0.85	2.04	0.212
Year of survey -2009	2.45	1.60	3.74	<0.001
Males	3.68	2.67	5.05	<0.001
Aged between 18 and 34 years	1.96	1.47	2.60	<0.001
Having less than 12 years of education	1.88	1.39	2.53	<0.001

Table 4.6 presents the logistic regression results for respondents who said that community acceptance would make breastfeeding easier compared with respondents who didn’t report that as making breastfeeding easier. Year was entered as an interval variable; females were compared with males; those having a university education were compared with those who did not; and respondents not born in Australia were compared with those who were.

Table 4.6 Associations from logistic regression for who thought that community acceptance would make breastfeeding easier

Community acceptance would make breast feeding easier	OR	95% CI		*p value*
Year of survey[a]	1.04	1.03	1.07	<0.001
Females	1.30	1.12	1.49	<0.001
University educated	1.57	1.36	1.82	<0.001
Born in a country other than Australia	1.30	1.12	1.52	<0.001

[a] The year of survey was entered in this logistic regression and all of the poisson regressions as an interval variable.

5 EXPLORE TRENDS IN RECOMMENDED DIETARY BEHAVIOURS AND THE FACTORS INFLUENCING OR DRIVING THESE CHANGES: ADDRESSING OBJECTIVE TWO

> "…over or under estimates of behaviors that may result from self-reports would not influence our findings with respect to trends. Quite often in public health, the primary interest is on whether and how change occurs, i.e. is there an increasing or decreasing trend for a particular phenomenon; generally there is less interest in the actual value of a specific variable…The methodological consequence is that less attention can be paid to biases in the estimated value of a variable, since, if we can assume that these are stable over time (as quite often is reasonable in repeated measurements based on independent samples), the possible bias will not influence trend estimates" (Campostrini et al., 2006, p 133).

As described in Chapter one, section 1.1.1, the ultimate goal is to find pathways to support development of interventions designed to shift the distribution of the population in the direction of better diet and nutrition by approaching the analysis of cross sectional surveys with more specific questions and sophisticated statistical techniques. This chapter addresses the questions: a) what has been happening over time in relation to consumption of two recommended food groups; b) what is the frequency of eating fast food; and c) what are the trends related to BMI. The statistical analysis identifies trends over time, the influences from environmental and societal events on these trends and what the future trends are likely to be. To do this the statistical procedures of time series regression and forecasting are used.

Time series regression analysis has been used by economists for many years and has been increasingly appearing in psychosocial analyses of behaviours over time related to treatments and interventions. It is a relatively new technique in health promotion although it has appeared in public health and epidemiological papers, particularly in relation to disease outbreaks or patterns (Tian et al., 2015) and to informing the status of health or an intervention over time (Campostrini et al., 2006; Wagenaar, Sherr, Fernandes, & Wagenaar, 2015) or a particular drug use and its effect on an outcome (Helgason et al., 2004; Wang & Bhattacharyya, 2015). More recently its use has appeared in the general health literature (Guo et al., 2015; Hsieh, 2013; Kleinberg & Hripcsak, 2011; Li, Li, Liang, Fang, & Cao, 2013; Ligges, Ungureanu, Ligges, Blanz, & Witte, 2010; Moineddin et al., 2008; van Gils et al., 2014) and psychosocial literature (Goldin et al., 2014; Grant et al., 2014) but has rarely appeared in the health promotion literature. The benefit of time series analysis with cross sectional population health is that provided the temporal sequence has enough data points, trends about what the population is doing in relation to key health behaviours can be monitored; changes related to health promotion campaigns can be posited (and with the application of statistical techniques commonly used in economics, also temporally causally attributed (Granger & Newbold, 1986); and forecasts made with estimates of effects in relation to external variables such as cost, interventions and unexpected global or local events.

To date most of the use of time series analysis has been to examine change over time using interrupted time series which looks at events or means before and after an intervention such as a health promotion campaign (Luangasanatip et al., 2015; Pollard, Miller, et al., 2008; Taylor et al., 2013; Wolters, Paul, Li, & Rothwell, 2015) or change in the law (Campostrini et al., 2006). None of these has used the forecasting function or examined possible temporally contiguous events such as the global financial crisis. This is a gap that is explored in this chapter.

5.1 The subjects of the forecasting

In Western Australia, there has been an active health promotion campaign program aimed at increasing the consumption of healthy foods, increasing physical activity and controlling weight. The subjects of the campaigns have been developed in line with the evidence concerning the health benefits of eating particular food groups and of controlling weight, which have been recently outlined and updated in the 2013 ADG (National Health and Medical Research Council, 2013a) particularly where evidence suggests WA adults are falling well short of dietary guidelines (Australian Bureau of Statistics, 2014a). A critical review of the role of fruit and vegetables in the prevention of chronic disease concluded that a diet high in these promotes good health (Boeing et al., 2012).

In 2006, the WHO called increasing obesity a global epidemic (World Health Organization, 2006) with an estimated 2.8 million people dying as a result of being overweight or obese (World Health Organization, 2011). A new set of clinical practice guidelines have been developed to try to address the increasing prevalence of excess weight in Australia (National Health and Medical Research Council, 2013c). In WA there is evidence for increasing BMI with an age standardised prevalence of 28.2% of WA adults aged 18 years and over in 2011 and 2012 (Australian Bureau of Statistics, 2013a) and a weighted prevalence of 28.3% of adults aged sixteen years and over in the obese range in 2012 which dropped marginally to 27.8% in 2013 (Radomiljac & Joyce, 2014). No confidence intervals were given in the table for the 2012 prevalence but the 95% confidence interval for the 2013 estimate overlapped it (25.9,29.6) suggesting that the difference between the two years was not a statistically significant difference.

In terms of the relative importance of fruit, vegetables and excess weight to health, a diet low in fruit has been ranked fourth as a risk factor for burden of disease; excess weight ranked sixth and a diet low in vegetables ranked seventeenth (Murray & Lopez, 2013). The monitoring and forecasting of these risk factors provides an evidence base for evaluation and planning of public health programs.

5.2 MEASURES AND METHODS

The data used for examining trends in consumption over time and forecasting future trends comes from the HWSS conducted over the years 2002 to 2013. Table 5.1 shows the questions used in the time series analysis.

Evidence has shown that at a population level, people tend to over-report their height and under-report their weigh (Connor Gorber, Tremblay, Moher,

& Gorber, 2007). In Australia, using the 1995 National Health Survey data, a correction formula was proposed to adjust for this (Hayes, Kortt, Clarke, & Brandrup, 2008) and this formula has been applied to the HWSS in their reporting (Joyce, 2011). This formula was updated in 2011 based on the 2007-2008 National Health Survey (Hayes, Clarke, & Lung, 2011) and it is this correction that is used on the HWSS data for this research.

Table 5.1 Variables used in the time series analysis, HWSS 2003-2012

Questions for use with the time series projections	Response categories
How many serves of vegetables do you usually eat each day? A serve of vegetables is equal to half a cup of cooked vegetables or 1 cup of salad.	Recoded as a number (with decimal places for part serves) and 991 for less than one serve this is converted to .5 for analysis. Don't know and refused are also recorded.
How many serves of fruit do you usually eat each day? A serve of fruit is equal to one medium piece, two small pieces of fruit or one cup of diced fruit.	Recoded as a number (with decimal places for part serves) and 991 for less than one serve which is converted to .5 for analysis? Don't know and refused are also recorded.
How many times a week on average, do you have meals or snacks such as burgers, pizza, chicken or chips from places like McDonalds, Hungry Jacks, Pizza Hut or Red Rooster?	Recoded as a number (with decimal places for part serves) and 991 for less than one serve which is converted to .5 for analysis? Don't know and refused are also recorded.
What is your height without shoes?[1]	Recorded as centimetres OR feet and inches
How much do you weigh without clothes or shoes?[1]	Recorded as kilograms OR stones and/or pounds

1 Height and weight are converted to meters and kilograms respectively

5.2.1 Additional measures

Because part of this objective was to evaluate the effect of significant events happening over time which might have influenced the trajectory of consumption patterns or BMI, some additional information was added to the aggregated time series dataset. These were:

1. Estimates of the consumer price index (CPI) for fruit, vegetables and dairy based on quarterly CPI estimates provided by the Australian Bureau of Statistics.
2. The time period when the global financial crisis (GFC) was at its peak in most developed countries and also in Australia, June 2007 to Dec 2008 (Australian Bureau of Statistics, 2013b)

3. The four *Go for 2&5*® fruit and vegetable campaigns, the first ran from April 2002 to June 2005 (the campaign actually started before the HWSS started); the second from September and October 2006; the third from May 2008 to September 2009 and the fourth from May to September 2011.

The first *Go for 2&5*® campaign was a total immersion campaign with television, radio, newspapers, brochures, billboard and grocery store logos and ran continuously over the four years. None of the other *Go for 2&5*® campaigns was total immersion and the time varied from just three months in 2006 to sixteen months in 2008-2009. Running at some of the same months were:

1. The *Find Thirty* campaign which ran in May 2005 & Mar, May, Aug, Oct & Nov 2010 and was designed to promote physical activity.
2. The *Australia Better Health* campaign which ran in Mar, Sep and Oct 2009 & May 2010 and was designed to promote better lifestyle habits to promote better health.
3. The *Measure Up* campaign which ran from Oct 2010 to June 2011 and was designed to encourage lifestyle changes to reduce risk of chronic disease.
4. The *Live Lighter Campaign* which ran from June 2012 to Sept 2012 and was designed to promote weight loss and increase physical activity.

Also added for BMI analysis was the SEIFA quintile. As previously described in Chapter 3, section 3.1, SEIFA is a measure of relative social disadvantage and is an area based variable that is applied to the Statistical Local Area in which the respondent lives. The basic assumption is that people living within a particular quintile are likely to have similar sociodemographic characteristics.

5.2.2 Analysis

Tables for estimated mean consumption of vegetables, fruit, fast foods and BMI by gender are produced using weights generated by IPF raking using age, sex and geographic marginal totals and probability of selection.

Prior to aggregating the data to make time series datasets, multivariate regression spline (MVRS) models were conducted for possible non linear changes in trajectory associated with age and the variables of interest. The Durbin Watson test was conducted to see if the variables of interest were autocorrelated in the un-aggregated data. Autocorrelation is the correlation between the elements of a series with itself and others from the same series separated from them by a given interval, called a lag and is a common feature of a time series (Durbin, 1970).

The data for each outcome variable were set up as a time series dataset using date which was derived by year and month from April 2002 to December 2013. The measurement units for the aggregation were means for fruit, vegetable, mean number of times that fast food was eaten each week and mean BMI. IPF raking weight using age, sex and geographic area was applied and data aggregated by month. For BMI, the aggregated data was additionally extracted by month and by each SEIFA quintile.

Missing values for months when data was not collected[2] were imputed using Stata's time series missing value imputation procedure. The imputations were based on the adjacent observed values for the two months before and after the missing values. Then variables for time-related events were created which included times when health promotion campaigns were being run for the variables being modelled; the time the Global Financial Crisis was having its greatest impact and the quarterly mean CPI for fruit and vegetables. Each of the time-related events was created as a dummy variable with zero the times before and after the event and one indicating the time of the event. The CPI quarterly estimate was entered for each month of the quarter. As implicit

[2] These were primarily months prior to 2005 which were times when funding was not yet allocated. By 2005 funding became established and since that time data has been collected every month of the year.

in time series models, the primary variable of interest is time and the additional variables examine what, if any, significant effect they were having on the outcome variable over the time period being examined.

A stable model about the current situation for each of the outcome variables of interest with these time-related events was established. Post estimation tests included the Durbin Watson test for serial autocorrelation; a test for heteroskedasticity which is change in the variance of the observations over time; a test for evidence of an omitted predictor variable; a test for influential observations using variable inflation estimates; and an additional test for serial autocorrelation. Where heteroskedasticity was found to be present, autoregressive conditional heteroskedasticity (ARCH) estimators were used.

The resultant time series regression models for each outcome variable were used to predict what the future might look like if nothing changed. Forecasts were also made using Holt Winters smoothing when the data indicated that the trends over time were linear (Becketti, 2013). The past trajectory of BMI with future forecasts was assessed by SEIFA quintile with forecasting.

Using vector autoregressive analysis with Lütkepohl statistics to determine optimal lags and GFC and CPI entered as exogenous variables (Lütkepohl, 2005, p 387), two Granger causality tests were conducted: first for fruit and vegetable consumption with health promotion campaigns relevant to the increased consumption of these and using GFC and the CPI for fruit and the CPI for vegetables as exogenous variables; second for BMI and fast food consumption with health promotion campaigns relevant to decreases in these and using GFC and the CPI for dairy as exogenous variables . Post estimation tests included an Eigenvalue test of the stability of the model over time; a test for the normality of dependent and independent variables over time; a test for autocorrelation of the residuals and a set of causality tests based on the Granger causality definition (Granger, 2003; Wiener, 1956). An extra chi square test of the significance of the lags in the Granger causality model was also used (Becketti, 2013, p 337).

5.3 RESULTS

5.3.1 Un-aggregated data characteristics of fruit and vegetables

Table 5.2 shows the annual mean consumption of serves of vegetables and fruit daily and the annual mean number of times fast food was consumed per week by gender.

Table 5.2 Mean daily serves of fruit and vegetables and mean number of times fast food is consumed weekly by gender, HWSS 2002-2013

	Daily serves of fruit		Daily serves of vegetables	
	Females	Males	Females	Males
Year	Mean (95%CI)	Mean (95%CI)	Mean (95%CI)	Mean (95%CI)
2002	1.82 (1.76,1.87)	1.56 (1.50,1.62)	2.82 (2.75,2.89)	2.45 (2.37,2.53)
2003	1.80 (1.73,1.88)	1.76 (1.64,1.88)	3.00 (2.90,3.10)	2.55 (2.43,2.66)
2004	1.80 (1.71,1.88)	1.61 (1.50,1.72)	2.97 (2.85,3.09)	2.66 (2.51,2.82)
2005	1.82 (1.76,1.87)	1.66 (1.60,1.72)	3.20 (3.12,3.27)	2.95 (2.85,3.04)
2006	1.69 (1.64,1.74)	1.54 (1.48,1.61)	3.16 (3.09,3.24)	2.82 (2.72,2.92)
2007	1.71 (1.66,1.77)	1.57 (1.49,1.64)	3.18 (3.09,3.27)	2.86 (2.74,2.98)
2008	1.78 (1.73,1.83)	1.59 (1.53,1.66)	2.99 (2.92,3.06)	2.65 (2.56,2.74)
2009	1.77 (1.72,1.81)	1.66 (1.61,1.72)	2.91 (2.85,2.96)	2.54 (2.48,2.61)
2010	1.82 (1.78,1.87)	1.70 (1.64,1.77)	3.06 (2.99,3.12)	2.67 (2.58,2.76)
2011	1.68 (1.64,1.73)	1.56 (1.50,1.62)	2.94 (2.88,3.01)	2.57 (2.48,2.65)
2012	1.72 (1.67,1.77)	1.62 (1.55,1.68)	2.93 (2.86,3.00)	2.50 (2.41,2.59)
2013	1.72 (1.67,1.76)	1.63 (1.57,1.70)	2.87 (2.80,2.93)	2.45 (2.36,2.54)

The minimum recommended daily serves of fruit was two and over the years the mean serves were not far off that goal with more than one and a half serves eaten by both males and females over the time period. There was a pattern of consumption for females from 2002 to 2005 where mean consumption was generally higher than in the subsequent years with the exception of 2010. This pattern was not observed for males who showed more variability over the time period compared with females.

For vegetables, the minimum recommended daily serves of vegetables was five and the annual mean serves hovered around three serves for females and two and a half serves for males over the time period. For both genders, there is a slight downward trend since 2011, after an upward trend from 2002 to about 2007.

Unobserved Components Models (UCM) conducted on means serves of fruit and vegetables found no seasonal effects or cycles. Multivariable spline regression (MVRS) identified some differences in age trajectories for vegetable consumption (Figure 5.1).

The figure shows that for all ages, there was an upward trajectory until April 2006 when the consumption started to decline but at differing rates and amounts. For adults aged sixteen to twenty-five years the consumption started at the lowest point and although it increased, it remained slightly lower than for any other age group except the twenty-five to thirty-four year age group. For ages twenty-five to forty-four the increases, decreases and rates of change were very similar although the older group (thirty-five to forty-four) consumption remained marginally higher.

For ages forty-five to fifty-four, there was an increase in consumption in May 2010 which appears to have been maintained. The fifty-five to seventy-four age groups showed very similar patterns with two trajectory changes. These age groups were the ones who had the highest consumption from the start and maintained that over time. The first trajectory change which occurred in April 2005 in common with all other age groups showed that the upward trend is slowing down and decrease in consumption starting. Then the second change in September 2007 when the decrease slows down and changes to a slight increase which appears to be maintained over time. The oldest age group, those aged seventy-five and over show that they started at a high rate but over time have gradually decreased their consumption. These results, particularly the first trajectory change noted across all ages tracks almost exactly a major health promotion campaign aimed at increasing fruit and vegetable consumption, targeting those aged 25-64 specifically.

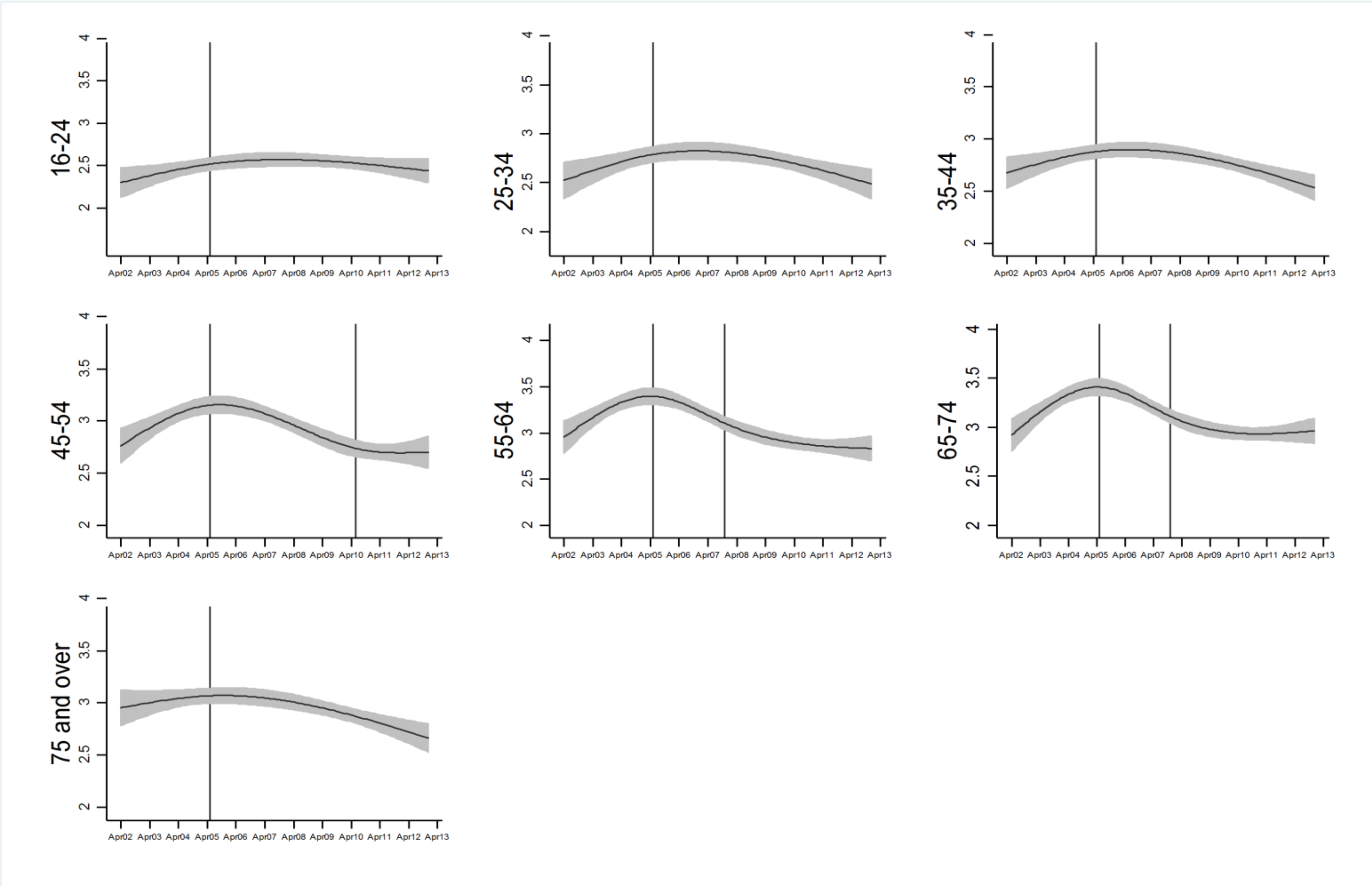


Figure 5.1 Comparison of the trajectory over time for mean serves of vegetables by age, HWSS 2002-2013

5.3.2 Aggregated data characteristics

The raw data time series for each of the variables to be forecast are shown by gender for daily serves of fruit in Figure 5.2 and Figure 5.3 shows daily serves of vegetables.

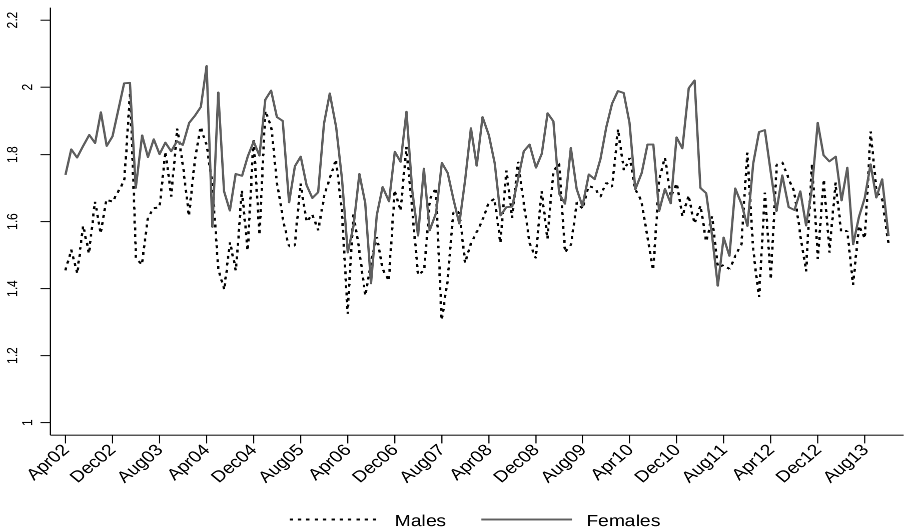


Figure 5.2 Graph of time series for daily consumption of fruit by gender, April 2002 to December 2012, HWSS

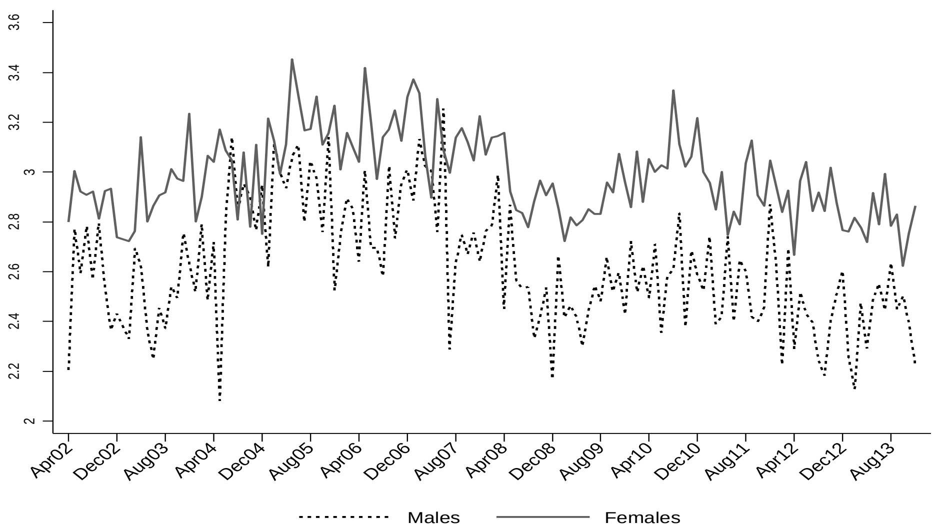


Figure 5.3 Graph of time series for daily consumption of vegetables by gender, April 2002 to December 2013, HWSS

Table 5.3 shows the correlations between the all the aggregated variables that were investigated in a time series analysis. The highlighted variables

Table 5.3 Correlations between the variables in the aggregated data, HWSS 2002-2013

	Mean Vegetables	Mean Fruit	Mean fast food	GFC	Go for 2 & 5® (1)	Go for 2 & 5® (2)	Go for 2 & 5® (3)	Find 30	Australia Better Health	Go for 2 & 5® (4)	Measure up	Live Lighter	CPI Fruit	CPI vegetables
Daily fruit consumption	-0.01													
Times fast food eaten weekly	0.16	**0.3**												
Global financial Crisis (06/07-12/08)	0.11	-0.1	-0.08											
Go for 2 & 5 (1)*	-0.06	**0.38**	**0.73**	**-0.24**										
Go for 2 & 5 (2)	0.16	-0.11	0.04	-0.05	-0.07									
Go for 2 & 5 (3)	**-0.29**	-0.06	-0.19	**0.36**	**-0.23**	-0.04								
Find 30 campaign (4)	0.13	0.04	0	-0.08	-0.05	-0.03	-0.08							
Australia Better Health campaign (5)	-0.06	0	-0.05	-0.07	-0.11	-0.02	**0.2**	0.18						
Go for 2 &5 (6)	-0.09	**-0.28**	-0.1	-0.08	-0.12	-0.02	-0.07	-0.04	-0.03					
Measure up campaign (7)	-0.02	0.01	-0.09	-0.1	-0.16	-0.03	-0.1	**0.23**	-0.04	**0.26**				
Live Lighter campaign (8)	-0.07	-0.14	-0.18	-0.07	-0.11	-0.02	-0.06	-0.04	-0.03	-0.03	-0.04			
CPI** for Fruit	-0.08	**-0.44**	**-0.67**	0.07	**-0.76**	0.17	-0.01	-0.03	0.01	**0.32**	**0.3**	**0.19**		
CPI for Vegetables	-0.26	**-0.3**	**-0.81**	0.09	**-0.77**	-0.08	0.16	0.06	0.04	**0.25**	**0.31**	**0.25**	**0.77**	
Natural log of BMI	-0.13	**-0.36**	**-0.67**	0.01	**-0.63**	0.14	-0.02	0.01	0.01	0.12	0.02	**0.25**	**0.67**	**0.68**

*The brackets indicate which of the four Go for 2 & 5® were in the field. (1) April 2002 – June 2005; (2) Sep & Oct 2006 (3) May 2007-Sep 2008 (4) Mar, May, Oct and Nov 2010 (5) Mar, Sep and Oct 2009 and May 2010 (6) May to Sep 2011 (7) Oct 2010 to June 2011 (8) June-Sep 2012 ** CPI Consumer Price Index – Perth 2002 to 2013 quarterly were tested for interactions in the time series regression analysis. The results for the time series analysis of the mean daily consumption of fruit and vegetables are presented first followed by the results for the time series of the mean times fast food was consumed over a week and mean BMI. The dates for each of the campaigns are shown under the table and are presented in a month and year format to indicate the time period when a particular campaign was running. The times for GFC period and shown and the CPI for fruit and vegetables are quarterly indicators.

5.4 TRENDS FOR FRUIT AND VEGETABLE CONSUMPTION

This section examines the trends over time for fruit and vegetable consumption by times when health promotion campaigns were running, by gender and by age.

5.4.1 Trends for fruit and vegetable consumption when health promotion campaigns were running

When the trends for fruit and vegetable consumption are plotted against the CPI for each along with the times when the major health promotion campaign Go for 2 & 5® (C1 to C4) were running, two features stand out (Figure 5.4). The first is that there is an association between consumption and the CPI for each, particularly when the CPI showed a major increase such as shown in the fruit CPI in the late autumn early winter of 2006 and the late winter early spring months of 2011 and to a lesser extent the vegetable CPI for the months from May 2008 to September 2009. The second is that for vegetable consumption there appears to be a significant increase during the period of the first Go for 2 & 5® campaign which was a full saturation campaign run over almost three years.

Figure 5.5 shows the mean serves when the Go for 2 & 5® health promotion campaigns were running using a quadratic curve fit for the overall trend over time as the changes are not linear. The campaign lines are fractional-polynomial prediction plots for the months the campaigns were running. The first campaign, a full saturation campaign run from April 2002 to June 2005 showed a clear increase over time and the third campaign run during the time when the GFC impact was at its highest showed an apparent effect

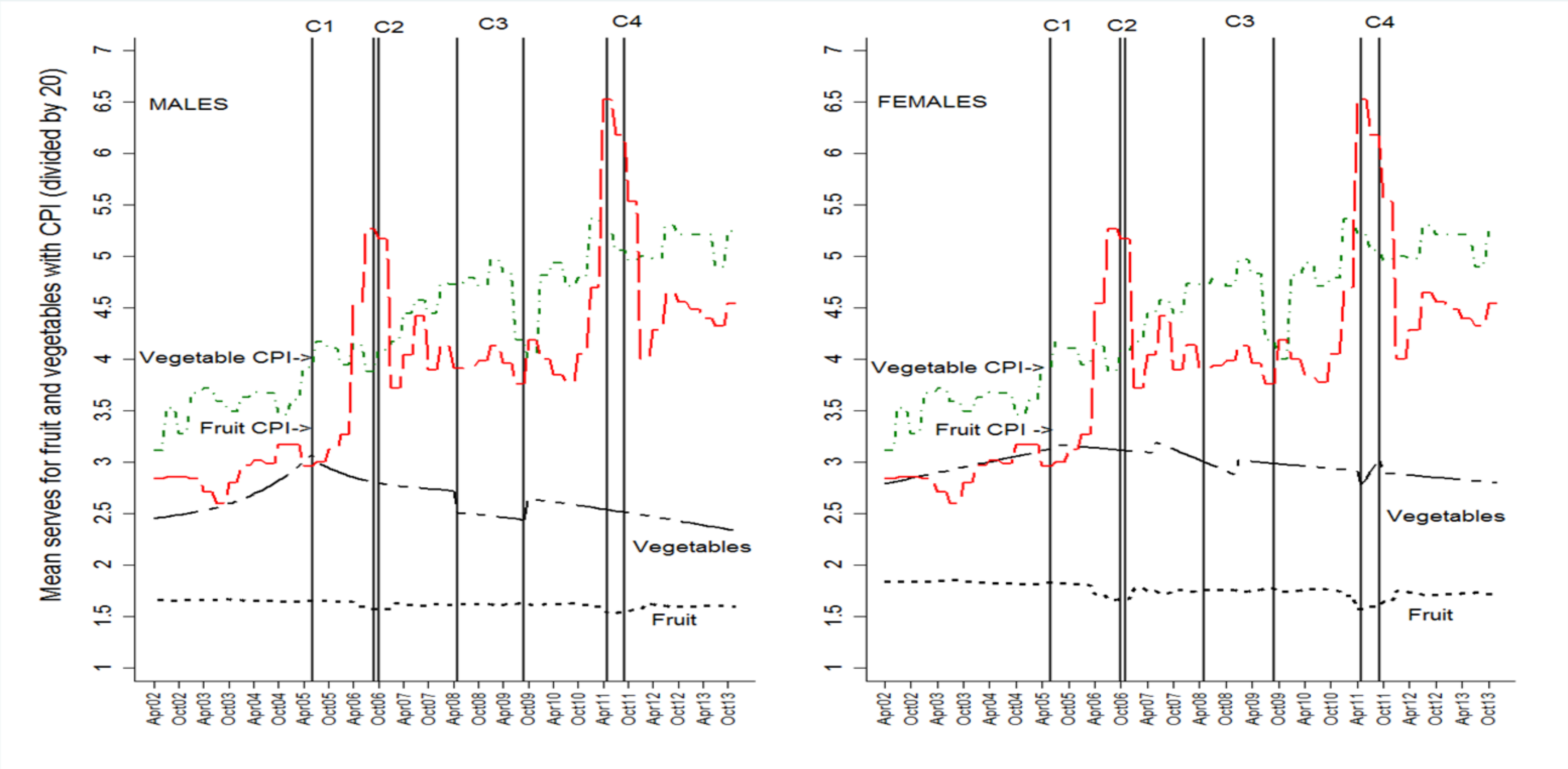


Figure 5.4 Trends over time by CPI on fruit and vegetables and with health promotion Go for 2 & 5 ® campaigns by gender age 16 and over, HWSS 2002-2013

Legend: The vertical lines show when the Go for 2 & 5 ® campaigns were in the field. C1-from April 2002 to June 2005; C2- running September and October 2006; C3-from May 2008 to September 2009; and C4- from May to September 2011. The Vegetable Consumer Price Index (CPI shown in green) and Fruit CPI (shown in red) were divided by 20 to allow for them to be added to the figure for comparative purposes. The black dotted line is the mean consumption of fruit and the dashed line is the mean consumption of vegetables.

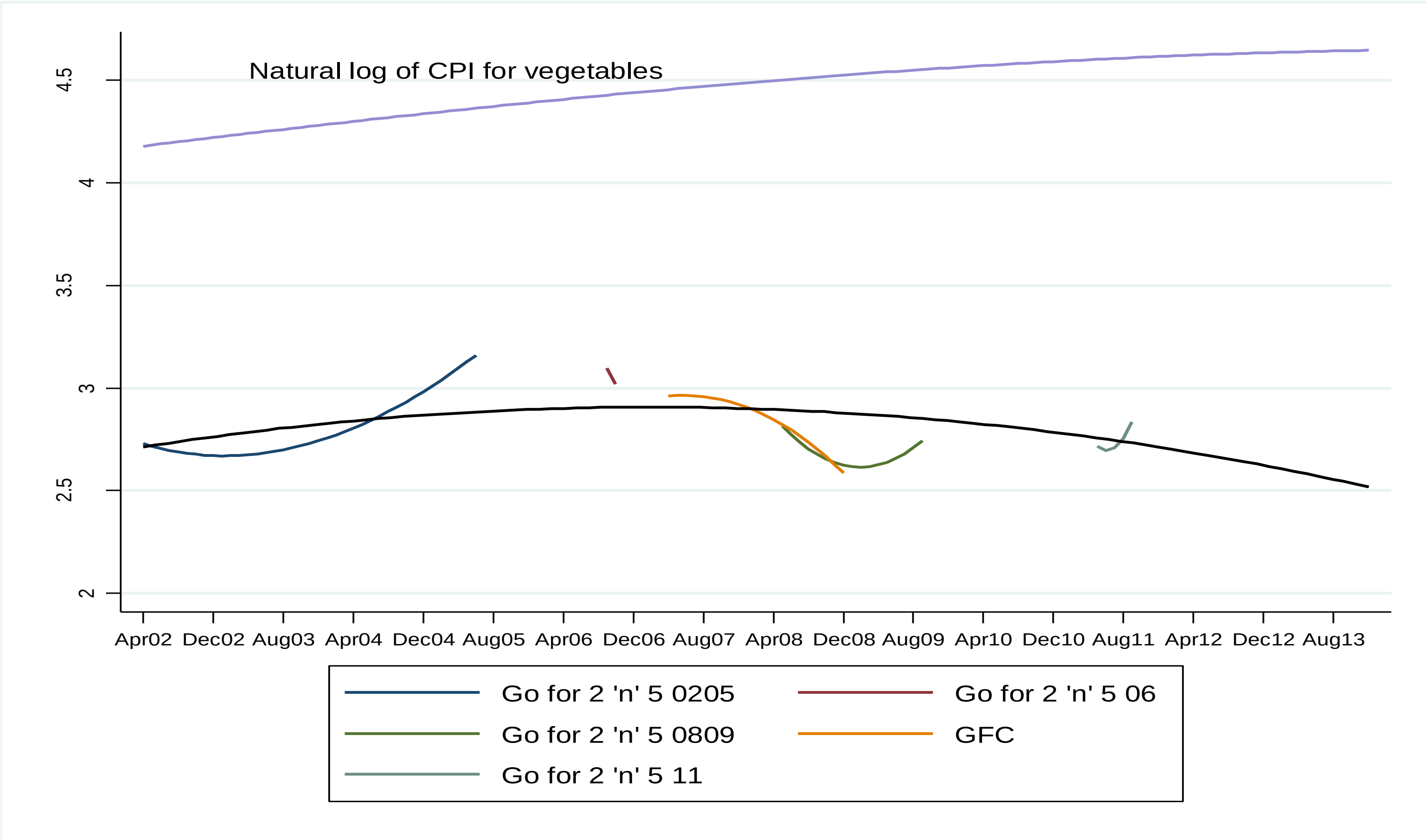


Figure 5.5 Values for mean consumption of vegetables using quadratic curve fit for overall trend and fitted curves for the times Go for 2 & 5® campaigns were running, HWSS 2002-2013

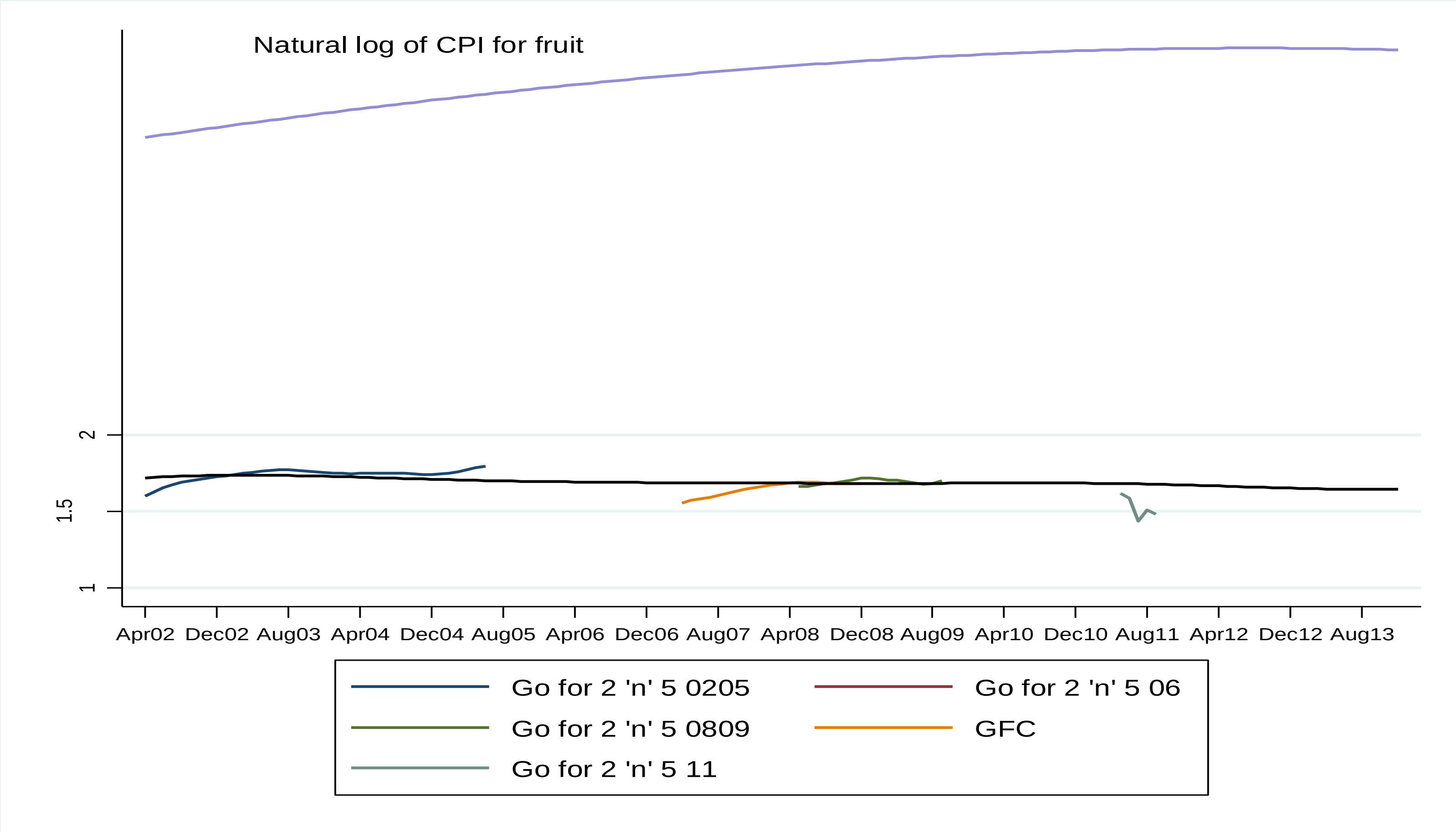


Figure 5.6 Values for mean consumption of fruit using non seasonal Holt Winters smoothing for overall trend and curves for the times Go for 2 & 5® campaigns were running, HWSS 2002-2013

followed by a recovery once the GFC impact had lessened. The CPI for vegetables does not appear to affect the mean serves of vegetables for the 2002-05 campaign but overall the mean serves of vegetables decline as CPI increases with an apparent increase in the effect of the CPI.

Figure 5.6 shows the mean serves when the Go for 2 & 5® health promotion campaigns were running using non seasonal Holt Winters smoothing. Unlike vegetables, the campaigns do not appear to be related to change over time.

5.4.2 Trends for fruit and vegetable consumption by age and gender

Figure 5.7 shows the trend over time for the consumption of daily fruit and vegetables for males and females. Fruit consumption shows very little change over time although consumption for females had decreased. Vegetables show much more variation with increases followed by decreases and an overall downward trend.

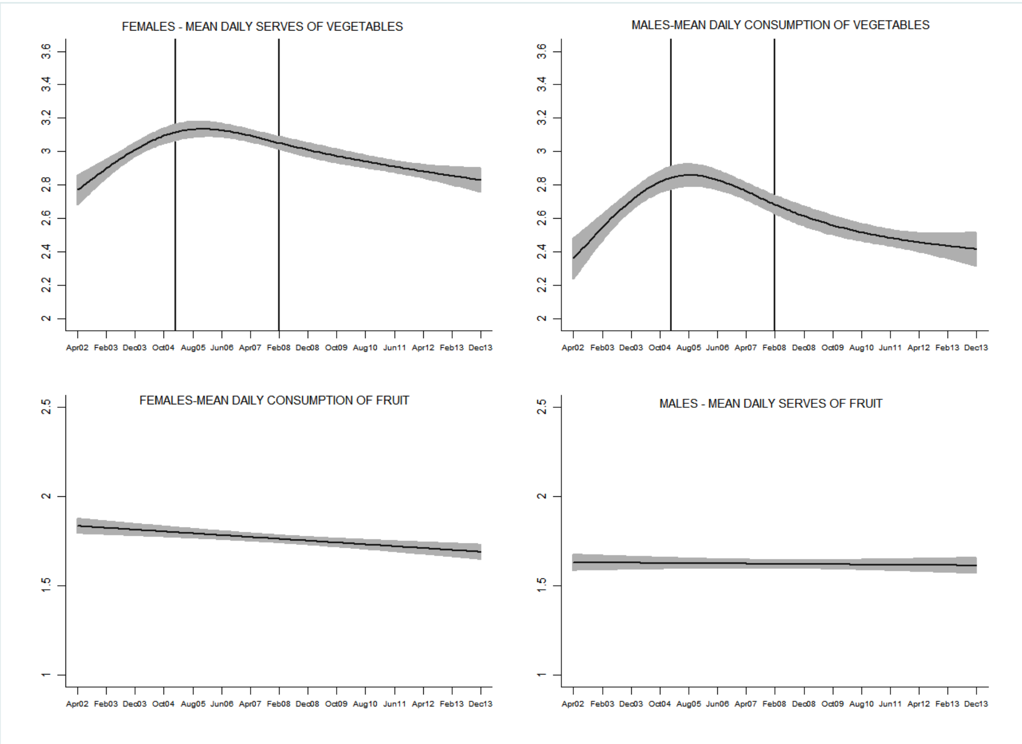


Figure 5.7 Fitted curves showing the pattern of mean daily consumption of fruit and vegetables for males compared with females over time, April 2002 to December 2013

As the target group for campaigns related to fruit and vegetables were adults aged twenty-five to sixty-four years, this group is compared with all ages in

Figure 5.8. For both vegetables the target age group shows a higher consumption across time with a slower rate of decrease although both graphs show two changes in the trajectory of the trend as shown for gender. For fruit, the trend is linear over. The target group shows a higher consumption level at the start of the time series but also shows a faster rate of decline over time compared with all ages suggesting that those aged sixteen to sixty-four years and those over sixty-four years have a consistent consumption trend over time.

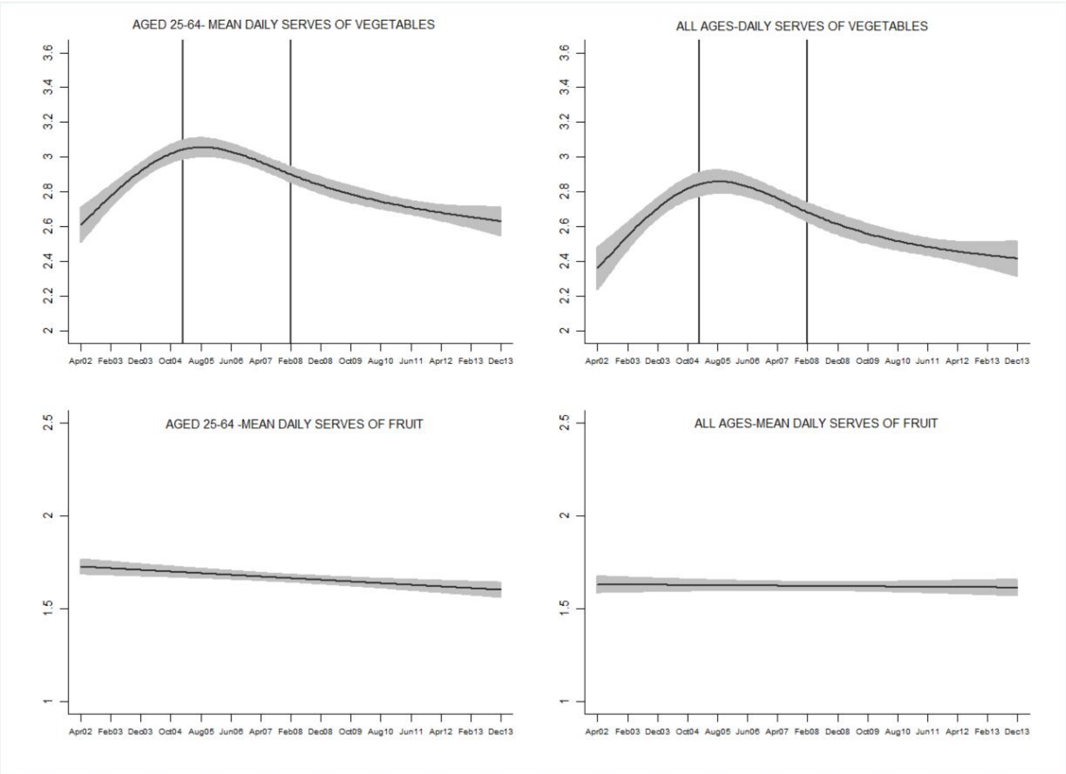


Figure 5.8 Fitted curves showing the pattern of mean daily consumption of fruit and vegetables for adults aged 25-64 years compared with all ages over time, April 2002 to December 2013

5.4.3 Vegetable consumption trends and forecasts

The regression results for the associations with vegetable consumption over time for females, males, the target age group which was 25-64 years and for all persons while not showing serial autocorrelation did show variance inflation factors (VIF) over the recommended outside limit of ten. The autoregressive conditional heteroskedasticity (ARCH) model confirmed the significant associations of the regression models with WALD chi squares all yielding significant estimates of *p<0.001*. ARCH models were used to predict future consumption. Table 5.4 shows the regression results for females and Table 5.5 for males. In the tables the dates are shown as year and month to indicate when the campaign was running and to indicate which campaign was interacting with time. For both males and females date was significantly negatively associated with serves of vegetables showing a decrease over time. The model fit was good for both genders (males: r^2=.69, p<0.001; females r^2=.51, p<0.001).

Table 5.4 Unadjusted and adjusted regression of associations with trends over time for daily vegetable consumption for females, HWSS 2002-2013

Females	Coef.	95% CI	SE	t	*p*	β
Date (April 2002 - Dec 2013)	-0.17	(-0.20,-0.13)	0.02	-10.1	<0.0001	-0.97
Go for 2 & 5® (04/02-06/05)	0.47	(0.24, 0.70)	0.12	4.01	<0.0001	1.24
Go for 2 & 5® (04/02-06/05)/Date interaction	0.65	(0.46,0.83)	0.09	6.86	<0.0001	2.2
Go for 2 & 5® (05/08-09/09)	-0.25	(-0.32,-0.17)	0.03	-6.74	<0.0001	-0.05
Go for 2 & 5® (05/11-09/11)	-4.2	(-7.19, -1.20)	1.51	-2.77	0.006	-4.55
Go for 2 & 5® (05/11-09/11)/Date interaction	4.11	(1.14,7.08)	1.5	2.74	0.007	4.5
Second trajectory change (02/08)	0.03	(0.01,0.06)	0.01	2.31	0.022	0.2
Adjusted model						
Date (April 2002 - Dec 2013)	-0.17	(-0.20,-0.13)	0.02	-10.1	<0.0001	-0.98
Go for 2 & 5® (04/02-06/05)	0.46	(0.22, 0.69)	0.12	3.81	<0.0001	1.2
Go for 2 & 5® (04/02-06/05)/Date interaction	0.64	(0.45,0.83)	0.1	6.6	<0.0001	2.16
Go for 2 & 5® (05/08-09/09)	-0.24	(-0.31, -0.17)	0.04	-6.49	<0.0001	-0.46
Second trajectory change (02/08)	0.03	(0.01,0.06)	0.01	2.08	0.039	0.18
Constant	3.11	(3.08,3.14)	0.02	196.8	<0.0001	

In the unadjusted model for females, the higher standardised coefficients noted in relation to the 2011 campaign show that the negative main effect was cancelled by the positive interaction with an overall change of -0.09 at that time. The inflated VIF for females were in relation to these dates and in the ARCH model they were not significant and dropped from that model and an adjusted regression model run. The coefficient of determination was little changed in the adjusted model (original model r^2=.54, p <0.001 compared with adjusted model r^2=.51, p<0.001), indicating that the 2011 campaign effect was minor in explaining variance within the regression. The adjusted model had the same significant associations and was the one used to forecast future trends.

The first Go for 2 & 5®, conducted from early 2002 to June 2005 as a multi-strategy campaign described elsewhere (Pollard, Miller, et al., 2008), had a statistically significant main effect and a date interaction showing an increase in consumption while it was running. For males, it was the most important influence in serves of vegetables as indicated by the standardised coefficient (β= 6.81, *p<0.001*) and in the adjusted model, the important influence for females also (β= 2.16, *p<0.001*).

Table 5.5 Regression of associations with trends over time for males, daily vegetable consumption, HWSS 2002-2013

Males	Coef.	95% CI	SE	t	*p*	β
Date (April 2002 - Dec 2013)	-0.52	(-0.70,-0.33)	0.09	-5.55	<0.0001	-2.47
Go for 2 & 5® (04/02-06/05)	1.99	(1.19,2.79)	0.04	4.91	<0.0001	4.24
Go for 2 & 5® (04/02-06/05)/Date interaction	2.47	(1.47,3.47)	0.51	4.9	<0.0001	6.81
Go for 2 & 5® (05/08-09/09)	-0.21	(-0.28, -0.14)	0.04	-5.82	<0.0001	-0.33
First trajectory change (02/05)	-0.26	(-0.42, -0.10)	0.08	-3.17	0.002	-1.25
Second trajectory change (02/08)	0.12	(.040, .019)	0.04	3.19	0.002	0.56
Constant	2.95	(2.81,3.08)	0.07		<0.0001	

The Go for 2 & 5® campaigns were targeted at the age range twenty-five to sixty-four year and the next two regression analyses show the effect of the age range (Table 5.6) compared to all ages from sixteen years (Table 5.7). The regressions show significant associations with fruit and vegetable consumption for three of the campaign periods with positive association with the first two but a negative association with the campaign run from May 2008 to September 2009.

Table 5.6 Regression of associations with trends over time for adults aged 25-64 years, daily vegetable consumption, HWSS 2002-2013

Aged 25-64 years	Coef.	95% CI	SE	t	*p*	β
Date (April 2002 - Dec 2013)	-0.21	(-0.25,-0.17)	0.02	-10.58	<0.0001	-1.00
Go for 2 & 5® (04/02-06/05)	0.52	(0.31,0.74)	0.11	4.79	<0.0001	1.11
Go for 2 & 5® (04/02-06/05)/Date interaction	0.69	(0.52,0.87)	0.09	8.06	<0.0001	1.91
Go for 2 & 5® (05/08-09/09)	-0.20	(-0.27, -0.12)	0.04	-5.07	<0.0001	-0.30
Constant	2.95	(2.92,2.99)	0.02	156.81	<0.0001	

Table 5.7 Regression of associations with trends over time for all adults, daily vegetable consumption, HWSS 2002-2013

Associates - all ages	Coef.	95% CI	SE	t	*p*	β
Date (April 2002 - Dec 2013)	-0.37	(-0.56,-0.19)	0.09	-3.97	0.001	-2.03
Go for 2 & 5® (04/02-06/05)	1.32	(0.52,2.12)	0.41	3.26	<0.0001	3.25
Go for 2 & 5® (04/02-06/05)/Date interaction	1.72	(0.71,2.72)	0.51	3.39	0.001	5.44
Go for 2 & 5® (05/08-09/09)	-0.21	(-0.28, -0.14)	0.04	-5.80	<0.0001	-0.37
First trajectory change (Feb 2005)	-0.16	(-032, -0.00)	0.08	-2.00	0.048	-0.90
Second trajectory change (Feb 2008)	0.08	(.01, .015)	0.04	2.23	0.027	0.45
Constant	3.06	(2.94,3.19)	0.07	45.88	<0.0001	

Figure 5.9 shows the forecast for 2014 to 2018. The figure compares the forecast using a linear predictive model compared with a model based on Holt Winters smoothing and locally weighted regression estimates. The linear predictions show a steep dropping off of vegetable consumption over the next five years whereas the Holt Winters model shows a decrease that more closely resembles the volatility of the previous years.

Figure 5.10 shows the forecast for ages twenty-five to sixty-four (the target age for the campaigns) and for all ages for 2014 to 2018. All ages show lower mean daily consumption of vegetables compared with the target group. As with the gender comparison of models, the locally weighted regression model based on Holt Winters smoothing showed a much less dramatic decrease in vegetable consumption than the predicted estimates based on a linear model.

In common with each method of projection is the forecast of a continuing decline in the amount of vegetables eaten daily. These forecasts are based on the assumption that no further campaigns will be conducted and that prices will not change from the 2013 CPI. While these assumptions are not likely to be accurate, the forecast models do show that there is a continuing need to promote vegetable consumption and to monitor the consumption over time.

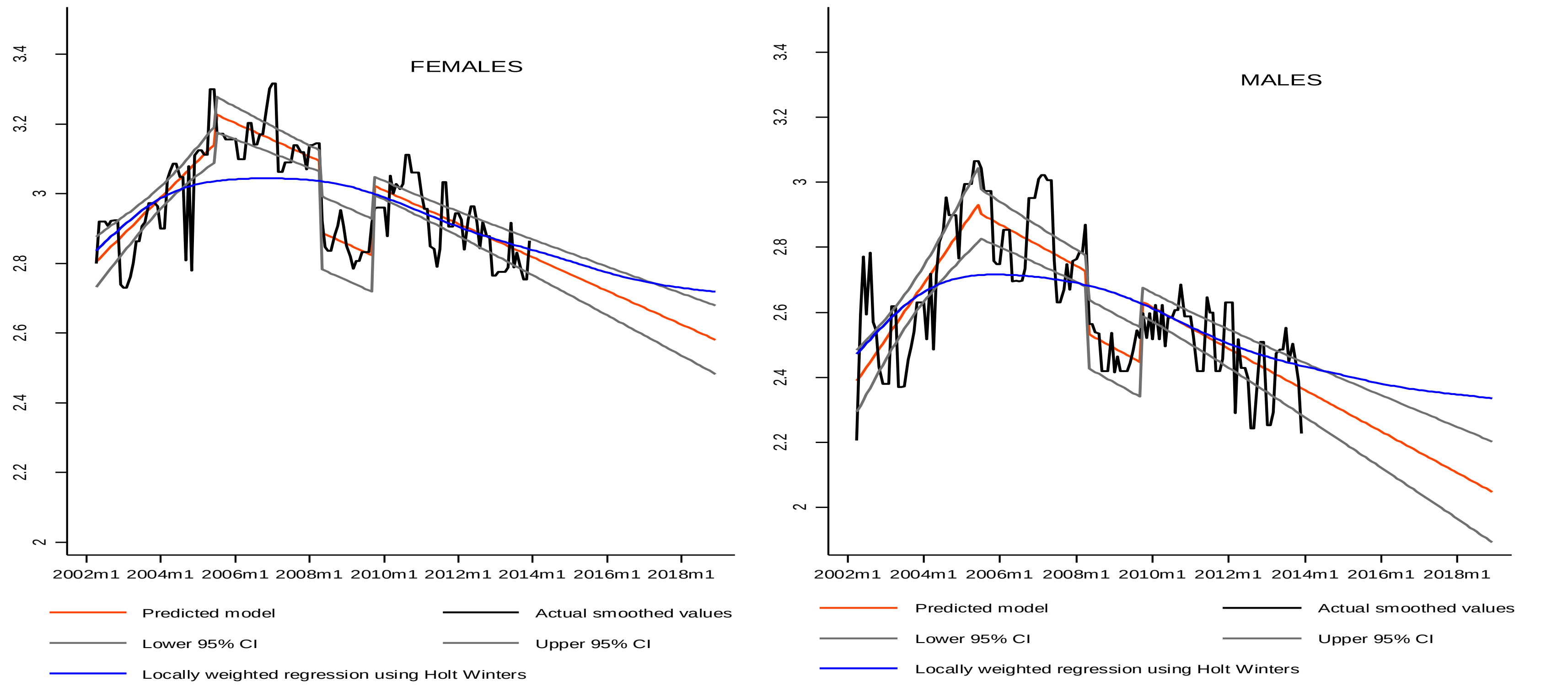


Figure 5.9 Predicted values for mean consumption of vegetables by gender with 95% CI compared with predicted estimates fitted by locally weighted regression using Holt Winters by gender, 2014-2018 based on HWSS 2002-2013

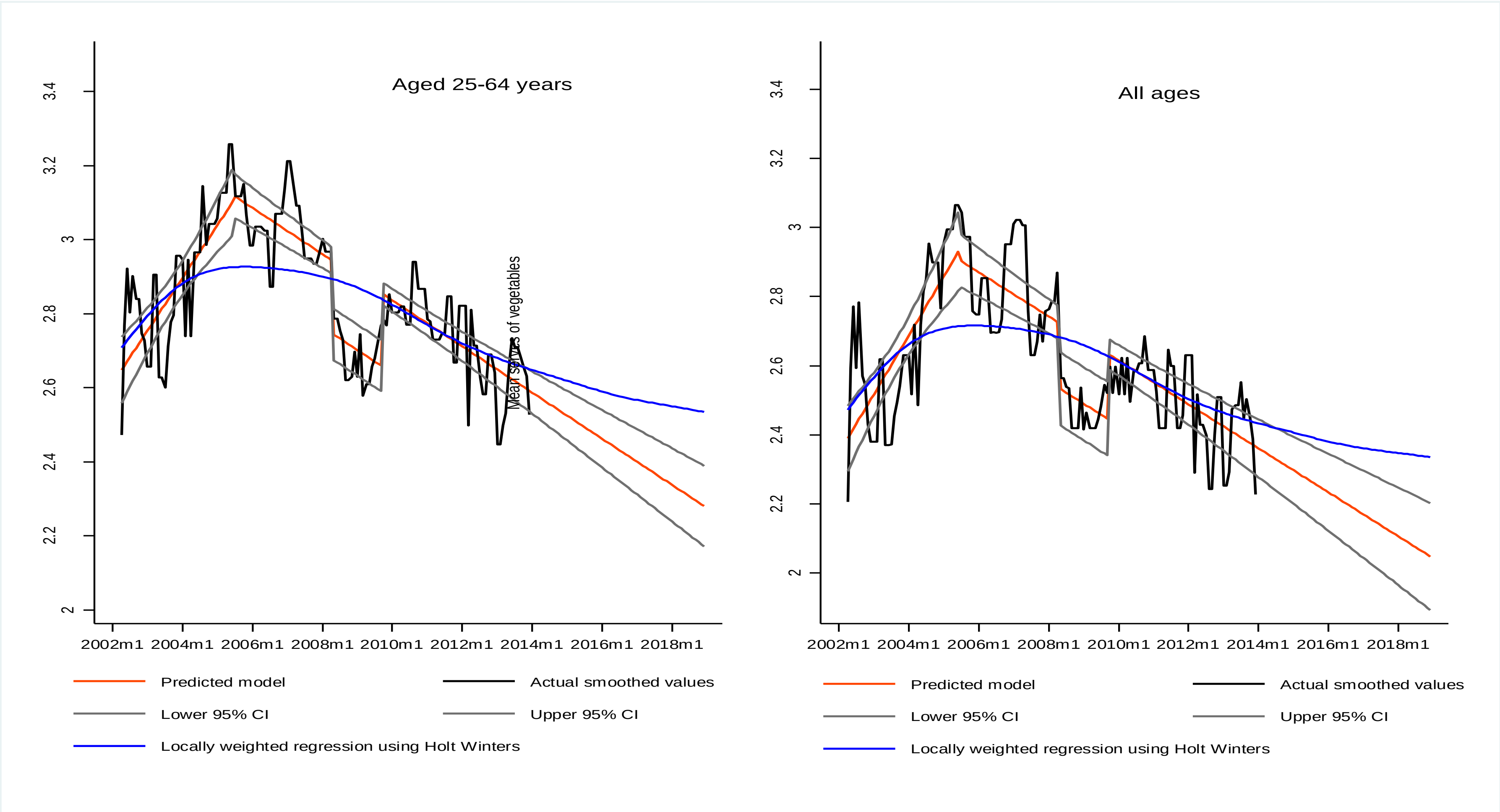


Figure 5.10 Predicted values for mean consumption of vegetables with 95% CI compared with predicted estimates fitted by locally weighted regression using Holt Winters by age, 2014-2018 based on HWSS 2002-2013

5.4.4 Fruit consumption trends by age and gender

Fruit consumption did not have any time related changes in trajectory for either gender or age so the analysis was done for persons. Table 5.8 shows that two things predicted mean daily fruit consumption, time and CPI for fruit. These showed serial autocorrelation ($\chi 2=23.23$, $p<0.0001$) and a relatively poor fit ($r^2=0.19$, $p<0.0001$). This suggested that that what drives fruit consumption is more complex than time or cost.

Table 5.8 Regression of associations with trends over time for adults aged 16 years and over, daily fruit consumption, HWSS 2002-2013

Associates - persons	Coef.	95% CI	SE	t	*p*	β
Date (April 2002 - Dec 2013)	0.001	(0.001,0.223)	0.000	2.03	0.045	0.22
Quarterly CPI for fruit	-0.003	(-0.002,-0.58)	0.001	-5.22	<0.0001	-0.58
Constant	1.62	(1.35,1.89)	0.136	11.90	<0.0001	

The greatest influence on fruit consumption was the CPI for fruit and forecasts were made using the last five years the basis for four assumptions. The first assumed that the CPI for fruit was the same as for the previous five years; the second was that the CPI for fruit was the same as for the previous five years but without the spike associated with the weather that had occurred in 2011, for these quarters, the 2012 CPI was substituted; the third was that the CPI for fruit had increased by one cent per quarter for each year being forecast; and the fourth was that the CPI for fruit had increased by five cents per quarter for each year being forecast. Figure 5.11 shows the effect of these assumptions. When the spike that occurred in the CPI for fruit in 2011 is part of the forecast, it is reflected with a corresponding predicted decrease in 2017 and that effect doesn't occur when CPI has changed so that no spike occurs. The increase by one cent a quarter and five cents a quarter for each year of the forecasted values shows a slight flattening of the predicted consumption patterns but as the effect of the CPI and the date were both very small and predicted relatively little of the variance, this very small change would be expected.

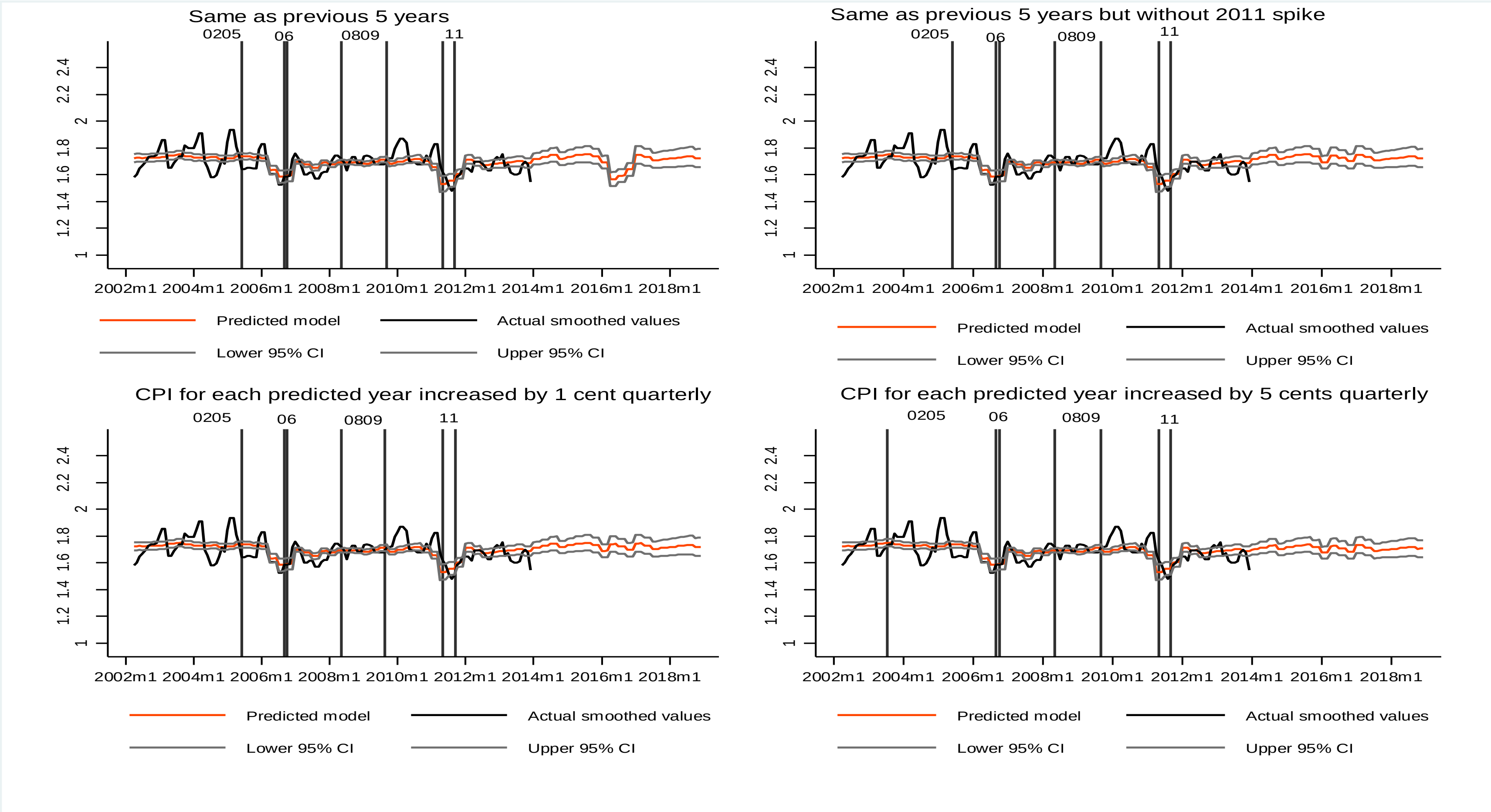


Figure 5.11 Predicted values for mean consumption of fruit with 95% CI by different CPI estimates quarterly and times Go for 2 ‘n’ 5 campaigns were running, 2014-2018 based on HWSS 2002-2013

5.5 FAST FOOD CONSUMPTION AND BMI

This section examines the trends over time for the consumption of fast food and for BMI. These variables were examined together as evidence has suggested they are related (Miller, Joyce, Carter, & Yun, 2014; Viner & Cole, 2006).

5.5.1 Fast food consumption trends by age and gender

The number of times that fast food is eaten per week has been steadily declining for both males and females over time (Table 5.9).

Table 5.9 Mean number of times fast food is consumed weekly by gender, HWSS 2002-2013

	Fast food per week	
	Females	**Males**
Year	**Mean (95%CI)**	**Mean (95%CI)**
2002	0.83 (0.76,0.89)	1.30 (1.20,1.39)
2003	0.74 (0.71,0.78)	1.15 (1.08,1.21)
2004	0.76 (0.70,0.83)	0.97 (0.90,1.04)
2005	0.64 (0.60,0.68)	0.97 (0.90,1.03)
2006	0.60 (0.56,0.63)	0.90 (0.81,1.00)
2007	0.55 (0.52,0.58)	0.92 (0.84,1.01)
2008	0.53 (0.49,0.56)	0.82 (0.76,0.88)
2009	0.52 (0.48,0.55)	0.80 (0.75,0.85)
2010	0.55 (0.51,0.59)	0.84 (0.78,0.91)
2011	0.50 (0.46,0.54)	0.75 (0.69,0.82)
2012	0.41 (0.38,0.45)	0.68 (0.62,0.74)
2013	0.40 (0.37,0.42)	0.69 (0.62,0.76)

Unobserved Components Models (UCM) conducted weekly consumption of fast food found no seasonal effects or cycles. The raw data time series for the mean number of times fast food is eaten a week is shown in Figure 5.12.

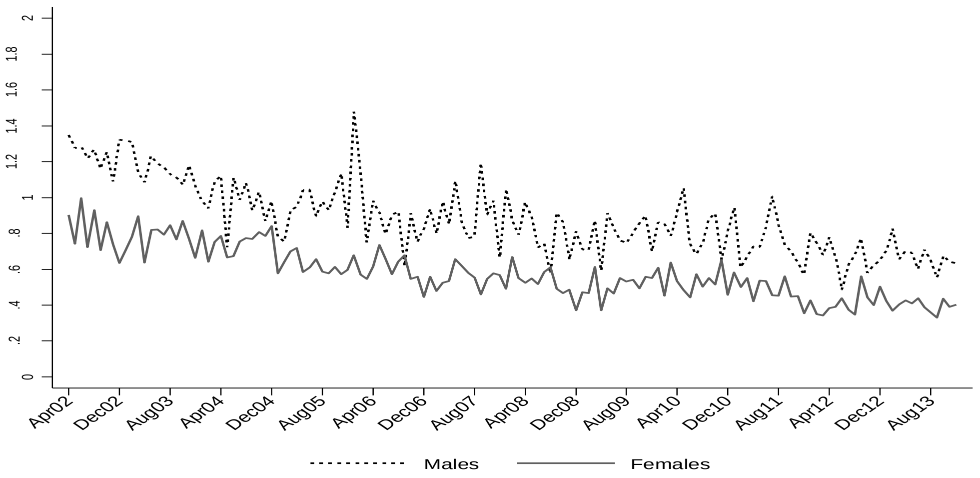


Figure 5.12 Graph of time series for times fast food eaten weekly by gender, April 2002 to December 2013, HWSS

The number of times fast food is consumed weekly changes by gender and age group Figure 5.13.

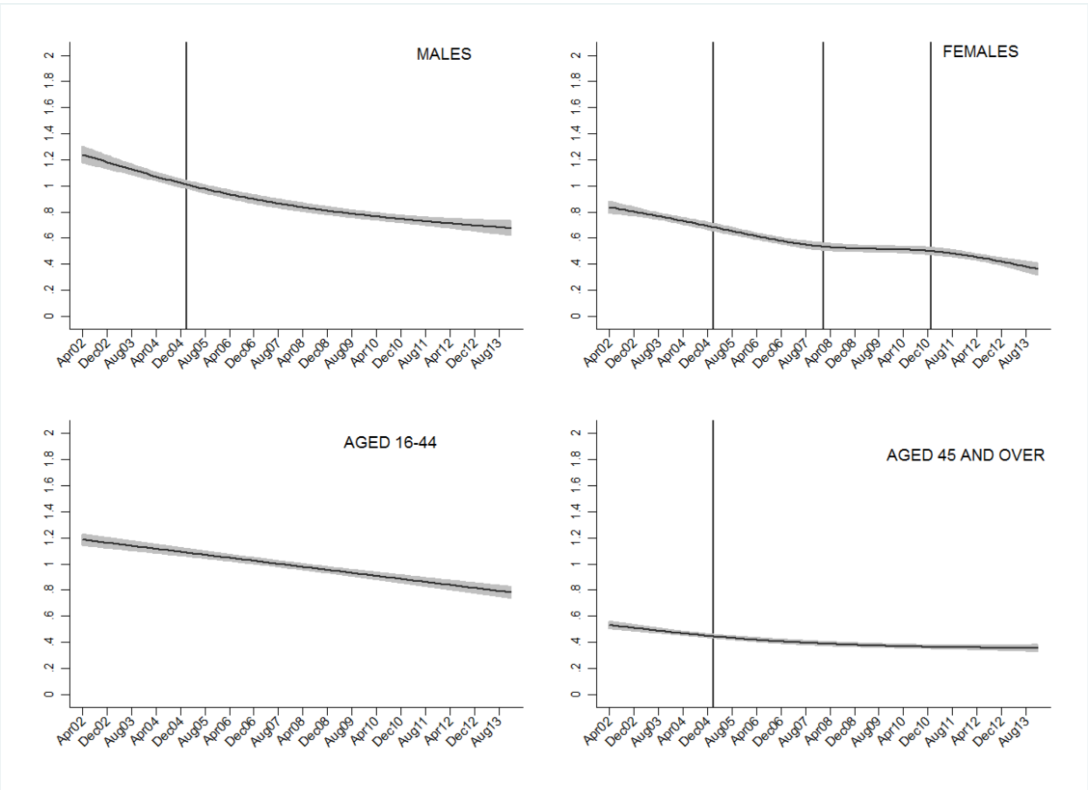


Figure 5.13 Fitted curves showing the pattern of mean weekly consumption of fast food by sex and age over time, April 2002 to December 2013

Both males and young people eat fast food more often a week than females and people aged forty-five years and over. For females there are three changes in the rate of change, one in February 2005 showing an increasing rate of decline, one in February 2008 showing a slowing down of the rate of decline and a slight increase in consumption and one in January 2011 showing an increase in the rate of decline. Males and people aged forty-five and over also show a change in the trajectory over time and both occur at February 2005. However for males, the change is a slowing down of the rate of decline in weekly consumption whereas for people aged forty-five and over it shows a slight increase both in the rate of change and the direction, indicating an increase in consumption over time for this age group. All the groups showed a linear downward trend in times fast food was consumed weekly. Table 5.10 shows the regression outcome for females, reflecting the three changes in the rate of change. The model was a good fit (r^2=0.76, p<0.0001) with no serial autocorrelation (χ2=0.7, p=80). For females, the most influential event was the GFC which was associated with a decrease in weekly consumption.

Table 5.10 Regression of associations with trends over time for females for mean times fast food consumed weekly, HWSS 2002-2013

Females	**Coef.**	**95% CI**	**SE**	**t**	***p***	**β**
No Global Financial Crisis	-0.12	(-0.13,-0.11)	0.01	-20.36	<0.0001	-0.85
Global Financial Crisis (06/2007-12/2008)	-0.27	(-0.51,-0.03)	0.12	-2.19	0.030	-0.09
First trajectory change (02/08)	-0.02	(-0.03,-0.01)	0.01	-3.73	<0.0001	-0.16
Second trajectory change (02/08)	0.01	(-0.00,-0.02)	0.01	1.83	0.069	0.08
Third trajectory change (01/11 2011)	-0.01	(-0.02, -0.00)	0.01	-2.12	0.036	-0.09
Constant	0.58	(0.57,0.59)	0.01	96.13	<0.0001	

Changes in the rate of the trajectory, either upward or downward were not associated with any campaign or with costs indicating that some other influence may have been in the environment at that time. The model for males was based on different associations shown on Table 5.11.

Table 5.11 Regression of associations with trends over time for males for mean times fast food consumed weekly, HWSS 2002-2013

Associates - males	Coef.	95% CI	SE	t	*p*	β
Date (April 2002 - Dec 2013)	-0.52	(-0.70,-0.33)	0.09	-5.55	<0.0001	-2.47
Go for 2 & 5® (04/02-06/05)	1.99	(1.19,2.79)	0.04	4.91	<0.0001	4.24
Go for 2 & 5® (04/02-06/05)/Date interaction	2.47	(1.47,3.47)	0.51	4.9	<0.0001	6.81
Go for 2 & 5® (05/08-09/09)	-0.21	(-0.28, -0.14)	0.04	-5.82	<0.0001	-0.33
First trajectory change (02/05)	-0.26	(-0.42, -0.10)	0.08	-3.17	0.002	-1.25
Second trajectory change (02/08)	0.12	(.04, .019)	0.04	3.19	0.002	0.56
Constant	2.95	(2.81,3.08)	0.07		<0.0001	

For males, the Go for 2 & 5® run during 2002 to 2005 and again in 2006 were associated with increases in mean times fast food was eaten weekly and were the variables that most influenced the model, followed by time. By contrast the Go for 2 & 5® run in 2008-2009 was associated with a decrease in consumption but was the least influential variable in the model. As with the model for females, the model was a good fit (r^2=0.67, p<0.0001) with no serial autocorrelation (χ2=0.2, p=67).

When the data were examined by age group the younger age group (sixteen to forty-four years) showed a decrease in weekly fast food consumption associated with the Go for 2 & 5® run during 2002 to 2005 and the Go for 2 & 5® run 2008-2009, but an increase in weekly fast food consumption associated with the Go for 2 & 5® run during 2011 (Table 5.12).

Table 5.12 Regression of associations with trends over time for adults aged 16-44 years for mean times fast food consumed weekly, HWSS 2002-2013

Associates - adults aged 16-44 years	Coef.	95% CI	SE	t	*p*	β
Date (April 2002 - Dec 2013)	-0.003	(-0.00,-0.002)	0.003	-11.02	<0.0001	-0.69
Go for 2 & 5® (05/08-09/09)	-0.07	(-0.13,-0.003)	0.03	-2.07	0.041	-0.13
Go for 2 & 5® (05/11-09/11)	0.10	(-0.01,-0.22)	0.06	1.77	0.079	0.11
Constant	2.67	(2.34,2.98)	0.15	17.52	<0.0001	

The biggest influence on the model was time showing a small decrease (β=-0.69). The original model showed serial no autocorrelation (χ2=22, p=14) and was a reasonable fit with the data (r^2=0.48, p<0.0001).

For adults aged 45 years and over change over time was the biggest influence in the model (β=-0.64) and also the variable associated with the biggest decrease. As with the younger adult group the Go for 2 & 5®, run 2008-2009, was associated with a decrease in weekly consumption (Table 5.13). The model was a reasonable fit (r2=0.48, p<0.0001).

Table 5.13 Regression of associations with trends over time for adults aged 45 years and over for mean times fast food consumed weekly, HWSS 2002-2013

Associates - adults aged 45 years & over	Coef.	95% CI	SE	t	p	β
Date (April 2002 - Dec 2013)	-0.05	(-0.06,-0.04)	0.004	-10.41	<0.0001	-0.64
Go for 2 & 5® (05/08-09/09)	-0.03	(-0.06,-0.01)	0.010	-2.29	0.023	-0.15
First trajectory change (02/05)	-0.01	(-0.02,-0.002)	0.004	-2.50	0.014	-0.16
Constant	0.42	(0.41,0.43)	0.004	87.41	<0.0001	

Figure 5.14 shows the predicted values for mean number of times fast food consumed weekly by males, female, adults aged 16-44 and adults aged 45 and over. The lines indicate the point where the rate changes. With the exception of females, the changes in the rate were a faster decrease. For females in February 2008, the change indicated a slight increase but this was changed to a decrease in January 2011. At the same time as these downward trends over time for fast food consumption, there has been an increase in the mean BMI for both males and females. Table 5.15 presents the mean BMI for WA adults aged 16 years and over by gender comparing the three estimates, uncorrected for over-reporting height and over-reporting weight; the 2008 correction application and the 2011 correction estimates. The 2011 correction estimates is closer to the unadjusted BMI as people were making fewer reporting errors about height and for males also about weight (Hayes et al., 2011).

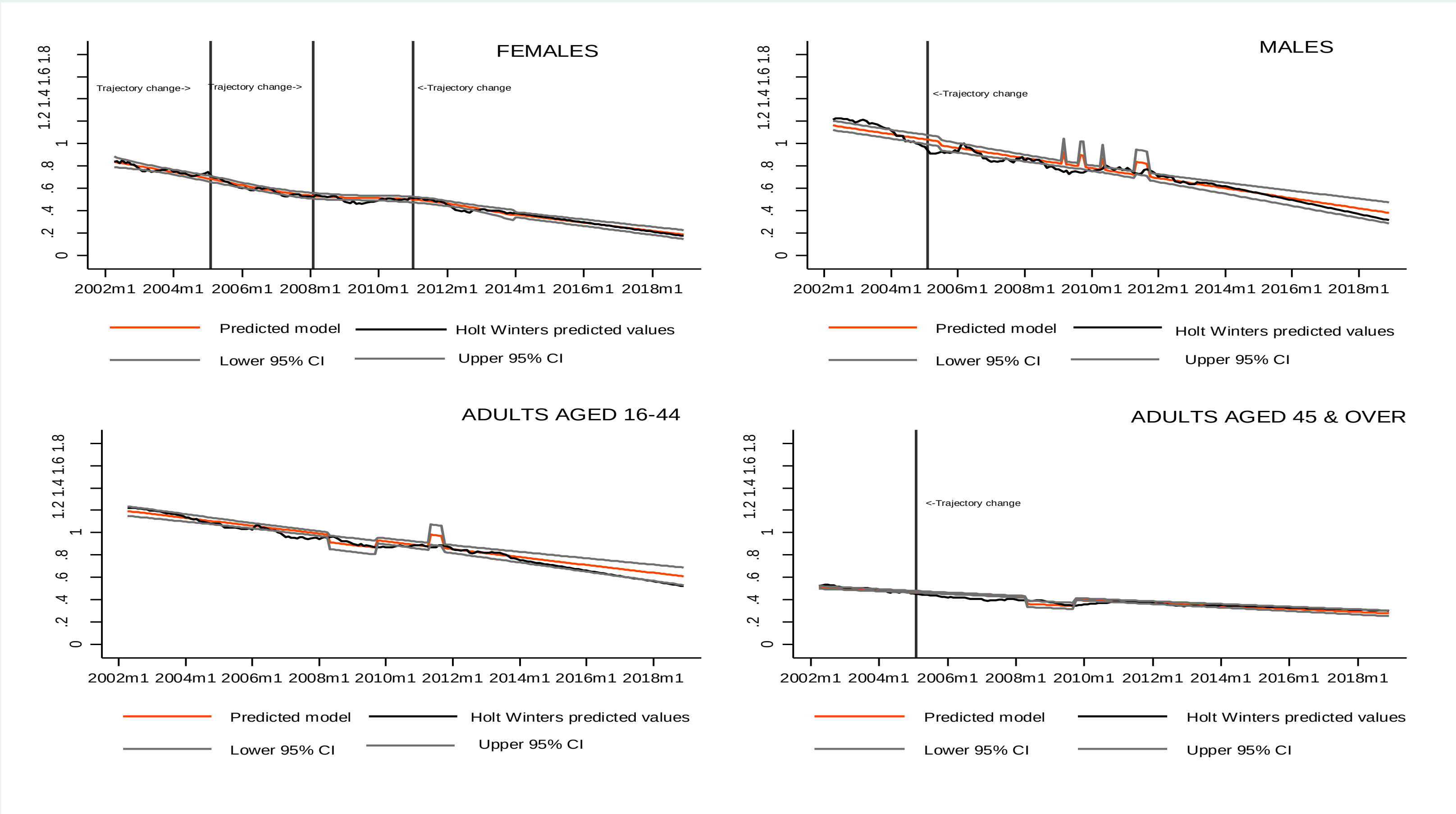


Figure 5.14 Predicted mean weekly consumption of fast food by gender and age over time compared with predicted estimates fitted by locally weighted regression using Holt Winters, 2014-2018 based on HWSS 2002-2013

Table 5.14 Mean BMI by gender and year with unadjusted and adjusted estimates, HWSS 2002-2013

	Females			Males		
	Unadjusted	**Adjusted using 2008 formula**	**Adjusted using 2011 formula**	**Unadjusted**	**Adjusted using 2008 formula**	**Adjusted using 2011 formula**
Year	Mean (95%CI)	Mean (95%CI)	Mean (95%CI)	Mean (95%CI)	Mean (95%CI)	Mean (95%CI)
2002	24.89 (24.64,25.15)	26.32 (26.05,26.59)	25.53 (25.27,25.78)	25.82 (25.58,26.06)	27.03 (26.78,27.28)	26.32 (26.07,26.56)
2003	24.79 (24.56,25.02)	26.23 (25.98,26.47)	25.43 (25.19,25.66)	25.63 (25.41,25.85)	26.84 (26.61,27.07)	26.13 (25.91,26.36)
2004	25.15 (24.81,25.50)	26.60 (26.24,26.96)	25.80 (25.45,26.15)	26.17 (25.88,26.46)	27.39 (27.09,27.70)	26.68 (26.39,26.98)
2005	25.18 (24.94,25.41)	26.65 (26.40,26.89)	25.86 (25.62,26.10)	26.16 (25.94,26.37)	27.39 (27.16,27.61)	26.69 (26.47,26.90)
2006	25.55 (25.31,25.78)	27.02 (26.78,27.27)	26.23 (26.00,26.47)	26.61 (26.36,26.86)	27.86 (27.60,28.12)	27.17 (26.92,27.43)
2007	25.47 (25.22,25.72)	26.93 (26.66,27.19)	26.14 (25.89,26.40)	26.58 (26.27,26.89)	27.82 (27.49,28.14)	27.12 (26.81,27.44)
2008	25.55 (25.30,25.80)	27.02 (26.76,27.28)	26.25 (26.00,26.50)	26.50 (26.23,26.77)	27.73 (27.45,28.01)	27.05 (26.78,27.32)
2009	25.71 (25.51,25.92)	27.18 (26.97,27.40)	26.39 (26.18,26.60)	26.68 (26.48,26.88)	27.93 (27.71,28.14)	27.23 (27.02,27.43)
2010	25.84 (25.61,26.07)	27.31 (27.07,27.55)	26.53 (26.30,26.76)	26.80 (26.55,27.05)	28.05 (27.79,28.31)	27.37 (27.12,27.62)
2011	25.95 (25.71,26.18)	27.43 (27.18,27.67)	26.67 (26.44,26.91)	26.98 (26.74,27.23)	28.24 (27.98,28.49)	27.57 (27.32,27.82)
2012	26.34 (26.10,26.58)	27.84 (27.59,28.09)	27.10 (26.85,27.34)	26.83 (26.57,27.09)	28.06 (27.79,28.33)	27.41 (27.15,27.67)
2013	26.33 (26.07,26.59)	27.82 (27.54,28.09)	27.07 (26.81,27.34)	26.99 (26.74,27.24)	28.24 (27.98,28.50)	27.61 (27.35,27.86)

Even given this updated adjustment, no mean estimate was within the normal range although up to 2005, the mean BMI had a lower confidence limit which was within the normal range. Since 2005 all means and confidence limits are within the grade one overweight category of BMI. For both men and women there has been an upward trend in mean BMI since 2002 with greater increases for women. Unobserved Components Models (UCM) found no seasonal effects or cycles for BMI. As the analysis is also being conducted on BMI in relation to socio economic disadvantage, Table 5.15 shows the mean BMI adjusted using the 2011 adjustment formulae for 2002 to 2013 by SEIFA quintile.

Table 5.15 Mean BMI by SEIFA Quintile and year, HWSS 2002-2013

Year	SEIFA Quintile 1	SEIFA Quintile 2	SEIFA Quintile 3	SEIFA Quintile 4	SEIFA Quintile 5
2002	26.90 (26.22,27.58)	26.83 (26.34,27.32)	26.28 (25.87,26.70)	25.94 (25.56,26.32)	25.57 (25.30,25.84)
2003	26.44 (25.98,26.89)	26.79 (26.29,27.28)	26.41 (26.03,26.80)	25.90 (25.51,26.28)	25.24 (25.01,25.48)
2004	26.89 (26.49,27.29)	26.73 (26.26,27.21)	26.57 (25.99,27.15)	26.44 (26.05,26.84)	25.90 (25.50,26.30)
2005	26.90 (26.49,27.31)	26.77 (26.39,27.15)	26.52 (26.09,26.95)	26.92 (26.60,27.24)	25.63 (25.39,25.87)
2006	27.29 (26.85,27.74)	27.83 (27.30,28.36)	26.60 (26.18,27.02)	27.20 (26.83,27.56)	26.07 (25.81,26.34)
2007	27.48 (26.98,27.97)	27.57 (27.07,28.08)	27.11 (26.65,27.57)	26.77 (26.31,27.22)	26.06 (25.76,26.36)
2008	26.98 (26.56,27.40)	27.24 (26.80,27.67)	27.02 (26.61,27.44)	27.14 (26.71,27.57)	26.06 (25.78,26.33)
2009	27.61 (27.18,28.05)	27.8 (27.39,28.22)	27.37 (26.97,27.77)	26.89 (26.59,27.18)	26.24 (26.02,26.46)
2010	27.71 (27.26,28.16)	27.54 (27.09,28.00)	27.05 (26.68,27.42)	27.27 (26.92,27.61)	26.54 (26.26,26.83)
2011	28.01 (27.45,28.57)	27.82 (27.29,28.34)	27.06 (26.71,27.41)	27.32 (26.97,27.67)	26.80 (26.52,27.08)
2012	27.93 (27.27,28.59)	28.05 (27.47,28.64)	27.42 (27.04,27.81)	27.63 (27.30,27.96)	26.66 (26.36,26.95)
2013	27.38 (26.74,28.02)	27.49 (27.08,27.90)	27.97 (27.53,28.41)	27.48 (27.12,27.84)	26.58 (26.26,26.91)

Generally, as the SEIFA quintile goes from most socially disadvantaged (Quintile one) to least socially disadvantaged (Quintile five) the BMI decreases (Figure 5.15).

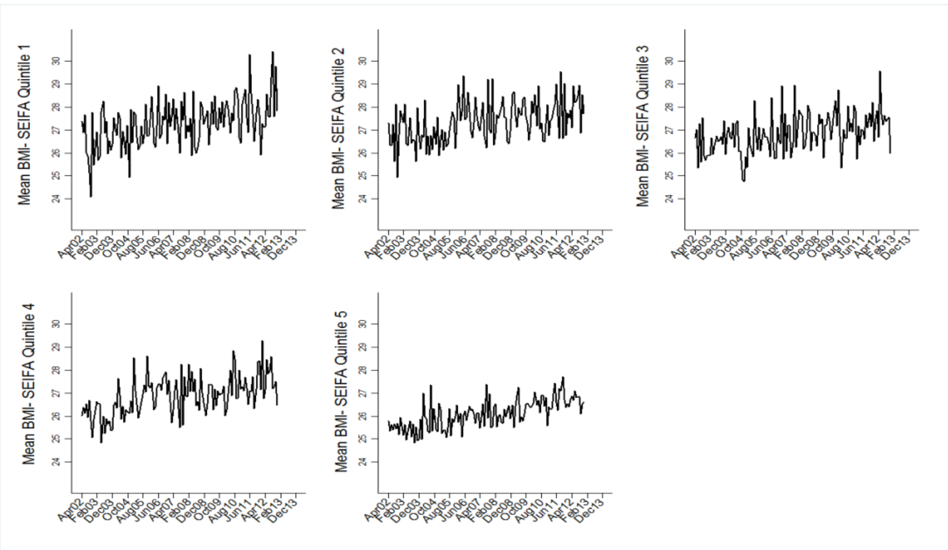


Figure 5.15 Graph of time series BMI by SEIFA, April 2002 to December 2013, HWSS

5.5.2 BMI trends by gender

BMI shows a linear upward trend for both males and females with females showing a slightly higher rate of increase (Figure 5.16).

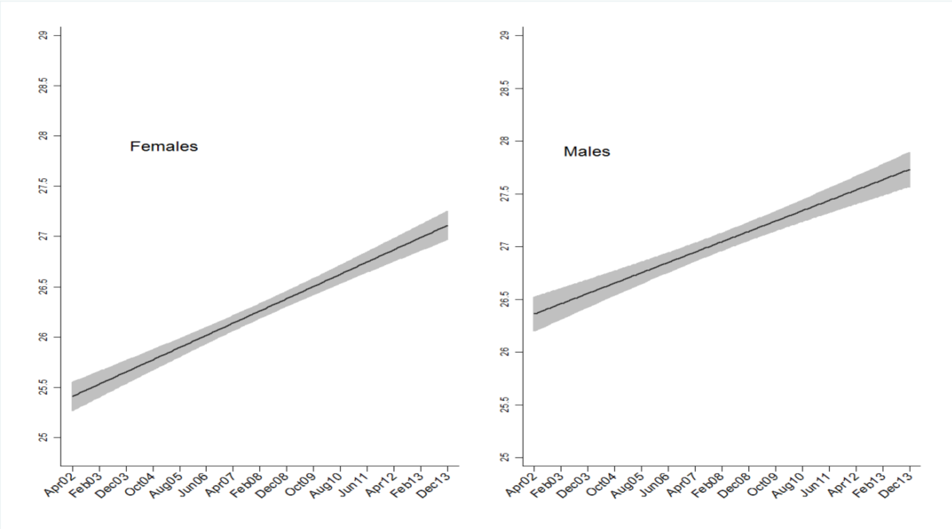


Figure 5.16 Fitted curves showing the pattern of mean BMI by gender over time, April 2002 to December 2013

Table 5.16 shows the regression outcome for females. The model was a good fit (r^2=0.61, p<0.0001) with no serial autocorrelation (χ2=0.02, p=0.89). The Go for 2 & 5® run during September and October 2006 was positively associated with BMI but was the least influential in the model (β=0.05). Time was the most influential variable in the model (β=0.80) and positively associated with BMI. The Measure up campaign run during October 2010 to June 2011 was significantly associated with BMI (β =-0.15, *p*<0.02).

Table 5.16 Regression of associations with trends over time for females for mean BMI, HWSS 2002-2013

Associates - females	Coef.	95% CI	SE	t	p	β
Date (April 2002 - Dec 2013)	0.01	(0.00-0.01)	0.00	14.8	<0.0001	0.80
Go for 2 & 5® (09/06-10/06)	0.79	(0.52,2.12)	0.41	3.26	<0.0001	0.01
Measure up (10/10-06/11)	-0.41	(0.01,0.06)	0.01	2.31	0.022	-0.15
Constant	18.86	(17.87,19.85)	0.12	199.22	<0.0001	

Table 5.17 shows the variables associated with BMI for males over time. The model was a reasonable fit (r^2=0.44, p<0.0001) with no serial autocorrelation (χ2=1.78, *p*=0.11). The Go for 2 & 5® run during 2002 to 2005 was negatively

associated with BMI whereas time was positively associated with BMI. Both were approximately equally influential (β=0.38 for date compared with β=0.33 for the campaign).

Table 5.17 Regression of associations with trends over time for males for mean BMI, HWSS 2002-2013

Associates - males	Coef.	95% CI	SE	t	p	β
Date (April 2002 - Dec 2013)	0.01	(0.00-0.01)	0.00	3.79	<0.0001	0.38
Go for 2 & 5® (04/02-06/05)	-0.46	(-0.74,-0.18)	0.14	-3.28	0.001	-0.33
Constant	23.79	(21.96,25.62)	0.93	25.71	<0.0001	

Figure 5.17 shows the predicted trends for the next five years by gender. Although the regression suggested a linear relationship, the relationship is not straightforward because when Holt Winters smoothing is applied to the data, the increase noted for males appears to be slowing down with a suggestion that BMI might be decreasing, whereas the trend for females is linear and shows no evidence of slowing down.

5.5.3 BMI by SEIFA quintile

As with gender, BMI shows an upward generally linear trend over time for each of the SEIFA quintiles when examined using fractional polynomial estimates (Figure 5.18).

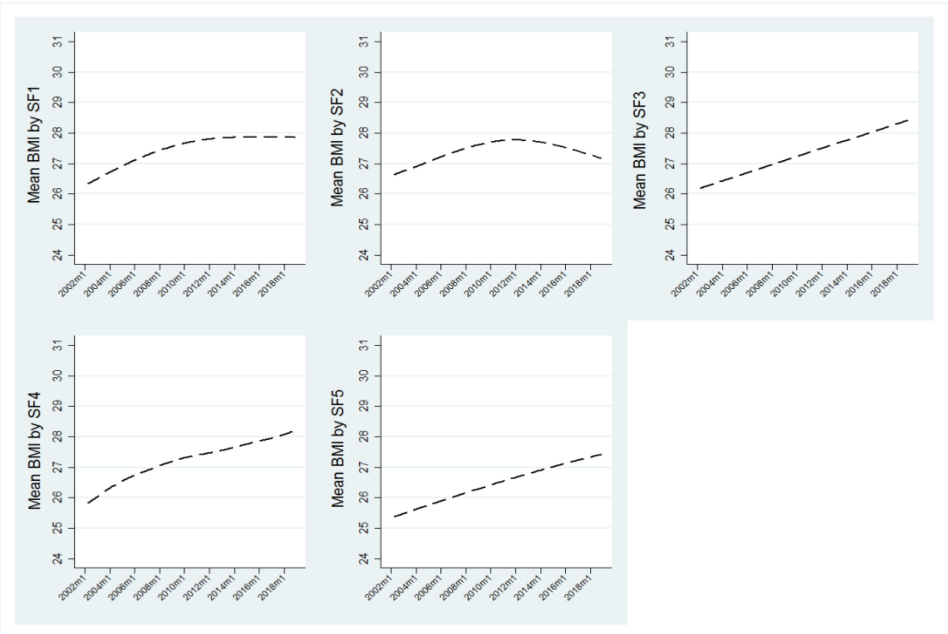


Figure 5.17 Fitted curves using fractional polynomial estimates showing the pattern of mean BMI by SEIFA Quintile over time, April 2002 to December 2013

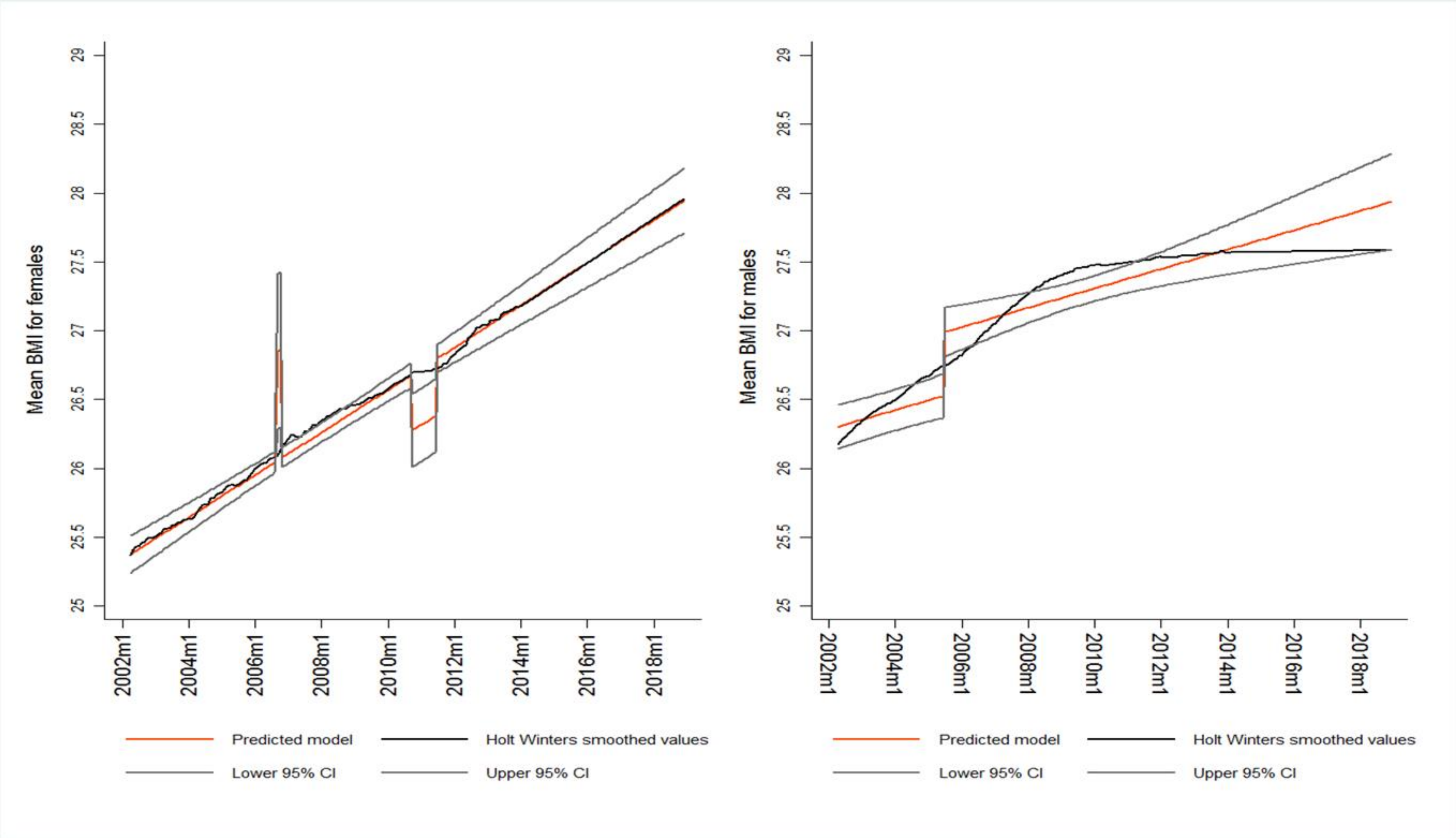


Figure 5.18 Predicted mean BMI by gender over time compared with predicted estimates fitted by locally weighted regression using Holt Winters, 2014-2018 based on HWSS 2002-2013

However, when Holt Winters smoothing is applied to the data, the trends look less linear with four of the five quintiles showing that slowing down of the linear upward trend (Figure 5.19). The only quintile that shows the increase continuing is quintile three.

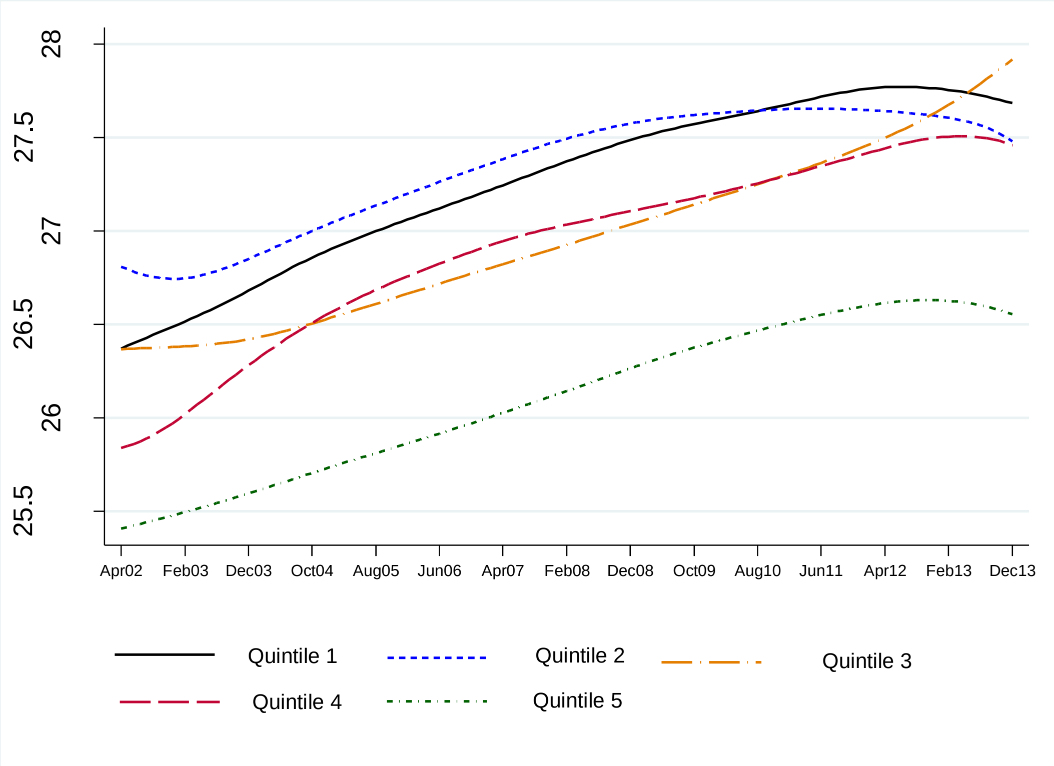


Figure 5.19 Fitted curves using Holt Winters smoothing showing the pattern of mean BMI by SEIFA Quintile over time, April 2002 to December 2013

Table 5.18 shows the variables associated with BMI for SEIFA quintile one over time. The model was a fair fit (r^2=0.20, p<0.0001) with no serial autocorrelation (χ2=0.27, p=0.60).

Table 5.18 Regression of associations with trends over time for SEIFA quintile one for mean BMI, HWSS 2002-2013

Associates - Quintile one	Coef.	95% CI	SE	t	*p*	β
Date (April 2002 - Dec 2013)	0.01	(0.01,0.40)	0.002	5.2	<0.0001	0.40
Live Lighter (06/12-10/12)	0.001	(0.00,0.002)	0.001	1.96	0.052	0.15
Constant	21.59	(19.43,23.5)	1.09	19.75	<0.0001	

The Live Lighter campaign run from June to October 2012 was positively associated with BMI as was time. The Live Lighter campaign had much less influence on the trend compared with time (β=0.40 for date compared with β=0.15 for the campaign).

Table 5.19 shows the variables associated with BMI for SEIFA quintile two over time. The model was a fair fit (r^2=0.18, p<0.0001) with no serial autocorrelation (χ2=0.80, p=0.37).

Table 5.19 Regression of associations with trends over time for SEIFA quintile two for mean BMI, HWSS 2002-2013

Associates - Quintile two	Coef.	95% CI	SE	t	p	β
Date (April 2002 - Dec 2013)	0.01	(0.00,0.01)	0.001	4.01	<0.0001	0.32
Live Lighter (06/12-10/12)	0.76	(-0.08,1.60)	0.43	1.78	0.077	0.14
Constant	23.32	(21.33,25.30)	1.00	23.27	<0.0001	

The Live Lighter campaign run from June to October 2012 was positively associated with BMI as was time. The Live Lighter campaign had much less influence on the trend compared with time (β=0.32 for date compared with β=0.14 for the campaign).

Table 5.20 shows that the only variable associated with BMI for SEIFA quintile three was time. The model was a fair fit (r^2=0.22, p<0.0001) with no serial autocorrelation (χ2=2.24, p=0.13).

Table 5.20 Regression of associations with trends over time for SEIFA quintile three for mean BMI, HWSS 2002-2013

Associates - Quintile three	Coef.	95% CI	SE	t	*p*
Date (April 2002 - Dec 2013)	0.01	(0.007,0.010)	0.001	6.43	<0.0001
Constant	20.74	(18.82,22.65)	0.97	21.43	<0.0001

Table 5.21 shows the variables associated with BMI for SEIFA quintile four over time. The model was a reasonable fit (r^2=0.32, p<0.0001) with no serial autocorrelation (χ2=1.75, p=0.18). The Go for 2 & 5 run during 2002 to 2005 was negatively associated with BMI whereas time was positively associated with BMI. Both were approximately equally influential (β=0.28 for date compared with β=-0.31 for the campaign).

Table 5.21 Regression of associations with trends over time for SEIFA quintile four for mean BMI, HWSS 2002-2013

Associates - Quintile four	Coef.	95% CI	SE	t	*p*	β
Date (April 2002 - Dec 2013)	0.01	(0.00-0.01)	0.002	2.6	0.01	0.28
Go for 2 & 5® (04/02-06/05)	-0.60	(-1.01,-0.19)	0.21	-2.89	0.004	-0.31
Constant	23.69	(21.01,26.38)	1.36	17.44	<0.0001	

Table 5.22 shows the variables associated with BMI for SEIFA quintile five over time. The model was a reasonable fit (r^2=0.44, p<0.0001) with no serial autocorrelation (χ2=0.90, p=0.34). Both time and the CPI for fruit were positively associated with BMI but date was more influential in the mode (β=0.47 for date compared with β=0.24 for the fruit CPI).

Table 5.22 Regression of associations with trends over time for SEIFA quintile five for mean BMI, HWSS 2002-2013

Associates - Quintile five	Coef.	95% CI	SE	t	*p*	β
Date (April 2002 - Dec 2013)	0.01	(0.00-0.01)	0.001	5.18	<0.0001	0.47
CPI for fruit	0.01	(0.002,0.02)	0.21	2.68	0.008	0.24
Constant	21.19	(19.88,22.50)	0.66	32.0	<0.0001	

Figure 5.20 shows the predicted trends for the next five years for each SEIFA quintile. As with gender, the relationship over time although generally linear is not the same for each quintile. Figure 5.21 shows the Holt Winter predicted values over the next five years for each SEIFA quintile to more clearly expose the ways in which the predictions differ.

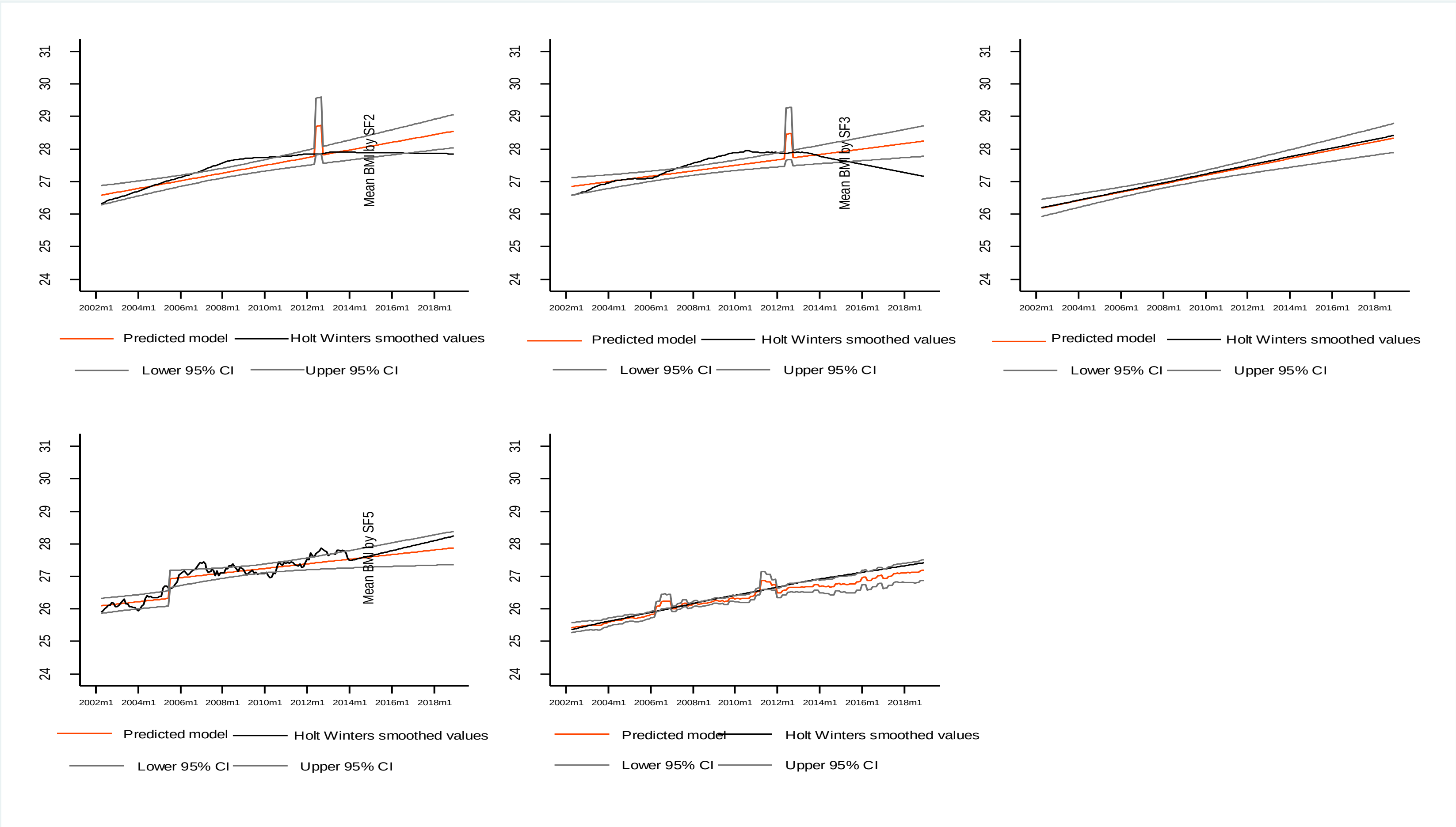


Figure 5.20 Predicted mean BMI by SEIFA Quintile over time compared with predicted estimates fitted by locally weighted regression using Holt Winters, 2014-2018 based on HWSS 2002-2013

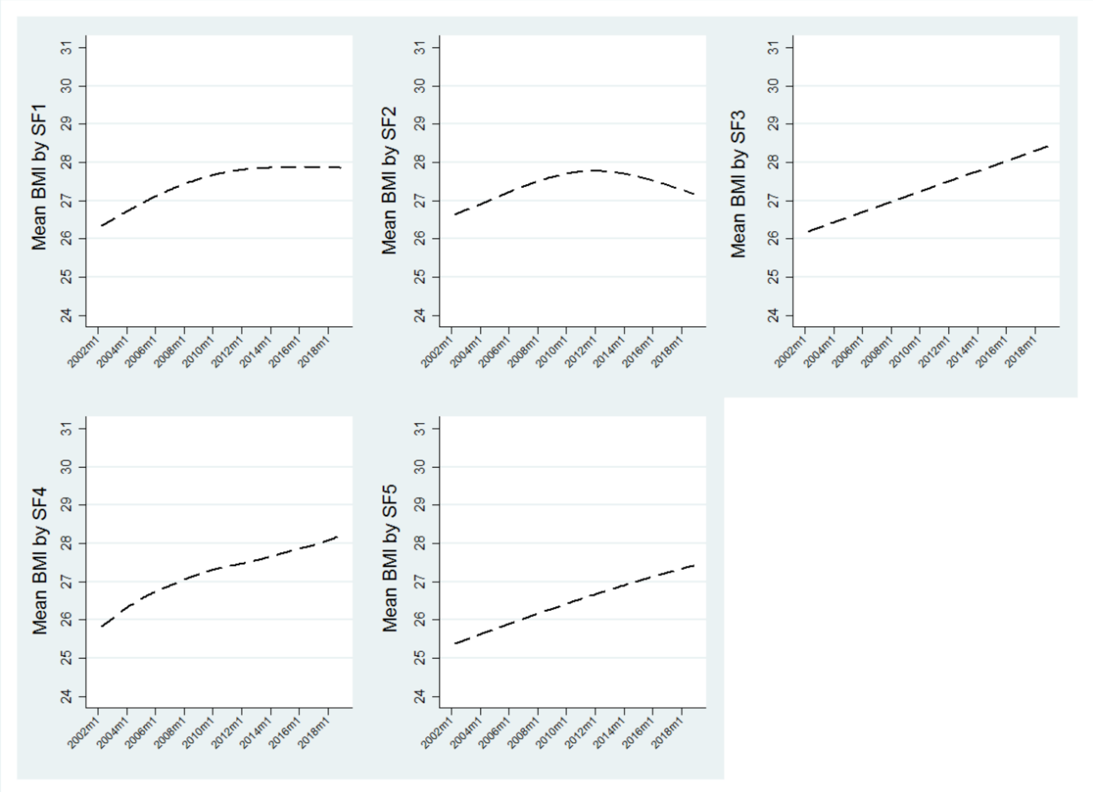


Figure 5.21 Predicted mean BMI by SEIFA Quintile over time using Holt Winters smoothing, 2014-2018 based on HWSS 2002-2013

For quintiles three, four and five, the trend over time is linear but for quintiles one and two, the trajectory changes to flatten out for quintile one and to start showing a decrease for quintile two. Mean BMI for quintiles three and four will catch up to and over take quintiles one and two in the next five years if the current trends persist. Quintile five still looks as if it will remain below a mean BMI of 28 in the next five years. All quintiles suggest that achieving a mean BMI of 24.9, the upper end of the normal weight range, is unlikely to happen in the next five years unless there is a major shift in the WA population weight.

5.5.4 Granger Causality

The test for the optimal number of lags for fruit and vegetable consumption suggested two. In this time series, each lag is equivalent to the mean for the proceeding month. The Granger causality tests for fruit and vegetable consumption controlling for the CPI for each as well as the Go for 2 & 5®

campaigns, found a significant sequential association between the first Go for 2 & 5® run from April 2005 to June 2005 for both genders (males: χ=12.78, *p*=0.002; females χ=23.39, *p*=<0.001). The association was stronger for the first lag for males but stronger for the second lag for females (Table 5.23).

Table 5.23 Granger Causality test for daily consumption of vegetables and Go for 2 & 5® 2002-2005, HWSS 2002-2013

Daily vegetable consumption						
Males	**Coef.**	**95% CI**		**SE**	**z**	***p***
Lag 1 (one month)	-0.08	-0.15	-0.01	0.04	-2.28	0.023
Lag 2 (two months)	-0.07	-0.14	0.00	0.03	-1.94	0.052
Females						
Lag 1 (one month)	-0.10	-0.2	0.00	0.05	-1.91	0.057
Lag 2 (two months)	-0.18	-0.27	-0.08	0.05	-3.54	<.0001

For BMI and fast food consumption, the Granger causality tests were conducted on persons as there were no differences in trends over time. The analysis found that the history of takeaway consumption is significantly associated with current BMI. The time series suggested that there were two lags associated with fast food consumption and BMI (Table 5.24). In this time series, each lag is equivalent to the mean for the preceding month. For fast food consumption, it is the length of the history of consumption that is associated with increasing BMI with the results showing that at least two months precede a significant increase in BMI (χ=7.17, *p*=0.028).

Table 5.24 Granger Causality test using of BMI and number of times fast food eaten weekly, HWSS 2002-2013

Mean number of times fast food eaten weekly						
Lags	**Coef.**	**95% CI**		**SE**	**z**	***p***
Lag 1 (one month)	-0.47	-1.26	0.03	0.41	-1.15	0.25
Lag 2 (two months)	-0.78	-1.55	-0.01	0.39	-2.00	0.05

There is a reciprocal association in the converse order where prior BMI is significantly associated with current fast food consumption (χ=12.92,

p=0.002). The reciprocal relationship is significant but as Table 5.25 shows over a shorter interval (one month).

Table 5.25 Granger Causality test using weekly fast food consumption and BMI, HWSS 2002-2013

Mean BMI						
Lags	**Coef.**	**95% CI**		**SE**	**z**	***p***
Lag 1 (one month)	-0.06	-0.10	-0.03	0.02	-3.36	0.001
Lag 2 (two months)	-0.02	-0.06	0.02	0.02	-1.06	0.290

The asymmetry of the two results can be interpreted in terms of the definition of causation used by Granger to suggest that frequent consumption of fast food causes an increase in BMI.

5.5.5 Summary of changes over time associated with fruit, vegetables, fast food and BMI

For fruit and vegetables, the forecast showed that without any changes over time, or with only changes related to cost for fruit, there is likely to be a continuing decrease in the mean consumption of both. The time series also showed that the first Go for 2 & 5® was positively associated with increases in the consumption of vegetables for both genders and was also associated with changes for the target age group twenty-five to sixty-four years. For all groups, it was the most influential variable in the model with the highest standardised coefficients. This same campaign run in 2008 and 2009 had the opposite association with decreases for all groups and some of this may be due to costing at least where fruit is concerned. It may also be due to the way in which the message was delivered as the Go for 2 & 5® had variable amounts and types of media coverage and variable amounts of other points of information such as stickers, posters and recipes.

For fast food, the Go for 2 & 5® was positively associated with fast food consumption for females during the first campaign period of 2002 to 2005. It is unlikely that a saturation campaign designed to increase consumption of fruit and vegetables and overall healthy eating is causally related to increased consumption of fast food when in 2008-2009 for all groups, this campaign is negatively associated with eating fast food. It may be that there was an increase in the number of fast food outlets in WA in this period. For all groups, this was the period of highest fast food consumption. The forecast shows that fast food consumption will decline providing circumstances remain the same as they currently are in WA. The opening of more fast food outlets may change the predicted trajectories. The Holt Winter predicted values are lower than those produced by the regression model and that outcome would be expected as the regression model includes other possible sources of variation than time alone. However, both show a linear downward trend.

Mean BMI shows an upward trend over time for females and for most SEIFA quintiles. For males and for people living in SEIFA quintile areas one and two, there appears to be a slowing down of the increase and for males and those living in SEIFA quintile area two, a predicted downward turn in mean BMI which look set to occur within the next two years. The health promotion campaigns Go for 2 & 5® run from 2002 to 2005 and Measure up run from June to September 2010 both were associated with a decrease in mean BMI. The Live Lighter campaign was also significantly associated with mean BMI but it was associated with an increase not a decrease for people living in SEIFA quintiles one and two. It is not clear why this might be the case nor why the CPI for fruit was associated with an increase in mean BMI for people living SEIFA quintile five areas. The findings, along with the coefficients of determination which were less than 50% for most models, suggest that the factors driving BMI are not fully represented in the measures available to use in temporal models. Other population based research suggests that at the population level, environment both social (Calzo et al., 2012; Cruwys, Bevelander, & Hermans, 2015; Robinson et al., 2014) and physical (Cetateanua & Jones, 2014; Miller et al., 2014; Patz, Frumkin, Holloway, Vimont, & Haines, 2014) influence BMI. There is also evidence that family (Loth, Wall, Larson, & Neumark-Sztainer, 2015; Loth et al., 2013; Russell, Worsley, & Liem, 2015) and epigenetics (Bradfield & Taal, 2012; Sandholt, Hansen, & Pedersen, 2012) are very important influences in how people reach their BMI.

The results from this investigation are generally in line with studies projecting obesity in Australia using measures that are based on actual height and weight measurements and linking records with mortality data which are used to create life tables. These show that obesity is likely to increase by sixty-five percent by 2025 (Walls et al., 2012).

There is some evidence that the difference between the less well educated compared with those who have greater education attainment will continue to increase if the present trend continues (Backholer et al., 2012). The data in this investigation suggests that the relationship between weight and social disadvantage is less simple than demonstrated by the life table research (see Figure 5.2.1). While the lower SEIFA quintiles are, at present, in line with expected higher BMI, the projections suggest that this will not continue and that it is the population living in SEIFA quintiles three and four, the middle quintiles in terms of social disadvantage are the areas where the mean BMI is likely to increase the most. The reason for these findings is not immediately obvious and needs further investigation. There are a number of areas which might offer some clarity. In WA, there has been a mining boom which has meant that many people, particularly young males, have been doing fly-in/fly-out shift work. Shift work has previously been shown to be associated with poorer diet and obesity (Nea, Kearney, Livingstone, Pourshahidi, & Corish, 2015). While it is not investigated in this thesis, the HWSS data set does ask about shift work and fly-in/fly-out working patterns. Ten percent of the males reported that they did fly-in/fly-out work (Radomiljac & Joyce, 2014). These workers also had a higher prevalence of obesity than other workers which is consistent with the research cited above. In addition, living in the Goldfields and Pilbara mining areas, where obesity levels are at their highest, over 80% of areas within these are classified as SEIFA quintiles 3, 4, and 5 (the more advantaged socio economic areas) which are the areas where the time series analysis in this thesis shows the highest rates of increase in BMI. Finally, there may be an age bias as well as age is associated with higher rates of obesity and may reflect the aging population (Black et al., 2015; Hugo, Taylor, & Dal Grande, 2008). The Granger causality tests suggest that changes in costs and health promotion programs in current time appear to have a causal relationship for fruit and vegetable consumption only when the campaign is full saturation and long running. There was a significant temporal and reciprocal association between fast food consumption and BMI. These results do not negate the significant associations shown for the health promotion programs in the regression analysis but they do suggest that these changes were temporally related and did not persist over the whole time series period. The only changes which were persistent and consistent over time were the relationship between fast food consumption and BMI.

6 DEVELOP A METHOD TO MEASURE CHANGING DIETARY PATTERNS: ADDRESSING OBJECTIVE THREE

The third objective is to use estimates of what the adult population aged eighteen to sixty-four years ate the previous day consistent with the ADG, as measured by the NMSS to create health eating indicators and evaluate the outcomes by confirmatory factor analysis and structural equation modelling. The method and development of these indicators was accepted for publication in July 2015.

Alison Daly, Christina M Pollard, Anne Deborah Kerr, Colin William Binns, Michael Phillips "Using short dietary questions to develop valid indicators of dietary behaviour for use in surveys exploring attitudinal and/or behavioural aspects of dietary choices" ***Nutrients*** 2015, *7*, 1-x manuscripts; doi:10.3390/nu70x000x.

6.1 COPY OF PAPER DESCRIBING THE DEVELOPMENT OF HEALTHFUL EATING INDICATORS

Abstract: For countries where nutrition surveys are infrequent, there is a need to have some measure of healthful eating in the interim to plan and evaluate interventions. This study shows how it is possible to develop healthful eating indicators based on dietary guidelines from a cross sectional population survey. Adults 18 to 64 years answered questions about type and amount of foods eaten the previous day including fruit, vegetables, cereals, dairy, protein and fluids. Scores were based on serves and types of food according to an established method. Factor analysis indicated two factors, confirmed by structural equation modeling: a recommended food healthful eating indicator (RF_HEI) and a discretionary food healthful eating indicator. Both yield mean scores similar to a dietary index validated against nutrient intake. Significant associations for the RF_HEI were education, income, ability to save and attitude toward diet; and for the DF_HEI gender,not living alone, living a socially disadvantaged area and attitude toward diet. The results confirm that short dietary questions can be used to develop healthful eating indicators against dietary recommendations. This will enable the exploration of dietary behaviours for 'at risk' groups, such as those with

excess weight, leading to more relevant interventions for populations and individuals.

Keywords: dietary behaviours; healthful eating indicators; structural equation modelling**;** cross sectional

6.2 INTRODUCTION

Evidence is increasing that the need to eat well as early as possible is inextricably linked to attainment and maintenance of a healthy weight and overall good health (Barker, Eriksson, Forsén, & Osmond, 2002; Barker, 2004; Belin et al., 2011; Vaiserman, 2014). In 2011-2102 Australia conducted its second national nutrition survey which coincided with the release of the updated Dietary Guidelines for Australia in 2013 (National Health and Medical Research Council, 2013a). The first release of results from the national nutrition survey indicate that the majority of people are not eating a diet consistent with the Dietary Guidelines (Australian Bureau of Statistics, 2014a). Previous reviews have shown that influencing people to eat well is a complex and difficult process (Brambila Macias et al., 2011; Buttriss et al., 2004) and that knowledge and attitudes in line with healthy eating do not necessarily translate into behaviour (Baranowski et al., 1999). Many studies conducted have provided important information about aspects of attitudes and beliefs and behaviours surrounding good eating habits in relation to families (Bergea et al., 2013; Larson et al., 2012); socio demographics (Beydoun & Wang, 2007); predictors of disordered eating behaviours and diet (Loth et al., 2014) and attitudes towards appearance and diet (Traill et al., 2012). One of the difficulties in being able to conduct these necessary investigations in countries where dietary surveys are infrequent, such as Australia, is that there is not enough current information about eating choices. What is needed is an interim measure that captures important aspects of diet that can be used to investigate how people make decisions about what they eat. A recent study showed that it is possible to get an indicator of healthy eating choices using four items (Pot, Richards, Prynne, & Stephen, 2014) and this study is an important step in developing measures that can be used with contextual data to provide a better picture of what drives eating choices. However such measures are limited as they cannot identify areas of diet which may be more important than others in determining problems related to overeating and poor nutrition. The purpose of this study is to investigate whether or not it is possible to use the dietary information collected by the Nutrition Monitoring Survey Series(NMSS) to develop a measure of who are meeting dietary guidelines.The NMSS uses short dietary questions developed to measure consumption of key food groups (Marks et al., 2001) that have been evaluated against weighed dietary records (Riley et al., 2001; Rutishauser et al., 2001).The questions are used to monitor high level population based adherence to the Australian Dietary Guidelines. These questions are not a measure of dietary intake nor are they a measure of nutrients, rather they are indicators of consumption of selected foods taken from the major food groups recommended for daily consumption. The underlying premise in using these questions to develop a healthful eating indicator is such an indicator can be viewed as a latent measure of diet quality. If the population is eating recommended serves and types of foods based on dietary guidelines, then they, by definition, must be eating a reasonable quality of diet. While imperfect, this latent assessment of diet quality can be used as a benchmark against which to assess the dietary behaviours and choices at a population level. This objective of this study is to develop a healthful eating by using the validated short dietary questions and the 2013 Dietary Guidelines for Australia. The development of such a healthful eating indicator will enable exploration of interactions and relationships with attitudinal and demographic data and has the potential to show previously unknown associations and interactions.

6.3 EXPERIMENTAL SECTION

Since 1995, about every three years over one thousand adults aged 18 to 64 years are interviewed using Computer Assisted Telephone Interviews (CATI) and asked questions about their attitudes and beliefs about diet. The surveys are managed by the Department of Health who grant ethics approval for the data collection. As the Australian Health Survey which included a nutrition survey on a subset of respondents was conducted in 2011-2012, only the NMSS 2012 survey data were used to develop the healthful eating indicator.

The sample was a stratified random sample according to area of residence drawn from the most recent Electronic White Pages for Western Australia. All sample households with an address were sent a Primary Approach Letter and every household in the initial sample was called up to ten times to achieve contact. Contacted numbers were eliminated if they were not a household or if there was no person living in the household within the age range. Households with more than one adult fulfilling the requirements were asked which adult had the most recent birthday and that adult was selected for interview. No substitutes were permitted. At least ten call backs were made to achieve an interview. Interviews took place during the 4 weeks between mid-July and mid-August. A raw response rate of not less than 70% was required based on households contacted within the eligible age range whether or not an interview was achieved. In 2012, 1548 people, 1005 females and 543 males aged between18 and 64 years were interviewed which was a response rate of 82.4% based on interviews attained divided by eligible households contacted.

6.3.1 Diet questions

The NMSS collects information on the previous day's consumption of food groups identified by the Australian Dietary Guidelines. The food groups covered include vegetable, fruit, cereals, dairy, and protein. Information on fluids used are also collected. The data is self-reported and questions were about the amount, and types of foods eaten "yesterday".

6.3.2 Sociodemographic indicators

Indicators of sociodemographic status included sex, age, education, income, employment status, living arrangements, perceived spending power and an area based indication of relative socioeconomic disadvantage known as SEIFA and developed by the Australian Bureas of Statistics (Australian Bureau of Statistics, 2013d).

6.4 DEVELOPING THE DIETARY GUIDELINE INDICATOR

There are only two dietary indices that have been developed for Australia. Both were based on the 1995 National Nutrition Survey and both used a combination of frequency foods were eaten; some consumption questions, for example fruit and vegetable consumption; and some behaviours such as whether or not meat was trimmed of fat. The first index, developed in 2007, used a relatively simple construction and had six dimensions based on the 2003 Australian Dietary Guidelines (Australian Institute of Health and Welfare, 2007). The second index developed in 2008 used a similar conceptual framework but had eleven components exploring more parts of the ADG which included a measure of alcohol consumption (McNaughton et al., 2008). While the NMSs does not collect information about alcohol consumption, there were more possible comparative scales with the 2008 index than with the 2007 index and for this reason it was selected as the model for the development of a NMSS healthful eating indicator (NMSS_HEI). The NMSS_HEI is based solely on consumption of key food groups the previous day. The dietary guideline index developed in 2008 (DGI_2008) used frequency as a rough indication for amount with each frequency of consumption assumed to be at least one serve. As the NMSS collects dietary data in amounts they can be converted into serves based on the recommendations for adults aged between 18 and 64 years (National Health and Medical Research Council, 2014). To accommodate the differences between frequency and consumption and to compensate for questions used in the DGI_2008 which were not asked in the NMSS, comparable measures for the NMSS data were developed. For example, in the DGI_2008 saturated fat consumption was based on the type of milk used and whether or not meat was trimmed of fat but the question about trimming fat from meat was not asked in the NMSS so saturated fat consumption is made up of the type of milk, cheese and yoghurt consumed and whether sausages and biscuits (high in saturated fat) were eaten. For type of grains, the DGI_2008 used only wholegrain bread but as there was information available for type of bread, rice pasta and breakfast cereals, all were used to in scoring type of grains consumption. Additional foods were also differently assessed. For the NMSS_HEI when people consumed more than the recommended number of serves of a particular food group the full score was given on the specific food component (e.g. cereals) but any serves above the recommended amount were assessed against the additional serve recommendations for each food group by age and sex (National Health and Medical Research Council, 2013a) and scores based on compliance with these. The only exceptions to the additional food score assessments were fruit and vegetables as the evidence base indicates that there are no known detrimental effects of consuming more than the recommended amounts of these foods (National Health and Medical Research Council, 2013a; Oyebode, Gordon-Dseagu, Walker, & Mindell, 2014). A full description of the way in which the index was constructed is given below in (Table 6.1). The table shows the ADG recommendation for each part of the scale with the way in which the score was assigned, what constitutes not meeting the recommendation and how derivation of the score differs from the DGI_2008.

6.4.1 Analysis

The total NMSS_HEI was the sum of the eleven individual components of the indicator described in Table 6.1. As with the previously developed DGI_2008, scores for each component are out of ten and as there are eleven measures, the total possible score is 110 with higher scores indicating the healthier eating. Exploratory factor analysis with confirmatory structural equation modelling (SEM) were conducted on the total NMSS_HEI to best identify structure of the model (Fumiaki Imamura & Jacques, 2011). The confirmatory SEM was conducted with the data unweighted allowing for an estimate of comparative fit (Iacobucci, 2009; Schreiber, 2008) and then the fit compared a SEM using the data weighted for survey sample design (Muthen & Satorra, 1995). Post estimation tests conducted on the structural equation model included the comparative fit index, the standardized root mean squared residual, the stability of the model using Wald tests and the coefficient of determination. Means were calculated for the score components of the two indexes with 95% confidence intervals. For the mean estimates, the data were weighted using Iterative Proportional Fitting applying a basic adjustment for the probability of selection and then fitting marginal proportional totals for age, sex and area of residence based on the 2011 Estimated Resident Population for Western Australia. Linear regressions on the two components were conducted. Differences at $p<.05$ or less were considered to be significant. Stata 13.1 was used for all analyses.

Table 6.1 How the NMSS_HEI scale was constructed based the ADG [6] with comparison to DGI_2008 (McNaughton et al., 2008)

Australian Dietary Guidelines 2013 using data collected in the NMSS 2012	Indication and description[a, b]	Criteria for maximum score (10)	Criteria for minimum score (0)	Difference with DGI _2008[c]
Enjoy a wide variety of nutritious foods	The number of different types of core foods eaten on the previous day. The following made up the variety score: vegetables; fruit; dairy and cereals	Eats four types of vegetables (4 was the median); any fruit; consumes one of milk, yoghurt or cheese; eats three types of cereal foods(breads, bread substitutes, breakfast cereals, rice or pasta)	Eats none of the foods	Used proportion of foods for each food group eaten at least once a week
Enjoy plenty of vegetables, including different types and colours, and legumes/beans	Serves of vegetables usually eaten. This question did not specify 'yesterday'	For males aged 19-50,at least six serves; for all others at least 5 serves	Eats none	Serves of vegetables & legumes per day
Enjoy fruit	Serves of fruit eaten yesterday	All groups, at least 2 serves	Eats none	Serves of fruit eaten per day
Enjoy grain (cereal) foods	Serves of cereals eaten yesterday	Males & females aged 18, at least 7 serves; males aged 19-64, at least 6 serves; females aged 19-50, at least 6 serves; females aged 51-64, at least 4 serves.	Eats less than recommended	Frequency of consumption
Mostly wholegrain and/or high cereal fibre varieties	Serves of wholegrain or wholemeal cereals eaten yesterday	Full score if all types of cereals eaten yesterday were wholemeal or wholegrain	No cereal foods were wholemeal or wholegrain	Only wholemeal bread was used

Australian Dietary Guidelines 2013 using data collected in the NMSS 2012	**Indication and description[a, b]**	**Criteria for maximum score (10)**	**Criteria for minimum score (0)**	**Difference with DGI _2008[c]**
Enjoy milk, yoghurt, cheese and/or alternatives, mostly reduced fat[d]	Serves of dairy foods used/consumed yesterday	Males & females aged 18, at least 3 1/2; males aged 19-64 and females aged 19-50, at least 2 ½ serves; females aged 51-64, at least 4 serves	Used/consumed no dairy foods yesterday	Frequency of consumption of dairy foods per day
Enjoy lean meats and poultry, fish, eggs, tofu, nuts and seeds, and legumes/beans	Serves of meat or fish eaten yesterday	Males & females aged 18, at least 2 ½ serves; Males aged 19-50, 3 or more serves; Females aged 19-50, 2 ½ or more serves; females aged 51-64, 2 or more serves.	Eats less than recommended	Frequency of consumption of meats and alternatives the previous day with proportion of lean.
Limit intake of foods high in saturated fat	Ate full fat dairy food or sausages or biscuits	The numbers of foods eaten were converted to a score out of ten and those who ate none got a score of 10	Ate all foods high in saturated fats	Used type of milk usually consumed as well as trimming fat from meat.
Limit intake of foods and drinks containing added sugars	Number of foods high in added sugar consumed yesterday including biscuits, soft drinks, crumpets, scones, muffins (cake type) and sugary breakfast cereals	No such foods eaten yesterday	Ate three types yesterday	Used frequency of consumption of cordial, fruit juice, soft drinks, jam, chocolate or confectionary

Australian Dietary Guidelines 2013 using data collected in the NMSS 2012	Indication and description[a, b]	Criteria for maximum score (10)	Criteria for minimum score (0)	Difference with DGI_ 2008[c]
To achieve and maintain a healthy weight, be physically active and choose amounts of amounts of nutritious food and drinks to meet your energy needs[f]	Extra serves of any foods except fruit and vegetables consumed which were above the additional serves guidelines	No additional serves eaten	Any additional serves above upper limit	Used a combination of added sugar and extra foods.

a Serves are estimated using the 2013 ADG definitions

b The maximum recommended serves or more is the basis for the maximum score but additional serves over recommended and more than recommended additional are then penalised under the extra serves score

c DGI_2008 DQI used each frequency of consumption to be a rough measure of a serve

d Dairy foods were weighted by fat content.

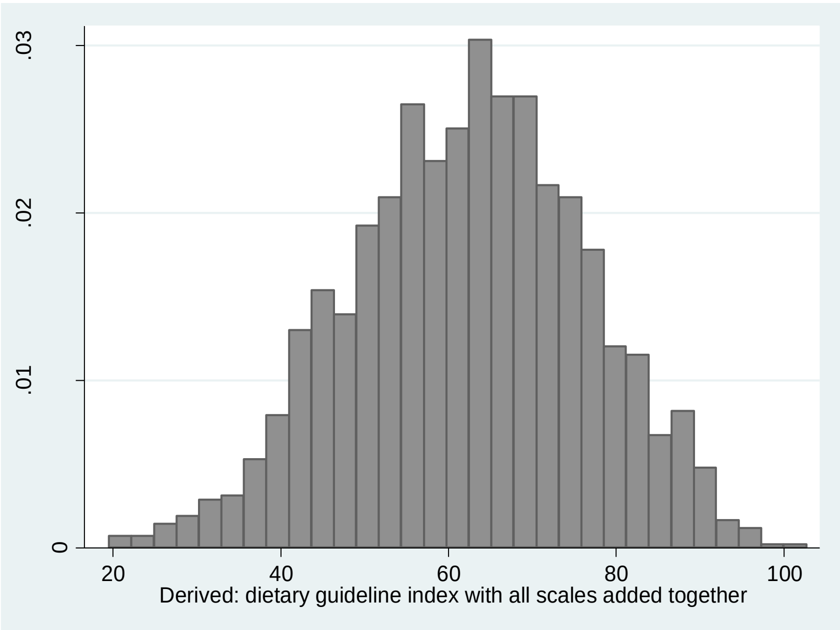
e Used the cut points for fluids suggested in Educators guide for the Australian Dietary Guidelines 2013 – the reference also suggests that “most” be in the form of water so 66% water was taken as an measure of “most” as there was no quantified amount suggested (E. G. National Health and Medical Research Council, 2013)

f The 2013 ADG provides an additional serves guideline for taller and more active adults and this was used to assess extra serves over and above these plus recommended

6.5 RESULTS

The initial NMSS_HEI score showed a wide distribution of scores that has no statistically significant departures from normality for kurtosis but is significantly negatively skewed (Figure 6.1). The exploratory factor analysis showed two factors, one which reflected the recommended components of the DGI, namely the variety, fruits, vegetables, grains, cereals, dairy, protein and fluids and one that reflected the discretionary components of the total NMSS_HEI, namely fats, sugar and additional serves. The SEM confirmed the two component structure of the NMSS_HEI and, as with the factor analysis, one reflected the major food groups (Recommended) and the other reflected additional serves and discretionary foods (Discretionary) with each variable contribution to the components statistically significant at $p<.01$.

Figure 6.1 Distribution of the DGI score, NMSS 2012



Statistically significant covariance were identified for a number of variables using post estimation tests and added to the model with all covariates remaining statistically significant at $p<.05$ or better. The addition of the covariance associations altered the p value for the protein score and the cereal score to $p>.05$. The biggest coefficients (contributors to the model) for the “Recommended” component were variety (β=0.62, *p=<0.0001*), fruit (β=0.46, *p=<0.0001*) and vegetables (β=0.37, *p=<0.0001*) with protein contributing least (β=0.002, ns). For the “Discretionary” component the contributors were sugar (β=0.74, *p=<0.0001*) followed by extra serves (β=0.71, *p=<0.0001*) and fat (β=0.45, *p=<0.0001*). The model is a non recursive model and post estimation tests showed it satisfied the stability condition. The raw component scores were negatively correlated but at a very low level (Spearman rho-.078 p<.05 and in the SEM covariance between the two scores failed to reach statistical significance. For the weighted SEM, the weighted coefficient of determination (CD) was 90.4% and the CD was 91% for the unweighted SEM. The post estimation statistics for the weighted SEM shown in Table 6.2 are considered to indicate a good fit with the data (Hu & Bentler, 1999; Iacobucci, 2009). For weighted models, no equivalent goodness of fit statistics other than the CD and the standardized root mean squared residual (SRMR) are possible because of the way in which standard errors are estimated, however both the weighted CD and the weighted SRMR are similar to the equivalent measures for the weighted model. As the data on which the SEM are based are drawn from a cross sectional population survey, the weighted model coefficients are the most appropriate for use and are the ones displayed in Figure 6.2.

Table 6.2 Post estimation statistics for the weighted SEM model, NMSS 2012

Fit statistic	Value	Description
Likelihood ratio*		
chi2_ms(33)	51.37	model vs. saturated
p > chi2	0.02	
chi2_bs(55)	1749.51	baseline vs. saturated
p > chi2	0	
Population error		
RMSEA	0.02	Root mean squared error of approximation
90% CI, lower bound	0.01	
90% CI, upper bound	0.03	
pclose	1	Probability RMSEA <= 0.05
Baseline comparison		
CFI	0.99	Comparative fit index
TLI	0.98	Tucker-Lewis index
Size of residuals		
SRMR	0.02	Standardized root mean squared residual
CD	0.91	Coefficient of determination

*While the chi square is <.05, the very large sample size would predict that. The chi square divided by the degrees of freedom is <3 indicating an acceptable chi square for a sample this size (Iacobucci, 2009).

Figure 6.2 Model produced by structural equation modelling showing two independent components with covariance, NMSS 2012

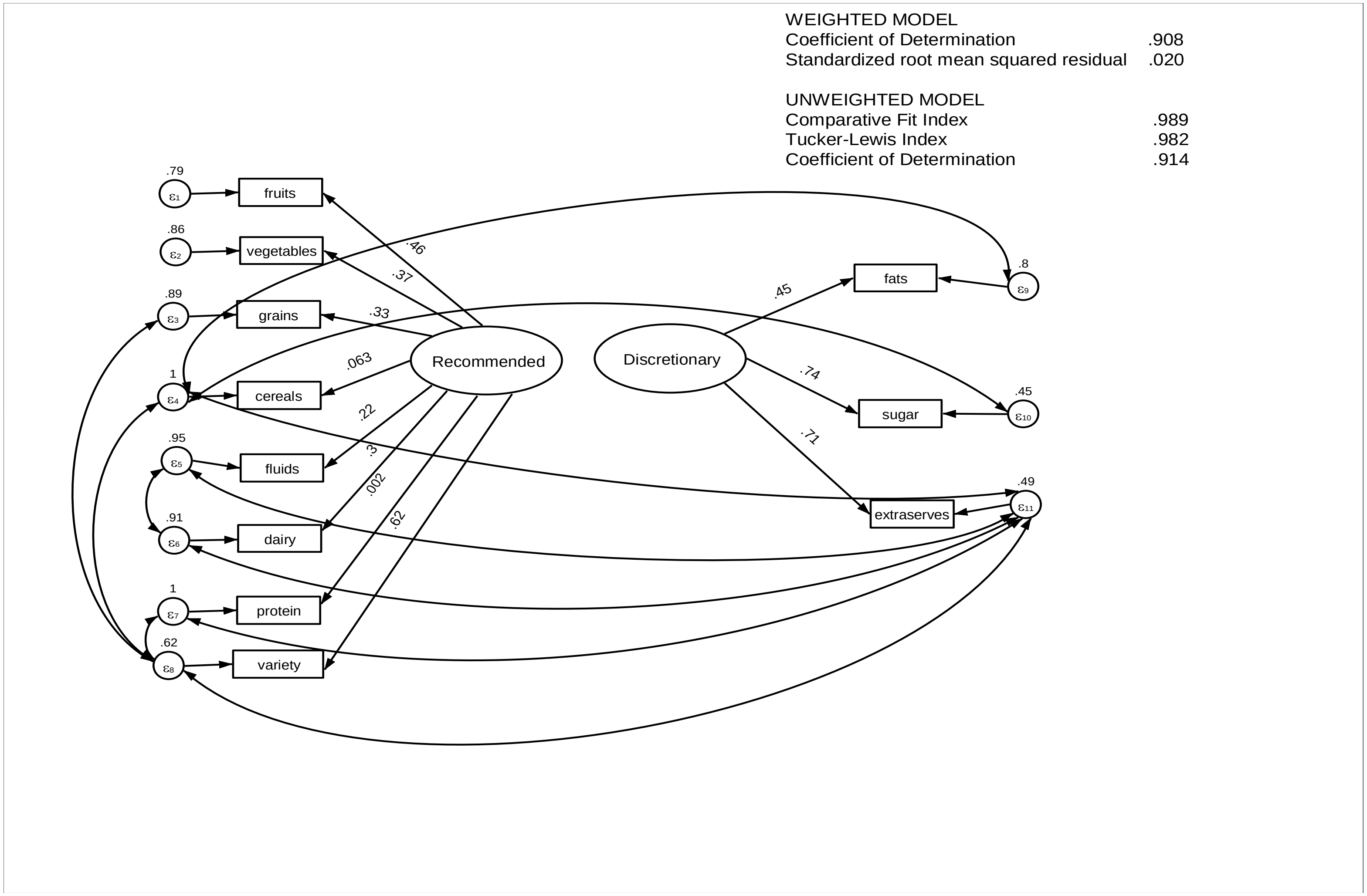


Table 6.3 Mean scores for each component identified by the SEM and percentage meeting the recommended dietary guideline in the 2013 ADG by sex

	Males			Females		
Dietary score component	RFI[1]	Diff >1 § with DGI_2008	% meeting RFI[2]	RFI[1]	Diff >1 § with DGI_2008	% meeting RFI[2]
Food variety	4.96 ± 0.15		5.58	5.33 ± 0.10		7.00
Vegetables	4.97 ± 0.14		8.39	5.66 ± 0.11		14.73
Fruit	6.88 ± 0.23		58.52	7.74 ± 0.14		68.06
Cereals	6.78 ± 0.19	y	38.48	5.98 ± 0.13		27.50
Wholemeal/grains	4.64 ± 0.27	y	43.76	4.95 ± 0.19	y	47.35
Protein (meat/fish)	3.54 ± 0.19	y	9.48	3.14 ± 0.13	y	6.79
Dairy	5.00 ± 0.16		10.32	4.88 ± 0.12		11.37
Fluids[3]	6.17 ± 0.14		15.29	6.11 ± 0.10	y	23.92

	Males			Females		
Dietary score component	DFI[1]	Diff >1 § with DGI_2008	% meeting DFI[2]	DFI[1]	Diff >1 § with DGI_2008	% meetin g DFI[2]
Fats	7.00 ± 0.14	y	24.49	7.12 ± 0.10		29.38
Sugar	6.20 ± 0.2		46.07	7.12 ± 0.10	y	58.10
Extra serves	4.01 ± 0.22		22.22	4.93 ± 0.17	y	33.83

1 Data are mean scores out of 10 weighted using raking

2 Data are percentages meeting recommendations (score of 10) weighted using raking

3 Proportion of fluids to water with 66% water used as top score of 10
§The mean score differed by more than 1 when the mean score of the NMSS_HEI was compared to the DGI_2008

The largest differences were for cereals (mean scale score: DGI_2008 Males 4.2 Females 5.6; NMSS_HEI: Males 6.8 Females 6.0) and eating meats/meat alternatives (mean scale score: DGI_2008: Males 9.8 Females 9.7; NMSS_HEI: Males 3.5 Females 3.1).As the NMSS didn't ask about consumption of any meat alternatives and as forty percent of the respondents reported that they had not eaten any of the meat or fish, the difference is not unexpected. No obvious explanation exists for the difference in the cereals score unless the DGI_2008 calculation didn't include breakfast cereals which were included in the

NMSS_HEI calculation. It may be that the updated 2013 ADG accounted for some of the differences in the proportions meeting guidelines with increases in the recommended serves of protein, dairy and cereals in the later version.

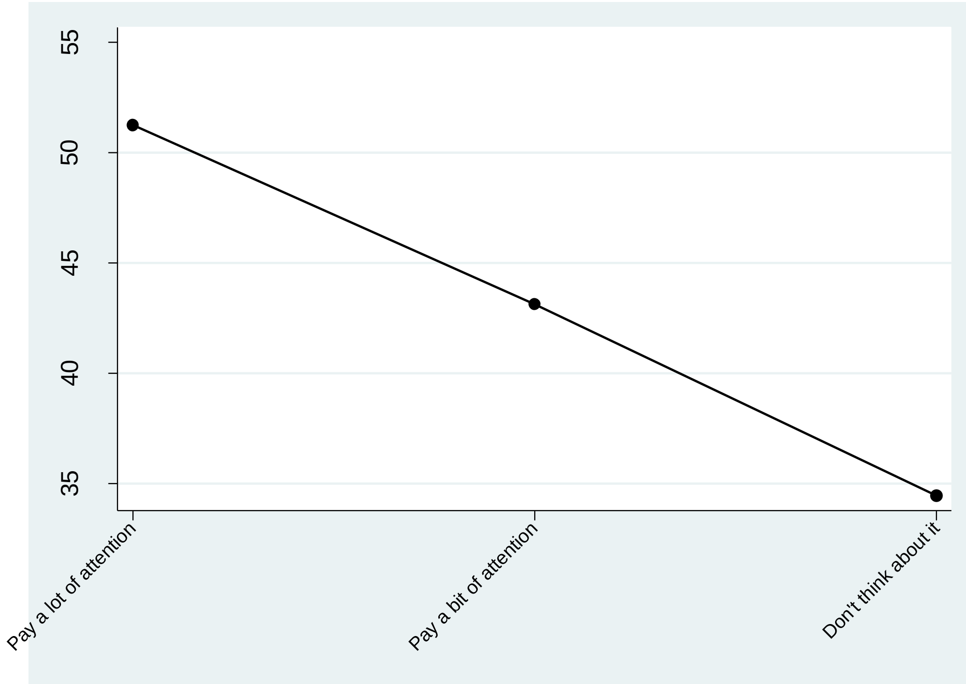
Using the two components established by the SEM, a recommended food healthful eating indicator (RF_HEI) and a discretionary food healthful eating indicator (DF_HEI) were calculated by weighting each variable making up the component by the standardised coefficients generated by SEM. Table 6.4 shows mean scores of selected socio demographic indicators and attitudes. The groups with the highest mean scores for the RF_HEI were people who paid a lot of attention to the health aspects of diet, being retired and doing home duties; the two lowest scores were people who don’t pay any attention to the health aspects of diet and being unemployed. For the DF_HEI the highest mean scores were for people living alone and people who paid a lot of attention to the health aspects of diet; the lowest scores were for people who live in the most socially disadvantaged areas and students.

After controlling for all the variables in table four, lower scores for the RF_HEI were significantly associated with lower education levels, having an annual household income less than $40,000, not being able to save any money and paying little or no attention to the health aspects of diet. For the DF_HEI, lower scores were significantly associated with being male, not living alone, living in the most socially disadvantaged areas of WA and paying little or no attention to the health aspects of diet. For the RF_HEI attitudes toward the health aspects of a healthy diet had a linear association with highest scores associated with paying a lot of attention to diet (Figure 6.3).

Table 6.4 Mean scores for RF_HEI and DF_HEI by selected socio demographics and attitude

Gender	RF_HEI Mean (95% CI)	DF_HEI Mean (95% CI)
Male	44.11[42.50,45.73]	16.64[15.77,17.50]
Female	47.61[46.46,48.76]	18.77[18.10,19.43]
Age group in years		
18-44	44.86[43.30,46.43]	16.66[15.82,17.50]
45-64	47.16[46.13,48.20]	17.53[16.92,18.14]
Highest level of education attained		
Up to Year 12	42.07[39.50,44.64]	18.07[16.67,19.47]
Year 12	43.40[40.38,46.43]	17.00[15.45,18.54]
TAFE/Trade	45.98[44.36,47.60]	17.89[17.01,18.77]
Tertiary	47.89[46.33,49.44]	17.70[16.76,18.64]
Annual household income		
Up to $40,000	46.29[45.26,47.32]	17.75[17.16,18.34]
More than $40,000	41.39[37.73,45.05]	17.15[15.53,18.78]
Perceived discretional income		
Can't save	41.88[39.69,44.08]	17.10[15.96,18.23]
Can save	47.16[46.07,48.26]	17.89[17.25,18.53]
SEIFA*		
SEIFA Quintile 1 (most disadvantaged)	43.64[40.13,47.15]	14.98[13.36,16.59]
SEIFA Quintile 5 (least disadvantaged)	46.96[45.13,48.78]	18.25[17.02,19.48]
Current Employment Status		
Employed	46.35[45.23,47.48]	17.94[17.31,18.57]
Unemployed	38.28[31.73,44.84]	17.78[13.49,22.07]
Home Duties	48.32[46.19,50.45]	17.28[15.71,18.85]
Student	40.85[36.12,45.58]	15.66[13.09,18.23]
Retired	48.90[46.38,51.43]	18.53[16.88,20.19]
Unable to work	36.38[29.35,43.40]	17.33[13.23,21.43]
Living Arrangements		
Living with family/partner	45.99[44.93,47.04]	17.67[17.09,18.25]
Living alone	42.30[39.24,45.37]	19.41[17.82,21.00]
Other	46.45[40.25,52.66]	16.64[13.02,20.26]
Residential area		
Metropolitan Perth	45.80[44.58,47.02]	17.67[16.98,18.36]
Rest of State	46.00[44.33,47.67]	17.76[16.88,18.64]
Country of Birth		
Australia	45.81[44.11,47.52]	17.35[16.43,18.27]
Other country	45.87[44.64,47.11]	17.86[17.16,18.56]
Attention to health aspects of diet		
Pay a lot of attention	51.47[50.21,52.72]	19.23[18.46,20.00]
Take a bit of notice	43.17[41.86,44.49]	16.68[15.86,17.49]
Don't really think much about it	33.13[28.93,37.33]	16.00[13.98,18.02]

Figure 6.3 Predictive margins of attention paid to diet with 95% CI



6.6 DISCUSSION

The aim of this study was to develop a measure that could be used during years when nutrition based dietary survey was not available. This proved possible and while there is no doubt that the RF_HEI and DF_HEI measures do not capture the whole range of foods eaten or have information to inform a nutrient intake assessment, they do provide a provide a basis from which to assess how the population is doing against dietary recommendations. The fact that the initial NMSS_HEI has two independent components provides new information about how the population is approaching their diet. One way is in line with dietary recommendations about serves and types from food groups; the other is in line with dietary recommendations about discretionary foods and additional serves. This means that the same person can have a score indicating healthful eating on one component but not on the other; well on both components or well on neither component. The regression analysis showed that the predictors of eating well for each component are, for the most part, not shared suggesting that what drives eating behaviours may stem from difference influences according to the types of foods being considered. This information is intrinsically different from research which uses cluster analysis on Australian dietary intake to identify food patterns for example, an eating pattern relatively high in fat and meat compared with an eating pattern higher in fruit and vegetables (Grieger et al., 2012) and research using factor, cluster analyses along or ranked regression conducted on data that has not been pre-scored against any standard such as dietary guidelines (Moeller et al., 2007). These methods identify eating patterns and then explore associations with health indicators (Amini, Shafaeizadeh, Zare, & Esmaillzadeh, 2012; W.-Q. Li et al., 2014; Xu, Houston, Locher, & Zizza, 2012), who is eating in line with particular patterns (Elstgeest, Mishra, & Dobson, 2012; Kant, 2004) and more recently other aspects such as how changes in individuals' dietary patterns affect obesity over time (Elstgeest et al., 2012; Pachucki, 2012) and mortality (Kant et al., 2000). The two independent components structure suggests that there may be different attitudes and perceptions associated with each that have the potential to inform health promotion and education approaches (Leˆ et al., 2013; Traill et al., 2012). Population groups such as those with excess weight can now be explored in more detail in relation to their eating choices. The healthful eating indicators as described in this study have not been explored by the each of the foods and eating patterns summarised by each indicator. Breakdown of the individual indicators by foods may offer additional information about eating patterns and choices which in turn could lead to more precise information about population groups 'at risk' due to poor diet. The ability of surveys such as the NMSS to allow the construction of a healthful eating indicator offers a rich source from which to explore important interactions between the psycho social aspects of diet such as attitudes, perceptions and intentions with knowledge and behaviours associated with healthy dietary patterns in the years when direct nutrition information is not available (Grunert, Shepherd, Traill, & Wold, 2012). The analyses in this paper did not explore interactions or the influence of attitudes on the healthful eating indicators as the aim was to develop healthful eating indicators. To investigate these associations further studies are planned.

As with any cross sectional survey data social desirability may determine some responses but in this case most of the responses are unlikely to be so biased as the respondent would need to be aware of all of the dietary guidelines in formulating their response. In this cross sectional survey as in most others (Galea & Tracy, 2007) there was an under representation of males relative to females suggesting a non response bias for males. The weighting process does adjust for this and having standard errors calculated by robust methods also helps, however, the recommendation for further NMSS data collection is that a stratified random sampling method using area, gender and age group be considered. Exploration of a more up-to-date source of telephone numbers should also be considered. It is unfortunate that the data from the six surveys could not be pooled but the different data collection methods and different questions for food eaten prohibited this. Consistency in this regard would also be beneficial.

6.7 CONCLUSIONS

It is possible to develop healthful eating indicators using validated short dietary questions for use in years when more complete nutrition data is not available. The identification of two independent indicators of healthful eating offers evidence that people approach diet in different ways. This finding suggests that fully investigating each indicator has the potential for better targeted and relevant interventions to improve diet quality in the population.

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Author Contributions

Alison Daly formulated the research question, designed the study, conducted the analysis and drafted the manuscript. Dr. Pollard formulated the research question, designed the study, reviewed and revised the manuscript and approved it for publication. Dr. Kerr formulated the research question, designed the study, reviewed and revised the manuscript and approved it for publication. Professor Binns formulated the research question, designed the study, reviewed and revised the manuscript and approved it for publication. Michael Phillips formulated the research question, designed the study, conducted the analysis, reviewed and revised the manuscript and approved it for publication.

Conflicts of Interest

The authors declare no conflict of interest.

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6.8 ADDITIONAL INFORMATION FROM THE ANALYSIS RELATED TO THE PAPER

There were three pieces of information that were not included in the published paper but were integral to the development of the scale and to the confidence in the results.

6.8.1 The basis for the healthful eating indicator serve estimates

The healthy eating indicators were based on estimating serves from foods representing the five recommended food groups. Questions about the amount, type, size and fat content were included in the 2012 NMSS so that consumption could be estimated. Table 6.5 shows the basis of determining mean scores for consumption for each of the five food groups (National Health and Medical Research Council, 2013d) used in the development of the health eating indicators described in Table 1 of the published article shown above. There are caveats around the serves on Table 6.5 such as the inclusion of an allowance for unsaturated fat and oils and the fact that the additional/discretionary serves category applies to undefined terms of ‘taller’ and ‘more active’. No attempt was made to define these terms in the estimates of scores. Rather they were applied for everyone within the sex and age range as shown on the table.

Table 6.5 Recommended serves for Five Food Groups adapted from the ADG 2013 (National Health and Medical Research Council, 2013d, pp 41 and 42)

Recommended average daily number of serves from each of the Five Food Groups							Additional serves for more active, taller or older persons
	Age	Vegetables	Fruit	Grains-mostly wholegrain and high fibre	Lean meats/fish	Milk/yoghurt/cheese mostly reduced fat	Additional serves from five food groups **OR** unsaturated spreads and oils **OR** discretionary
Males	18	5.5	2	7	2.5	3.5	0 - 5
Males	19-50	6	2	6	3	2.5	0 - 3
Males	51-64	5.5	2	6	2.5	2.5	0 - 2.5
Females	18	5	2	7	2.5	3.5	0 - 2.5
Females	19-50	5	2	6	2.5	2.5	0 - 2.5
Females	51-64	5	2	4	2	4	0 - 2.5

The new healthy eating indicators do not measure total diet, nor do they provide any basis for assessing daily nutrient intake. There is evidence that self-reported dietary intake is often under-reported (Mitka, 2013) but as others have argued, self-reported dietary intake is the only feasible way to assess dietary intake at a population level (Ioannidis, 2013; Subar et al., 2015). Most studies of dietary intake use a variety of measures such as FFQ and dietary records to assess a population's nutrient intake and short dietary questions are a level further away with less information about total diet and amount consumed. The time taken to collect information is assessed against the degree of accuracy and coverage required, previously discussed under sections 2.45.1 and 2.5.6. In this study, the purpose of the development of the healthy eating indicators is to provide a high level indication of general adherence to a dietary pattern or a set of guidelines. Measurement errors notwithstanding, validated short dietary questions, as used in the NMSS data collection, were considered adequate for this purpose based on a review of dietary measures (Thompson & Subar, 2012) and a recent discussion of the value of self-reported measures, their (Kirkpatrick & Collins, 2016). The dietary healthy eating indicators do not make any statements about the adequacy of the diet eaten the day before; rather they show how, with a small number of general questions around the ADG, dietary patterns can be developed at a population level which correspond in a very broad manner to those developed using a more traditional methodology, as described in Chapter 6.

6.8.2 Additional results from the factor analysis and the SEM

The following results were not part of the paper but add to the understanding of the indicators. The first is the information about the exploratory factor analysis. The factor analysis scree plot suggested that there were either one or two factors with only one Eigenvalue greater than one (Figure 6.4).

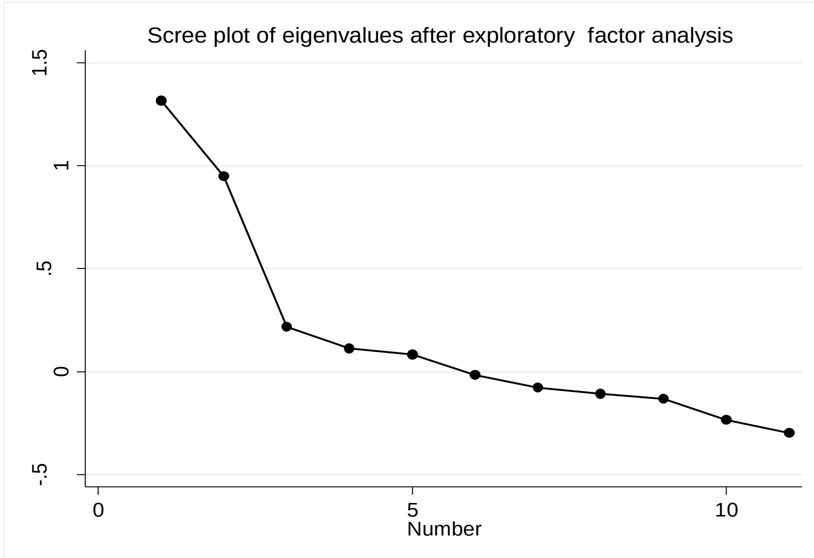


Figure 6.4 Scree plot of exploratory factor analysis of scores in the NMSS 2012

Table 6.6 Orthogonal varimax rotation solution for the NMSS_HEI showing two factors, NMSS 2012

Factor	Variance	Difference	Proportion	Cumulative
Factor1	1.29	0.31	0.71	0.71
Factor2	0.97	0.76	0.54	1.25
Factor3	0.22	0.10	0.12	1.37
Factor4	0.11	0.03	0.06	1.43
Factor5	0.08	.	0.05	1.48

Variable	Factor1	Factor2	Uniqueness
variety	-0.11	**0.55**	0.65
vegetables	0.04	**0.34**	0.87
fruits	0.04	**0.42**	0.80
fluids	0.04	**0.32**	0.85
dairy	-0.05	**0.34**	0.84
cereals	-0.30	**0.24**	0.78
grains	0.06	**0.23**	0.90
protein	-0.06	**0.16**	0.87
fats	***0.46***	0.04	0.78
sugar	***0.64***	0.12	0.55
extraserves	***0.74***	-0.12	0.44

	Factor1	Factor2
Factor1	0.96	-0.28
Factor2	0.28	0.96

The orthogonal varimax rotation identified two clear factors, one which reflected the recommended components of the DGI, namely the variety, fruits, vegetables, grains, cereals, dairy, fluids and protein and one that reflected the discretionary components of the DGI, namely fats, sugar and additional serves (Table 6.6). These results support results from an earlier study looking at eating patterns in sets of twins (van den Bree et al., 1999). The SEM confirmed the two component structure of the NMSS_HEI and, as with the factor analysis, one reflected the major food groups (Recommended) and the other reflected additional serves and discretionary foods (Discretionary). The main effects were all statistically significant except cereals and protein which changed when the covariance associations were added to the model (Table 6.7).

Table 6.7 Parameters for the SEM, NMSS 2012

Measurement		Standardized Coef.	Robust Std. Err.	z	P>|z|	95%CI	
fruits <-	Recommended	0.46	0.05	9.29	0.0000	0.36	0.55
	_cons	1.90	0.07	25.65	0.0000	1.76	2.05
vegetables<-	Recommended	0.37	0.05	7.40	0.0000	0.27	0.47
	_cons	2.02	0.04	45.68	0.0000	1.93	2.11
grains <-	Recommended	0.33	0.06	5.16	0.0000	0.21	0.46
	_cons	0.98	0.03	29.80	0.0000	0.92	1.05
cereals <-	Recommended	0.06	0.06	1.10	0.2720	-0.05	0.17
	_cons	1.95	0.06	33.77	0.0000	1.84	2.06
fluids <-	Recommended	0.22	0.05	4.64	0.0000	0.13	0.32
	_cons	2.33	0.05	51.63	0.0000	2.24	2.42
dairy <-	Recommended	0.30	0.05	6.23	0.0000	0.20	0.39
	_cons	1.70	0.04	39.26	0.0000	1.61	1.78
protein <-	Recommended	0.00	0.06	0.03	0.9730	-0.12	0.12
	_cons	1.00	0.03	33.57	0.0000	0.94	1.05
variety <-	Recommended	0.62	0.05	11.30	0.0000	0.51	0.72
	_cons	2.00	0.05	41.33	0.0000	1.91	2.09
fats <-	Discretionary	0.45	0.03	12.88	0.0000	0.38	0.51
	_cons	2.90	0.07	38.81	0.0000	2.75	3.05
sugar <-	Discretionary	0.74	0.04	20.76	0.0000	0.67	0.81
	_cons	1.83	0.04	45.36	0.0000	1.75	1.91
extraserves<-	Discretionary	0.71	0.04	18.21	0.0000	0.64	0.79
	_cons	1.06	0.03	32.06	0.0000	0.99	1.12
var(e.fruits)		0.79	0.04			0.71	).88
var(e.vegetables)		0.86	0.04			0.79	).94
var(e.grains)		0.89	0.04			0.81	).98
var(e.cereals)		1.00	0.01			0.98	I.01
var(e.fluids)		0.95	0.02			0.91	).99
var(e.dairy)		0.91	0.03			0.86	).97
var(e.protein)		1.00	0.00			1.00	I.00
var(e.variety)		0.62	0.07			0.50	).77
var(e.fats)		0.80	0.03			0.74	).86
var(e.sugar)		0.45	0.05			0.36	).57
var(e.extraserves)		0.49	0.06			0.39	).61
var(Recommended)		1.00	.			.	.
var(Discretionary)		1.00	.			.	

Measurement	Standardized Coef.	Robust Std. Err.	z	P>|z|	95% CI	
cov(e.grains,e.variety)	-0.16	0.07	-2.24	0.0250	-0.29	-0.02
cov(e.cereals,e.variety)	0.21	0.05	4.32	0.0000	0.12	0.31
cov(e.cereals,e.fats)	-0.11	0.04	-3.00	0.0030	-0.18	-0.04
cov(e.cereals,e.sugar)	-0.14	0.06	-2.47	0.0140	-0.24	-0.03
cov(e.cereals,e.extraserves)	-0.47	0.06	-8.50	0.0000	-0.58	-0.36
cov(e.fluids,e.dairy)	0.14	0.03	4.10	0.0000	0.07	0.21
cov(e.fluids,e.extraserves)	-0.10	0.04	-2.49	0.0130	-0.17	-0.02
cov(e.dairy,e.extraserves)	-0.24	0.04	-5.84	0.0000	-0.32	-0.16
cov(e.protein,e.variety)	0.20	0.05	3.94	0.0000	0.10	0.29
cov(e.protein,e.extraserves)	-0.15	0.04	-3.71	0.0000	-0.23	-0.07
cov(e.variety,e.extraserves)	-0.28	0.06	-4.99	0.0000	-0.39	-0.17

This additional information provides further evidence of the two factor nature of healthful eating in the WA population.

6.8.3 A basis for segmenting the population by level of adherence to the ADG

For use in further explorations of associations with each component of the NMSS_HEI, a weighted RF_HEI and DF_HEI were calculated using the SEM coefficients to weight each variable within the component. The RF_HEI weighted for survey design was 45.85 [44.85, 46.85] and the mean DF_HEI was 17.70 [17.14, 18.25]. As a nominal measure, the ADG recommended that a reasonably healthy diet is indicated by meeting at least 80% of the guidelines. Four groups were identified: those who were doing reasonably well, those who were ‘nearly there’; those who had ‘plenty of room for improvement; and those who needed ‘a serious overhaul’ (National Health and Medical Research Council, 2013d, p 6). While the healthy eating indicators described in the chapter are not really accurate measures of adherence to the ADG, the division into four groups based on percentage of adherence provides a good basis on which to divide the RF_HEI and the DF_HEI for purposes of segmenting the population.

Using the nominal measure, the percent of males and females from this survey who score at least 80% of either of the healthful eating indicators are shown in Table 6.8. Less than one in twenty people are scoring 80% of more on both indicators. Over half of those surveyed scored lower than 80% on both indicators.

Table 6.8 Percent of the WA adult population meeting either or both RF_HEI and DF_EHI, NMSS 2012

	Males	Females	Persons
Both RF_HEI & DF_HEI>=80%	1.90[0.91,3.94]	6.02[4.46,8.07]	3.95[2.95,5.26]
RF_HEI>=80% & DF_HEI<80%	6.00[3.88,9.17]	7.93[6.20,10.09]	6.96[5.51,8.76]
RF_HEI<80% & DF_HEI>=80%	25.80[21.54,30.56]	33.42[29.93,37.09]	29.59[26.75,32.58]
Both RF_HEI & DF_HEI<80%	66.31[61.13,71.12]	52.64[48.81,56.43]	59.51[56.26,62.68]

While this study used the ADG and short dietary questions in a Western Australian nutrition monitoring survey, the methods outlined can be adapted to any country's dietary guidelines provided short dietary questions are available to construct the index.

7 DEFINE THE KEY FACTORS THAT INFLUENCE SPECIFIC DIETARY BEHAVIOURS AND THEIR INTERACTIONS: ADDRESSING OBJECTIVE FOUR

The fourth objective was to use applications of a variety of statistical procedures to evaluate and synthesise information about beliefs, barriers and enablers to food choices from the NMSS into factors and then create and evaluat paths to eating patterns which show how the factors interact and their relative importance in choice of foods.

Previous research has identified that decisions about nutrition and weight control are two areas where simple explanations are inadequate to explain much of the variablity surrounding them, such as how they interact with food security (Ashe & Sonnino, 2013; Crawford & Webb, 2011), family (Baiocchi-Wagner & Talley, 2012; Cromley, Neumark-Sztainer, Story, & Boutelle, 2010; Leech et al., 2014) environment (Story, Kaphingst, Robinson-O'Brien, & Glanz, 2008; Swinburn et al., 1999; Wiig Dammann & Smith, 2011) and motives (Michaelidou, Christodoulides, & Torova, 2012). The complexity is also reflected in the use of theories to explain it (Grunert et al., 2012; Spahn et al., 2010; Webb, Sniehotta, & Michie, 2010) and frameworks to address it (Swinburn et al., 2013).

The purpose of this chapter is to identify, quantify and order determinants to healthy eating as defined by the health eating indicators developed in Chapter six. The analysis will examine the healthful eating indicators using a number of known different determinants including intentions to change (Di Noia & Prochaska, 2010; Michaelidou et al., 2012) , barriers and enablers to change (Larson et al., 2012; Skuland, 2015), knowledge about diet and nutrition (Dissen et al., 2011; Wang & Chen, 2012) and some known correlates of diet such as obesity (Atlantis, Barnes, & Ball, 2008), food insecurity (Bauer et al., 2015; Markwick, Ansari, Sullivan, Parsons, & McNeil, 2014; Morrissey, Jacknowitz, & Vinopal, 2014) and responsibility for food shopping (Aggarwal et al., 2014; O’Brien et al., 2014; Ollberding, Wolf, & Contento, 2010), preparation (Reicks, Trofholz, Stang, & Laska, 2014) and cooking skills (Hartmann, Dohle, & Siegrist, 2013).

7.1 METHODOLOGY

7.1.1 Measures

The dependent variables used throughout the analysis were the recommended healthful eating indicator (RF_HEI) and the discretionary healthful eating (RF_HEI) described in Chapter six. These indicators are made up of scores about food consumption both in terms of amount and type. The scores were assigned using the ADG and provide a measure of how closely the recommendations made in the guidelines were followed. The independent variables were derived from a variety of questions about perceptions and beliefs of healthy eating. A full description of the questions used in the analysis can be found in Appendix four. A brief description of these is provided below under the headings socioeconomic, intentions, attitudes/perceptions, knowledge and BMI.

Sociodemographic indicators: The following variables were used in the analysis, gender, age, education, income expressed as Australian dollars, employment status, living arrangements income, perceived spending power, area of residence, country of birth, aboriginality and Socio-Economic Indexes for Areas (SEIFA) which is an area based indication of relative socioeconomic disadvantage developed by the Australian Bureas of Statistics (Australian Bureau of Statistics, 2013d).

Intentions to change consumption of fruit, vegetables, calcium rich foods, fat and fatty foods and intentions regarding weight -the response categories were read out: Which of the following best currently describes you? I am currently trying to …; I am thinking about trying to …; I am not thinking about …; I already ….

Attitudes/Perception –response categories were read out 1) Rating of the level of attention paid to the health aspects of the foods from paying a lot of attention, paying a bit of attention or not thinking much about the health aspects.

2) Rating of cooking skills from can't cook, can boil an egg/BBQ, can cook basic foods, can cook a wide range to can cook almost anything.

Attitudes/Perception –responses were elicited from the respondent and multiple responses were recorded: Difficulties related to eating more fruit, vegetables, cereal foods and dairy foods and eating less fat and fatty foods as well as difficulties associated with losing weight

Knowledge – responses were elicited from the respondent and recorded as a single response: Knowledge of recommendations for daily serves of fruit and vegetables.

Knowledge- responses were elicited from the respondent and multiple responses were recorded: 1) Knowledge of the recommendations around the amount and type of fat used 2) Knowledge of health problems associated with eating to little fruit, vegetables, cereal foods and dairy foods. 3) Knowledge of health problems associated with eating too much fat and having excess weight.

Other: BMI using a self-reported height and weight with a calculation adjusting for over-reporting of height and under-reporting of weight (Hayes et al., 2011).

7.1.2 Analyses

Descriptive and regression analyses are used in a staged approach of drivers associated with each healthful indicator including a range of socio demographics, attitudes perceptions, knowledge and BMI. Means for the variables were calculated for the score components of the two indexes with 95% confidence intervals. The mean estimates were weighted using the IPF method described in Chapter 3, Section 3.3.1 using the basic adjustment for the probability of selection and then fitting marginal proportional totals for age, sex and area of residence based on the 2011 Estimated Resident Population for Western Australia. One-way ANOVA was used to establish within and between group statistical significance where appropriate using weighted estimates. Weighted regressions using the same IPF weight as used in the mean estimates were conducted on the variables in each descriptive table. Spearman correlation was conducted for variables where multiple responses were permitted and for the intentions to change behaviour. Tetrachoric factor analysis (Bonett & Price, 2005) was used to extract factors with either varimax or oblique rotation. Weighted regressions using the same IPF weight as used in the mean estimates were conducted on the variables in each descriptive table. These were entered as independent variables with either the recommended healthful eating indicator (RF_HEI) as the dependent variable or the discretionary healthful eating indicator (DF_HEI) as the dependent variable. Interactions between the variables were explored where one might be expected, such as with cooking skills that might interact with both age and gender. Bayesian Information Criteria (BIC) was used to choose models with highly correlated variables (Posada & Buckley, 2004). For the final regression models all the statistically significant variables from each of the previous regressions were entered as independent variables with the RF_HEI and the DF_HEI as dependent variables. Beta coefficients were calculated for the final models to determine the relative strength of the predictors in the model (de Vries, Engels, Kremers, Wetzels, & Mudde, 2003; Gao et al., 2008; Wensing, Vingerhoets, & Grol, 2001). As the IPF weight is used and robust standard errors produced, no post estimation tests were possible. The analysis was conducted in stages for each of the variable groups described in Section 7.1.1 for each of the indicators of healthy eating, namely the Recommended Food Healthy Eating Indicator (RF_HEI) and the Discretionary Food Healthy Eating indicator (DF_HEI). For both, the scores are an indicator of adherence to the ADG and a higher score indicates greater adherence. This section is set out with a description of the RF_HEI and the DF_HEI in relation to the variable group for each stage and identifying correlations of 0.20 and above although the correlation tables are not generally presented. Then a linear regressions with the RF_HEI and the DF_HEI scores as the dependent variable was conducted for each of the variable groups using either the individual variables or the factors. All variables or factors were entered into the regression analysis even if they were not shown to be statistically significantly different from the reference group in the descriptive tables as recommended in the STRATOS approach to analysis (Sauerbrei et al., 2014). The final two linear regressions for the RF_HEI and the DF_HEI used every variable and/or factor that had attained a statistical significance of p<=0.10 from previous stages for that indicator.

7.2 RESULTS

The results are presented by groups of variables with common themes in the following order: sociodemographics, intentions to change, difficulties in increasing healthy eating and decreasing fat consumption, knowledge and recommendations about key food groups, perceptions about what makes eating a healthy diet easier and other variables that could be associated with eating choices such as cooking skills and responsibility for food preparation.

7.2.1 Sociodemographics associated with the RF_HEI and the DF_HEI

Table 7.1 presents the mean RF_HEI and DF_HEI for the sociodemographic variables. Only three were not significantly associated with one or the other: Aboriginal or Torres Strait Islander origin, the area of residence within WA and country of birth.

Table 7.2 presents the regression results for socio demographic associations for the RF_HEI and Table 7.3 for the DF_HEI. Only the variables which have a statistically significant associations of $p<0.1$ are presented on the tables.

There are only two socio demographic variables which are associated with both the RF_HEI and the DF_HEI, these are being male and living alone. Both are associated with lower scores on both the RF_HEI and the DF_HEI, which means a lower adherence to the ADG recommendations for eating within recommended food groups and for eating within recommended amounts. At this stage, the RF_HEI model has an r^2 of 0.07 and the DF_HEI had an r^2 of 0.04 indicating that the socio demographics on their own are not producing good explanatory models, although they are mostly showing associations that are in the expected direction.

Table 7.1 Mean scores for RF_HEI and DF_HEI by the NMSS 2012 socio demographics

Socio demographic variables	RF_HEI (95% CI)	*p*	DF_HEI (95% CI)	*p*
Persons	45.85[44.85,46.85]		17.70[17.14,18.25]	
Male	44.11[42.50,45.73]		16.64[15.77,17.50]	
Female	47.61[46.46,48.76]	<0.0001	18.77[18.10,19.43]	<0.0001
Age group in years				
18-24	44.78[41.02,48.54]		16.21[14.18,17.87]	
25-34	45.26[42.36,48.16]		17.14[15.61,18.09]	
35-44	44.57[42.83,46.32]		18.22[17.28,18.23]	
45-54	46.26[44.81,47.72]		18.48[17.56,18.64]	
55-64	48.21[46.75,49.67]	0.015	17.87[17.01,18.07]	0.013
Highest level of education attained				
Up to Year 12	42.07[39.50,44.64]		18.07[16.67,19.47]	
Year 12	43.40[40.38,46.43]		17.00[15.45,18.54]	
TAFE/Trade/Diploma	45.98[44.36,47.60]		17.89[17.01,18.77]	
Tertiary	47.89[46.33,49.44]	<0.0001	17.70[16.76,18.64]	
Annual household income*				
Under $20,000	38.57[32.18,44.96]		18.15[15.45,20.86]	
$20,000 - $40,000	43.42[39.45,47.40]		16.43[14.55,18.30]	
$40,000 - $60,000	44.94[41.77,48.11]		16.33[14.56,18.09]	
$60,000 - $80,000	45.82[43.45,48.19]		18.53[16.97,20.09]	
$80,000 - $100,000	49.27[47.07,51.47]		18.17[16.84,19.50]	
$100,000 - $120,000	44.32[41.51,47.13]		17.52[15.96,19.07]	
$120,000 - $140,000	46.88[43.76,50.00]		18.17[16.26,20.08]	
More than $140,000	46.46[44.08,48.84]		17.92[16.79,19.04]	
Unsure/Dont know/Cant remember	43.10[39.42,46.77]		16.55[14.11,18.99]	
Refused read out	50.49[46.86,54.11]	<0.0001	18.95[16.50,21.40]	0.185
Aboriginality#				
No	45.89[44.88,46.90]		17.74[17.18,18.30]	
Yes	44.10[37.79,50.41]	0.807	15.34[10.57,20.11]	0.160

* This is the only variable where more than 2% answered don't know or refused. All other variables had 1% or less in the don’t know and refused categories combined and are not included in the tables or analysis.

Only 1.54% of the sample identified themselves of ATSI origin (n=22).

Socio demographic variables	**RF_HEI(95% CI)**	***p***	**DF_HEI (95% CI)**	***p***
Perceived discretional income				
Spending more money than get	44.09[37.31,50.88]		17.58[14.77,20.39]	
Just enough money to next pay	40.74[37.45,44.03]		16.21[14.73,17.69]	
Some money left over but spend	43.16[40.10,46.21]		17.56[15.47,19.66]	
Can save a bit every now	45.88[44.16,47.59]		18.27[17.23,19.31]	
Can save regularly	48.17[46.54,49.79]		17.34[16.42,18.25]	
Can save a lot	46.64[43.93,49.34]	<0.0001	18.99[17.35,20.63]	0.026
SEIFA Quintiles (Section 3.1.1)				
Quintile 1	43.69[39.54,47.85]		15.49[13.51,17.48]	
Quintile 2	44.33[41.83,46.82]		19.57[18.12,21.01]	
Quintile 3	45.65[42.87,48.43]		17.04[15.79,18.29]	
Quintile 4	46.35[44.67,48.03]		17.55[16.69,18.41]	
Quintile 5	46.96[45.13,48.78]	0.074	18.25[17.02,19.48]	<0.0001
Current Employment Status				
Employed	46.35[45.23,47.48]		17.94[17.31,18.57]	
Unemployed	38.28[31.73,44.84]		17.78[13.49,22.07]	
Home Duties	48.32[46.19,50.45]		17.28[15.71,18.85]	
Student	40.85[36.12,45.58]		15.66[13.09,18.23]	
Retired	48.90[46.38,51.43]		18.53[16.88,20.19]	
Unable to work	36.38[29.35,43.40]	<0.0001	17.33[13.23,21.43]	0.081
Living Arrangements				
Living with my parent(s)	43.69[39.54,47.85]		15.49[13.51,17.48]	
Living with other family	44.82[40.90,48.75]		19.04[16.90,21.17]	
Living with friends	46.53[38.81,54.24]		16.29[11.86,20.71]	
Living with a partner/kids	46.42[45.24,47.60]		17.98[17.28,18.69]	
Living with a partner/no kids	47.07[45.26,48.87]		17.82[16.83,18.81]	
Living alone	42.30[39.24,45.37]		19.41[17.82,21.00]	
Sole parent	46.19[40.18,52.20]	0.061	17.94[13.86,22.02]	0.001
Residential area				
Metropolitan Perth	45.80[44.58,47.02]		17.67[16.98,18.36]	
Rest of State	46.00[44.33,47.67]	0.820	17.76[16.88,18.64]	0.863
Country of Birth				
Australia	45.87[44.64,47.11]		17.86[17.16,18.56]	
UK or Ireland	46.43[44.20,48.65]		17.24[15.80,18.69]	
Other country	45.43[43.04,47.82]	0.762	17.42[16.23,18.61]	0.538

Table 7.2 Socio demographic variables with interactions associated with the RF_HEI, NMSS 2012

RF_HEI	Coef.	95% CI		Robust Std. Err.	t	P>|t|
Male	-3.20	-5.13	-1.26	0.99	-3.24	0.001
TAFE/Trade/Diploma/Tertiary education	3.25	0.88	5.62	1.21	2.69	0.007
Living alone	-3.28	-6.62	0.07	1.71	-1.92	0.055
Annual household income <$40,000	-3.71	-7.67	0.24	2.02	-1.84	0.066
Ability to save money from each pay period	3.96	1.61	6.30	1.19	3.31	0.001
Unemployed	-5.35	-11.15	0.44	2.96	-1.81	0.070
Student	-4.34	-9.00	0.32	2.38	-1.83	0.068
Retired	4.56	1.61	7.52	1.51	3.03	0.002
Unable to work	-6.34	-13.15	0.46	3.47	-1.83	0.068
Constant	42.92	40.13	45.71	1.42	30.18	<0.001

Table 7.3 Socio demographic variables with interactions associated with the DF_HEI, NMSS 2012

DF_HEI	Coef.	95% CI		Robust Std. Err.	t	P>|t|
Male	-2.17	-3.27	-1.07	0.56	-3.87	<0.001
Living with parents	-2.32	-4.30	-0.35	1.01	-2.31	0.021
Living alone	1.57	-0.17	3.31	0.89	1.77	0.078
Doing home duties	-1.65	-3.37	0.06	0.87	-1.89	0.059
SEIFA Quintile 1*	-2.56	-4.21	-0.91	0.84	-3.05	0.002
SEIFA Quintile 2	1.70	0.15	3.26	0.79	2.15	0.032
Constant	19.22	18.46	19.97	0.38	49.97	<0.001

***Quintiles range from 1 the most socially disadvantaged to 5 least socially disadvantaged.

7.2.2 Intentions to change to healthy eating and control weight

Table 7.4 shows the mean scores for intentions to change in directions consistent with healthy eating and weight. A modest correlation was found between intentions related to fruit and intentions related to vegetables (rho=0.29) however this did not appear to affect the regression model.

Table 7.4 Mean scores for RF_HEI and DF_HEI by the NMSS 2012 intentions to change

	RF_HEI		DF_HEI	
Intentions to change	**Mean (95% CI)**	***p***	**Mean (95% CI)**	***p***
Fruit				
I already eat enough	50.90[49.59,52.21]		18.50[17.73,19.26]	
I am not thinking about increasing	33.97[31.06,36.89]		16.72[14.76,18.68]	
I am thinking about increasing	40.88[38.73,43.03]		16.13[14.80,17.46]	
I am currently trying to eat more	44.98[43.20,46.77]	<0.0001	17.82[16.76,18.88]	0.0003
Vegetables				
I already eat enough	48.18[47.00,49.37]		18.20[17.46,18.94]	
I am not thinking about increasing	32.30[28.08,36.52]		16.01[14.33,17.68]	
I am thinking about increasing	42.10[38.97,45.24]		15.72[14.18,17.25]	
I am currently trying to eat more	44.99[42.93,47.05]	<0.0001	17.81[16.66,18.97]	0.0008
Calcium rich foods				
I already eat enough	47.79[46.28,49.31]		18.28[17.48,19.08]	
I am not thinking about increasing	42.02[40.28,43.77]		17.12[16.01,18.24]	
I am thinking about increasing	45.73[42.85,48.60]		17.31[15.87,18.76]	
I am currently trying to eat more	47.34[44.93,49.76]	<0.0001	16.99[15.46,18.52]	ns
Fat and fatty foods				
I already eat a low fat diet	48.49[46.95,50.04]		18.42[17.52,19.31]	
I am not thinking about cutting	43.39[39.94,46.85]		16.09[14.56,17.61]	
I am thinking about cutting down	41.42[38.94,43.89]		17.39[16.04,18.74]	
I am currently trying to eat less fat	45.83[44.26,47.39]	<0.0001	17.53[16.55,18.51]	0.009
Intentions to lose weight				
Not thinking or trying	46.82[45.27,48.37]		16.82[15.98,17.67]	
Thinking of trying to lose	44.22[42.04,46.40]		17.85[16.67,19.02]	
Trying to lose	45.07[43.55,46.58]	0.025	18.89[18.05,19.73]	0.0001

The variables on Table 7.4 were entered into regressions and the results shown on Table 7.5 for the RF_HEI and Table 7.6 for the DF_HEI.

Table 7.5 Intentions to change significantly associated with the RF_HEI, NMSS 2012

RF_HEI	Coef.	95% CI		Robust Std. Err.	t	P>|t|
Thinking of trying to eat more fruit	5.52	1.74	9.31	1.93	2.86	<0.001
Trying to eat more fruit	8.81	5.09	12.52	1.90	4.65	<0.001
Already eat enough fruit	14.08	10.59	17.57	1.78	7.91	<0.001
Thinking of trying to eat more vegetables	7.65	1.60	13.71	3.09	2.48	0.01
Trying to eat more vegetables	9.11	3.50	14.73	2.86	3.18	<0.001
Already eat enough vegetables	10.08	4.59	15.56	2.79	3.61	<0.001
Thinking of trying eat less fat/fatty foods	-3.61	-5.95	-1.27	1.19	-3.02	<0.01
Already eat a calcium rich diet	1.70	-0.09	3.49	0.91	1.87	0.06
Constant	26.93	22.09	31.76	2.47	10.92	<0.01

The comparison groups were: intentions about fruit and vegetables are compared with those who are not thinking about trying to eat more. The comparison group for intentions about eating less fat/fatty foods and eating a diet rich in calcium are all those who are not in the group.

Table 7.6 Intentions to change with interactions significantly associated with the DF_HEI, NMSS 2012

DF_HEI	Coef.	95% CI		Robust Std. Err.	t	P>|t|
Already eat enough vegetables	1.63	0.49	2.77	0.58	2.81	0.01
Already eat low fat diet	1.68	0.5	2.86	0.6	2.8	0.01
Already eat enough cereal food	-2.11	-3.26	-0.97	0.58	-3.62	<0.01
Not thinking about or trying to lose weight	-2.12	-3.21	-1.02	0.56	-3.79	<0.01
Constant	18.28	17.19	19.37	0.56	32.84	<0.01

The comparison groups for were: already eat enough vegetables and cereal, already eating a low fat diet and for not thinking about or trying to lose weight are compared with all those who are not in the group.

As with the socio demographics, intentions to change behaviour are differently associated with the RF_HEI where there is more intention to change compared with the DF_HEI where there is no intention to change. The RF_HEI model has an r^2 of 0.19 but the DF_HEI model has a low r^2 of 0.04.

7.2.3 Perceived difficulties in increasing healthy foods and decreasing fats and weight

Next the perceived difficulties with changing behaviour to achieve more healthful eating and weight are examined. Means for each of the difficulties by food type and weight are presented in Appendix four. Each of the areas investigated, namely, fruit, vegetables, cereals, fat/fatty food and weight were grouped into factors.

7.2.4 Difficulties increasing fruit consumption

The factor analysis for difficulties with increasing fruit consumption showed four factors (Table 7.7). The fourth factor is only one difficulty, lack of time to buy or prepare fruit, which remains on its own. The spearman correlation showed that there was only one association that was correlated at rho=0.2 or higher, the quality and variety of fruit (rho=0.21), reflected in factor one.

Table 7.7 Factors identified for difficulties in increasing fruit consumption using a varimax orthogonal rotation, NMSS 2012

Difficulties increasing fruit consumption	Factor one Eigenvalue 2.19	Factor two Eigenvalue 1.92	Factor three Eigenvalue 1.42	Factor four Eigenvalue 1.26
Don't like or lack of interest in fruit	-0.01	**0.64**	0.32	0.02
Fruit too expensive	**0.77**	-0.12	-0.10	0.13
Difficult to change eating habits	-0.08	-0.05	**0.91**	-0.02
No time to buy/prepare fruit	0.00	-0.06	0.03	**0.98**
Difficult to find good quality fruit	**0.68**	0.46	-0.12	0.03
Not enough variety/too seasonal	**0.84**	0.08	0.04	-0.14
Doesn't appeal in the cold weather	0.14	**0.67**	0.28	0.19
Difficult because of health issues	-0.04	**-0.91**	0.18	0.15
Difficult to access	**-0.63**	-0.04	**-0.60**	-0.46

Table 7.8 shows the regression results for the RF_HEI. The only variable that was not statistically significant associated was the stand alone time to buy or prepare fruit. The RF_HEI model had a low r^2 of 0.03. None of the factors identified for difficulties increasing fruit consumption were statistically significantly associated with the DF_HEI and no table was produced.

Table 7.8 Factors associated with difficulties increasing fruit consumption associated with the RF_HEI, NMSS 2012

RF_HEI	Coef.	95% CI		Robust Std. Err.	t	P>|t|
Factor one -quality and access	-2.39	-3.85	-0.94	0.74	-3.75	0.001
Factor two -not appealing and health	-4.69	-7.40	-1.98	1.38	-2.75	0.001
Factor three-difficult to change and access	-4.73	-7.94	-1.53	1.63	-1.75	0.004
Factor four-time to buy or prepare fruit	-1.03	-5.66	3.61	2.36	-0.75	0.664
Constant	47.49	46.36	48.62	0.58	0.25	<0.001

7.2.5 Difficulties increasing vegetable consumption

The factor analysis for difficulties with increasing vegetable consumption showed four factors (Table 7.9). The fourth factor "don't like vegetables" which remains on its own.

Table 7.9 Factors identified for difficulties in increasing vegetable consumption using a varimax orthogonal rotation, NMSS 2012

Difficulties increasing vegetable consumption	Factor one Eigenvalue 2.48	Factor two Eigenvalue 1.93	Factor three Eigenvalue 1.81	Factor four Eigenvalue 1.32
Don't like or lack of interest in vegetables	0.00	-0.09	-0.26	**0.89**
Vegetables too expensive	**0.67**	0.12	0.45	0.21
Difficult to change eating habits	0.21	0.24	**-0.61**	0.43
No time to buy/prepare vegetables	-0.06	**0.98**	0.10	-0.04
The effort it takes to prepare vegetables	0.08	**0.76**	-0.52	-0.09
Difficult to find good quality vegetables	**0.83**	-0.04	0.21	0.07
Not enough variety	**0.85**	-0.14	-0.12	-0.26
Difficult because of health issues	**-0.71**	-0.56	-0.09	-0.38
Difficult to access	0.24	0.04	**0.91**	-0.24

The spearman correlation showed that there were only two associations correlated at rho=0.2 or higher. These were the quality and expense of vegetables (rho=0.28) and the quality and variety of vegetables (rho=0.20). Both of these associations were reflected in factor one.

Table 7.10 shows the regression results for factors associated with increasing vegetable consumption and RF_HEI and Table 7.11 shows the regression results for RF_HEI.

Table 7.10 Factors associated with difficulties increasing vegetable consumption associated with the RF_HEI, NMSS 2012

RF_HEI	Coef.	95% CI		Robust Std. Err.	t	P>|t|
Factor one –expense/ variety/ quality/ health	0.42	-1.44	2.29	0.95	0.45	0.656
Factor two -time and effort	-0.31	-2.38	1.76	1.05	-0.29	0.769
Factor four-don't like vegetables	-12.18	-16.47	-7.88	2.19	-5.56	<0.001
Constant	46.59	45.47	47.72	0.57	81.30	<0.001

Table 7.11 Factors associated with difficulties increasing vegetable consumption associated with the DF_HEI, NMSS 2012

DF_HEI	Coef.	95% CI		Robust Std. Err.	t	P>|t|
Factor one –expense/ variety/ quality/ health	-0.08	-1.15	0.99	0.55	-0.14	0.887
Factor two -time and effort	0.27	-0.97	1.50	0.63	0.42	0.672
Factor four-don't like vegetables	-2.97	-5.24	-0.71	1.15	-2.58	0.010
Constant	17.84	17.19	18.50	0.33	53.56	<0.001

In both cases a dislike of vegetables was the only significant difficulty factor associated with trying to increase vegetable consumption, particularly for the RF_HEI. Both the RF_HEI and the DF_HEI models had low explained variance (RF_HEI: r^2 = 0.03, DF_HEI r^2 = 0.01].

7.2.6 Difficulties increasing cereal food consumption

The factor analysis for difficulties increasing cereal foods consumption showed three factors (Table 7.12). For each of the factors, high positive associations were offset by one high negative association but in each case a different one. Respondents, who didn't eat breakfast and perceived that they had no time to do so, also saw cereal food consumption as a possible means of gaining weight. For those who thought that cereals took too much time and effort to prepare also saw increasing consumption impacting their health. For those who didn't like cereal foods, the expense was a negative factor.

Table 7.12 Factors identified for difficulties in increasing consumption of cereal foods using a varimax orthogonal rotation, NMSS 2012

Difficulties increasing consumption of cereal foods	Factor one Eigenvalue 2.31	Factor two Eigenvalue 2.18	Factor three Eigenvalue 2.02
Don't like or lack of interest in cereal foods	-0.04	-0.12	**0.84**
Cereal foods too expensive	-0.14	-0.21	**-0.95**
Don't eat breakfast	**0.76**	-0.07	-0.01
No time to prepare	0.30	**0.86**	-0.16
The effort needed to prepare	0.33	**0.79**	0.38
No time to eat in the mornings	**0.70**	0.22	0.46
Difficult because of possible weight gain	**-0.94**	-0.12	-0.05
Difficult because of health issues	0.38	**-0.83**	-0.14

The spearman correlation showed that there was only one association that was correlated at rho=0.2 or higher. This was between the time and effort to prepare cereal foods (rho=0.25), reflected in factor two. The regression results for both RF_HEI and the DF_HEI showed no statistically significant differences associated with the three factors identified in relation to increasing cereal food consumption and no tables were produced.

7.2.7 Difficulties decreasing consumption of fats and fatty foods

The factor analysis for difficulties with decreasing consumption of fats and fatty foods showed that there was no clear factor structure for the difficulties mentioned. The spearman correlation showed that there was only one association that was correlated at rho=0.2 or higher between the time and effort it takes to shop for and prepare low fat food (rho=0.25). As there were no clear factors, each individual difficulty was entered into regressions for the RF_HEI and the DF_HEI. Table 7.13 shows the results for the RF_HEI. Only the perceived time and effort it needs to shop for and prepare low fat foods were significantly related to the RF_HEI although there was a weak association for this indicator and changing eating habits. The RF_HEI model had a low r^2 of 0.04.

Table 7.13 Difficulties decreasing fats/fatty food consumption associated with the DF_HEI, NMSS 2012

RF_HEI	Coef.	95% CI		Robust Std. Err.	t	P>|t|
Person preparing food uses fat	-1.30	-6.19	3.59	2.49	-0.52	0.602
Enjoy foods high in fat	-1.29	-3.57	1.00	1.16	-1.10	0.269
Hard to change eating habits	-3.16	-6.83	0.52	1.87	-1.69	0.092
Time it takes to shop/prepare low fat foods	-4.86	-8.62	-1.10	1.92	-2.54	0.011
Effort it takes to prepare low fat foods	-5.96	-10.66	-1.26	2.39	-2.49	0.013
Low fat foods not available lunch time	0.88	-3.04	4.79	2.00	0.44	0.661
Eat a lot of fast foods	0.88	-2.25	4.00	1.59	0.55	0.581
Constant	47.26	45.98	48.54	0.65	72.38	<0.001

There were no significant associations with any of the difficulties and the DF_HEI and no table was produced.

7.2.8 Difficulties controlling weight

The factor analysis for difficulties controlling weight showed three factors, all of which were complex in nature (Table 7.14).

Table 7.14 Factors identified for difficulties in controlling weight using a varimax orthogonal rotation, NMSS 2012

Difficulties controlling weight	Factor one Eigenvalue 3.15	Factor two Eigenvalue 2.71	Factor three Eigenvalue 2.11
Enjoy my food/helps me get through	0.27	**0.40**	-0.09
Eating habits hard to change	0.19	**0.37**	0.12
Don't like exercise	-0.20	-0.06	**0.63**
No time to exercise/work long hours	-0.09	**-0.50**	**0.45**
Eat out regularly	0.55	-0.15	**0.42**
Do shift work	0.02	**-0.91**	-0.04
No will power to exercise	**-0.48**	0.03	**0.52**
I don't exercise	**-0.86**	-0.21	-0.04
I like fattening food/have a sweet tooth	-0.32	**0.65**	-0.04
Have medical problems	-0.29	-0.14	**-0.81**
I like beer/alcohol	-0.36	**0.61**	-0.01
No time to shop for healthy food	**0.82**	-0.31	-0.08
No time to cook healthy food	**0.69**	-0.16	0.41
Eat what is provided/given/family eats	**0.52**	**0.58**	**0.47**

The first showed that not having the time to cook or shop for healthy food and eating what it provided was offset by not liking to exercise and not having the will power to do it anyway. The second factor showed indicated a general liking for food offset by not being a shift worker or having time to exercise. The third factor was about disliking exercise as well as having no will power to do it coupled with lack of time, eating our regularly and eating what is provided but not having medical problems.

The spearman correlation showed that there were two associations that was correlated at rho=0.2 or higher. The first was between having no will power to exercise and not liking exercise (rho=0.22) between the time and effort it takes to shop for and cook healthy food (rho=0.30). The regression analyses showed no significant associations for any of these factors with either the RF_HEI or the DF_HEI and no tables were produced.

7.2.9 Total perceived difficulties associated with healthy eating and controlling weight

The test whether or not the number of difficulties (barriers) to increasing consumption (fruit, vegetables and cereals) or decreasing (fats/fatty foods and weight) are cumulative, the totals for each of the five areas (fruit, vegetables, cereals, fat and weight) were used. Modest correlations were found between the total number of difficulties (barriers) mentioned for each food type and weight (Table 7.15). The association with the highest coefficient was retained where one variable effect cancelled out another due to the correlation between the two.

Table 7.15 Spearman correlation matrix for total number of difficulties mentioned in relation to eating more fruit, vegetables and cereal foods; eating less fat/fatty foods and losing excess weight, NMSS 2012

	# of fruit difficulties	# of vegetable difficulties	# of cereal difficulties	# of fat difficulties
# of vegetable difficulties	0.37			
# of cereal difficulties	0.20	0.12		
# of fat difficulties	0.19	0.25	0.14	
# of weight difficulties	0.15	0.15	0.13	0.24

Table 7.16 shows the means for total difficulties mentioned. The results of the regression for the total number of difficulties in changing behaviour to healthier eating for the RF_HEI are shown on Table 7.17 and for the DF_HEI on Table 7.18. The DF_HEI scores appear to have a complex relationship to the number of difficulties in changing behaviour to healthier eating as the statistically significant finding with regard to the number of difficulties in losing excess weight disappears when it is entered on its own. For this reason the entire model is shown but only the total number of difficulties in trying to lose weight variable will be entered into the final regression model for the DF_HEI. Both the RF_HEI and the DF_HEI models had low explained variance (RF_HEI: $r^2 = 0.04$, DF_HEI $r^2 = 0.01$].

Table 7.16 Mean scores for total number of difficulties mentioned for the RF_HEI and DF_HEI by the NMSS 2012

Total difficulties mentioned	RF_HEI Mean (95% CI)	*p**	DF_HEI Mean (95% CI)	*p**
Increasing fruit consumption*				
0	48.50[47.18,49.83]		17.83[17.04,18.62]	
1	42.88[41.25,44.51]		17.79[16.91,18.67]	
2	45.68[41.50,49.86]		16.91[14.99,18.84]	
3	36.61[31.87,41.36]	<0.0001	15.63[11.8,19.46]	0.388
Increasing vegetable consumption**				
0	47.07[45.90,48.24]		18.04[17.35,18.73]	
1	43.56[41.31,45.82]		16.61[15.58,17.65]	
2	44.67[41.62,47.71]	0.0002	18.38[16.4,20.35]	0.010
Increasing cereal foods consumption**				
0	47.33[46.19,48.47]		17.63[16.96,18.29]	
1	42.31[40.35,44.27]		17.99[16.91,19.06]	
2	44.93[38.19,51.67]	<0.0001	16.87[13.83,19.90]	0.569
Decreasing fat consumption*				
0	46.84[45.49,48.19]		18.00[17.15,18.86]	
1	46.4[44.81,47.99]		17.27[16.48,18.07]	
2	43.09[40.00,46.19]		19.08[17.42,20.74]	
3	36.30[29.76,42.84]	<0.0001	14.53[10.96,18.09]	0.002
Losing weight*				
0	46.22[44.4,48.05]		17.16[16.20,18.12]	
1	45.72[44.27,47.17]		17.75[16.93,18.58]	
2	45.25[42.92,47.57]		18.91[17.55,20.28]	
3	46.22[42.83,49.61]	0.820	17.07[15.20,18.94]	0.042

* Totals greater than 3 recoded back to 3; ** totals greater than 2 recoded back to 2

Table 7.17 Total number of difficulties to changing behaviour to more healthful eating/weight associated with the RF_HEI, NMSS 2012

RF_HEI	Coef.	95% CI		Robust Std. Err.	t	P>|t|
Total difficulties eating more fruit	-2.58	-3.93	-1.23	0.69	-3.75	<0.001
Total difficulties eating more cereal foods	-2.5	-4.66	-0.34	1.1	-2.27	0.023
Total difficulties eating less fat/fatty foods	-1.67	-3.06	-0.29	0.71	-2.37	0.018
Constant	49.59	48.05	51.14	0.79	63.03	<0.001

Table 7.18 Total number of difficulties to changing behaviour to more healthful eating/weight associated with the DF_HEI, NMSS 2012

DF_HEI	Coef.	95% CI		Robust Std. Err.	t	P>|t|
Total difficulties eating more fruit	-0.45	-1.32	0.42	0.45	-1.01	0.313
Total difficulties eating more vegetables	-0.19	-1.16	0.78	0.50	-0.38	0.702
Total difficulties eating more cereal foods	0.14	-0.91	1.19	0.54	0.27	0.790
Total difficulties eating less fat/fatty foods	-0.37	-1.20	0.46	0.42	-0.87	0.383
Total difficulties trying to lose weight	0.64	0.00	1.29	0.33	1.96	0.050
Constant	17.72	16.71	18.73	0.52	34.35	<0.001

For each of the areas there was an option to say that there were no difficulties. Table 7.19 shows the correlations for perceiving no difficulty associated with changing behaviour to maintain healthier eating.

Table 7.19 Spearman correlation matrix for perceiving that there were no difficulties mentioned in relation to eating more fruit, vegetables and cereal foods; eating less fat/fatty foods and losing excess weight, NMSS 2012

	No difficulty eating more fruit	No difficulty eating more vegetables	No difficulty eating more cereal foods	No difficulty eating less fat/fatty foods
No difficulty eating more vegetables	0.39			
No difficulty eating more cereal foods	0.23	0.18		
No difficulty eating less fat/fatty foods	0.23	0.26	0.17	
No difficulty controlling weight	0.12	0.16	0.15	0.25

In the regressions, the association with the highest coefficient was retained where one variable effect cancelled out another due to the correlation between the two. Table 7.20 shows the regression results for the RF_HEI and Table 7.21 for the DF_HEI.

Table 7.20 No perceived difficulties in changing behaviour to more healthful eating/weight associated with the RF_HEI, NMSS 2012

DF_HEI	Coef.	95% CI		Robust Std Err.	t	P>|t|
No difficulty eating more fruit	4.37	2.35	6.4	1.03	4.24	<0.001
No difficulty eating more cereal foods	3.60	1.37	5.83	1.14	3.17	0.002
Constant	41.4	39.41	43.4	1.01	40.8	<0.001

For the RF_HEI perceiving no difficulty in eating more fruit or cereal foods was associated with increased scores as was no difficulty in eating more vegetables for the DF_HEI. There was a decrease in scores for the DF_HEI for those who perceived no difficulty in controlling weight. Both the RF_HEI and the DF_HEI models had low explained variance (RF_HEI: $r^2 = 0.04$, DF_HEI $r^2 = 0.01$].

Table 7.21 No perceived difficulties in changing behaviour to more healthful eating/weight associated with the DF_HEI, NMSS 2012

DF_HEI	Coef.	95% CI		Robust Std. Err.	t	P>|t|
No difficulty eating more vegetables	1.16	0.00	2.32	0.59	1.97	0.050
No difficulty in controlling weight	-1.06	-2.26	0.14	0.61	-1.73	0.083
Constant	17.40	16.46	18.34	0.48	36.32	<0.001

7.2.10 Knowledge indicators for food groups

The next set of results are about knowledge of the recommended serves of vegetables and fruit as well as knowledge about the health effects associated with not enough fruit and vegetables or cereal foods; with eating too much fat; and with excess weight.

Knowledge of the minimum number of serves recommended for daily consumption is not known by 45.8% of the population of WA for fruit and 48.5% of the population for vegetables (not shown in the table). Table 7.22

present the mean scores for the RF_HEI and the DF_HEI by knowledge of recommendations.

Table 7.22 Mean scores by knowledge of recommendations for the daily serves of fruit and vegetables, NMSS 2012

Knowledge of recommendations	RF_HEI Mean (95% CI)	*p**	DF_HEI Mean (95% CI)	*p**
Daily serves of fruit				
Less than recommended or don't know	36.05[31.63,40.47]		16.78[14.18,19.38]	
More than recommended minimum*	46.84[45.44,48.25]		17.56[16.73,18.39]	
Correct at minimum 2 serves daily	46.16[44.78,47.54]	<0.0001	17.89[17.11,18.66]	0.456
Daily serves of vegetables				
Less than recommended or don't know	43.15[41.55,44.76]		17.35[16.51,18.19]	
More than recommended minimum*	55.36[52.15,58.57]		19.86[16.80,22.91]	
Correct at minimum 5 serves daily	47.84[46.59,49.09]	<0.0001	17.91[17.14,18.67]	0.144

*Technically these are also correct as the recommended serves per day are a minimum amount. However, the question specifically asked about the recommended daily serves and two serves of fruit and five serves of vegetables are those used in health promotion campaigns.

This uncertainty about what is the exact amount of fruit consumption affects the mean RF_HEI score more than does uncertainty about the exact amount of vegetable consumption. The RF_HEI score for the population who think that the recommended serves of vegetables is greater than five is higher than both other groups and although not significant, also appears higher for the DF_HEI. Table 7.23 shows the regression results for the RF_HEI.

Table 7.23 Knowledge of recommendations about serves of fruit and vegetables associated with the RF_HEI, NMSS 2012

RF_HEI	Coef.	95% CI		Robust Std. Err.	t	P>|t|
Daily serves of fruit>2	10.80	6.16	15.44	2.37	4.56	<0.001
Minimum of two serves daily	10.11	5.48	14.75	2.36	4.28	<0.001
Constant	36.05	31.63	40.47	2.25	16.00	<0.001
Daily serves of vegetables >5	12.20	8.61	15.79	1.83	6.66	<0.001
Minimum of five serves daily	4.69	2.65	6.73	1.04	4.52	<0.001
Constant	43.15	41.55	44.76	0.82	52.62	<0.001

The RF_HEI model had low explained variance for each set of recommendations (Daily serves of fruit: $r^2 = 0.03$, daily serves of vegetables

$r^2 = 0.04$]. There were no statistically significant associations for these recommendations and the DF_HEI. No table was produced.

7.2.11 Knowledge of health problems associate with eating too little fruit and vegetables

Next to be considered are the knowledge about health problems associated with the consequences of not eating a healthy diet or having excess weight. The factor analysis for health problems associated with eating too little fruit and vegetables showed three factors (Table 7.24).

Table 7.24 Factors identified for problems associated with eating too little fruit and vegetables using an oblique rotation, NMSS 2012

Too little fruit and vegetables	**Factor one Eigenvalue 2.83**	**Factor two Eigenvalue 2.16**	**Factor two Eigenvalue 1.74**
Bowel cancer	-0.26	**0.51**	-0.34
Heart disease	**-0.81**	-0.18	-0.11
Constipation	0.02	**0.67**	0.00
Digestion problems/reflux	0.10	**0.74**	0.01
Intestinal problems/obstruction	0.12	**0.65**	0.02
Skin problems	0.28	0.23	0.18
Scurvy/beri beri / rickets	0.32	-0.24	**-0.51**
Excess weight	-0.31	-0.12	0.11
Vitamin & mineral deficiencies	**0.64**	-0.18	-0.27
Poor immunity/resistance/prone to colds	**0.51**	-0.13	0.15
Aenemia/ iron deficiency	**0.63**	-0.23	0.00
Lack of fibre	0.17	0.28	0.04
Tired/sluggish/slow	0.23	-0.19	**0.61**
General health problems	-0.05	0.00	**0.86**
Cancer	-0.44	-0.09	-0.09
Diabetes	**-0.67**	-0.26	0.14

The spearman correlation showed that there were four associations that was correlated at rho=0.2 or higher. These were constipation and digestion problems (rho=0.24); digestion problems and intestinal problems (rho=0.27); heart disease and diabetes (rho=0.26) and having low immunity and iron deficiency (rho=0.24). The first factor identified for health problems with too little fruit and vegetables is around having deficiencies associated with lack of iron, immunity and vitamins/mineral and skin problems but not mentioning heart disease, diabetes, cancer or excess weight. The second factor is having bowel, lack of fibre and digestion problems. The third is about being generally unwell and tired but not mentioning diseases associated with lack of vitamins in fruit and vegetables.

The spearman correlations (Table 7.25) showed that all the belief totals were correlated. Health problems associated with excess weight were relatively highly correlated with health problems associated with too little fruit and vegetables and with too much fat/fatty food.

Table 7.25 Spearman correlation matrix for total number of health problems mentioned in relation to eating more fruit, vegetables and cereal foods; eating less fat/fatty foods and losing excess weight, NMSS 2012

	# of health problems with too little fruit and vegetables	# of health problems with too little cereal foods	# of health problems with too much fat/fatty foods
# of health problems with too little cereal foods	0.36		
# of health problems with too much fat/fatty foods	0.38	0.26	
# of health problems with excess weight	0.41	0.26	0.41

The total number of health problems mentioned by type of food uses the same premise as for the other total measures; the more knowledge of health problems the higher the scores on the RF_HEI and the DF_HEI (Table 7.26).

Table 7.27 shows the regression results for the RF_HEI and for the DF_HEI. For both the RF_HEI and the DF_HEI the total number of problems associated with excess weight was associated with higher scores. For the RF_HEI, the total number of health problems associated with not eating enough cereal foods was also associated with a higher score.

Table 7.26 Mean scores for total number of health problems mentioned for the RF_HEI and DF_HEI, NMSS 2012

Total health problems mentioned	RF_HEI (95% CI)	*p**	DF_HEI (95% CI)	*p**
Associated with not enough fruit & vegetables*				
0	41.7[38.69,44.7]		19.87[17.99,21.75]	
1	44.78[43.05,46.52]		17.42[16.51,18.32]	
2	46.06[44.37,47.75]		18.07[17.12,19.02]	
3	48.25[45.65,50.85]		17.32[15.9,18.74]	
4	47.59[43.47,51.71]		16.89[14.51,19.27]	
5	51.76[45.75,57.77]	<.0001	14.74[11.86,17.62]	0.003
Associated with not enough cereal foods**				
0	43.1[41.52,44.68]		17.78[16.81,18.75]	
1	46.79[45.11,48.46]		17.8[16.88,18.72]	
2	46.33[43.77,48.88]		16.87[15.54,18.2]	
3	50.19[46.5,53.88]		18.69[16.96,20.42]	
4	49.91[46.47,53.35]	<.0001	18.33[15.81,20.84]	0.312
Associated with too much fat/fatty foods*				
0	40.84[33.29,48.4]		17.43[12.48,22.38]	
1	43.08[40.82,45.34]		18.54[17.13,19.96]	
2	44.78[42.93,46.63]		17.38[16.41,18.36]	
3	48.21[46.37,50.05]		17.91[16.9,18.91]	
4	47.63[45.19,50.08]		17.35[15.94,18.76]	
5	45.58[41.61,49.56]	<.0001	16.57[14.32,18.83]	0.365
Associated with excess weight***				
0	42.33[36.15,48.52]		18.61[12.6,24.61]	
1	42.03[39.04,45.01]		17.89[16.41,19.36]	
2	44.41[42.33,46.5]		17.49[16.43,18.55]	
3	46.14[44.37,47.9]		17.26[16.21,18.32]	
4	48.76[46.44,51.09]		17.63[16.13,19.12]	
5	47.14[43.83,50.45]		18.29[16.45,20.12]	
6	49.91[46.07,53.76]	<.0001	19.02[17.03,21.01]	0.541

*total number of problems above 5 recoded back to 5; **total number of problems above 4 recoded back to 4; ***total number of problems above 6 recoded back to six

For the DF_HEI, a lower score was associated with the total number of problems associated with not eating enough fruit and vegetables. Both the RF_HEI and the DF_HEI models had low explained variance (RF_HEI: r^2 = 0.03, DF_HEI r^2 = 0.01].

Table 7.27 Total number of health problems associated with the RF_HEI, NMSS 2012

RF_HEI	Coef.	95% CI		Robust Std. Err.	t	P>|t|
Total health problems with not eating cereal foods	1.38	0.47	2.30	0.47	2.97	0.003
Total health problems with excess weight	1.18	0.42	1.94	0.39	3.05	0.002
Constant	40.78	38.44	43.1	1.20	34.12	<0.001

Table 7.28 Total number of health problems associated with the DF_HEI, NMSS 2012

DF_HEI	Coef.	95% CI		Robust Std. Err.	t	P>|t|
Total health problems with not enough fruit & vegetables	1.38	0.47	2.30	0.47	2.97	0.00
Total health problems with excess weight	1.18	0.42	1.94	0.39	3.05	0.00
Constant	40.78	38.44	43.13	1.20	34.12	<0.001

7.2.12 Perceptions about what makes eating a healthy diet easier

The next stage examines what people believe would make it easier to eat healthy. The mean scores by each response category are shown on Table 7.29.

Table 7.29 Mean scores for RF_HEI and DF_HEI by beliefs about what would make eating healthy easier, NMSS 2012

What would make eating healthy easier*	RF_HEI Mean (95% CI)	*p*	DF_HEI Mean (95% CI)	*p*
Cheaper healthy foods	46.19[45.12,47.27]	0.017	17.65[17.05,18.26]	0.544
More healthy food options in fast food outlets	46.11[44.97,47.25]	0.195	17.88[17.26,18.51]	0.127
Knowing more ways to prepare healthy foods	45.79[44.67,46.92]	0.822	17.55[16.91,18.18]	0.140
Knowing quicker ways to prepare healthy foods	45.59[44.52,46.66]	0.095	17.60[16.98,18.21]	0.298
More information on which foods are healthy	45.67[44.53,46.81]	0.239	17.64[16.98,18.29]	0.711
Knowing more about cooking	44.64[43.30,45.98]	<0.0001	17.28[16.53,18.04]	0.019
My family/partner enjoyed healthy foods	45.37[44.18,46.57]	0.037	17.38[16.71,18.04]	0.024
Ability to buy more healthy food snacks	45.54[44.38,46.70]	0.027	17.43[16.79,18.07]	0.009
Healthy food easier to find in supermarket	46.16[45.02,47.30]	0.208	17.59[16.93,18.24]	0.409
Detailed information on food labels	45.87[44.87,46.88]	0.922	17.68[17.09,18.27]	0.743
Unhealthy foods had a coloured symbol	46.27[45.16,47.37]	0.057	17.83[17.21,18.45]	0.128

*Compared with not saying this would make it easier

Only four of the means are statistically significantly associated with RF_HEI and three with the DF_HEI. The three significant ways to make healthy diet easier that were common to both were knowing more about cooking, family/partner enjoyed healthy meals and ability to but more healthy snacks.

Table 7.30 shows the correlations between the ways in which it was perceived to be easier to eat healthy ranged from quite low (0.15) to quite high (0.59). The higher correlations were logical but in order to examine the relative strength of each, they were first entered separately into the regression model and then those that were statistically significantly associated were entered together and the ones which retained statistical significance kept.

The factor analysis for the beliefs for what would make healthy eating easier identified two factors but as Table 7.31shows, none of the values in factor two are larger than the corresponding values for the same variable in factor one making it essentially a one factor solution.

The results of the regressions for each of the possible ways to make it easier to eat healthy are shown on Table 7.32 for the RF_HEI and Table 7.33 for the DF_HEI.

Table 7.30 Spearman correlation matrix for the ways in which it might be easier to eat healthy, NMSS 2012

	Cheaper food	Healthy take away food	Easier ways to prepare	Quicker ways to prepare	More information	Ability to cook	Family enjoyed	Easier to buy health snacks	Easier to find food	Labels on food
Healthy take away food*	**0.21**									
Easier ways to prepare	0.18	**0.22**								
Quicker ways to prepare	0.19	0.19	**0.59**							
More information	0.21	0.19	**0.41**	**0.36**						
Ability to cook	0.12	0.14	0.41	0.36	0.44					
Family enjoyed	0.16	0.14	0.34	0.35	0.38	0.43				
Easier to buy health snacks	0.22	0.30	0.18	0.25	0.26	0.25	0.28			
Easier to find food	0.22	0.21	0.30	0.30	0.39	0.25	0.27	0.33		
Labels on food	0.18	0.16	0.17	0.20	0.27	0.20	0.24	0.17	0.28	
Symbols on unhealthy food	0.15	0.17	0.19	0.20	0.21	0.19	0.19	0.19	0.26	0.35

*Descriptions have been truncated to enable the whole table to be displayed.

Table 7.31 Factors identified for making it easier to eat healthy using a varimax orthogonal rotation, NMSS 2012

	Factor one Eigenvalue 5.26	Factor two Eigenvalue 0.98
Cheaper healthy foods	0.51	0.24
More healthy food options in fast food outlets	0.52	0.29
Knowing more ways to prepare healthy foods	0.80	-0.45
Knowing quicker ways to prepare healthy foods	0.82	-0.32
More information to decide which foods are healthy	0.80	-0.10
Knowing more about cooking	0.76	-0.34
My family/partner enjoyed healthy foods	0.72	-0.15
Ability to buy more healthy food snacks	0.65	0.32
Healthy food easier to find in supermarket	0.72	0.24
Detailed & understandable information on food labels	0.66	0.36
Unhealthy foods had a coloured symbol on the label	0.57	0.32

Table 7.32 Beliefs about making things easier to eat healthy associated with the RF_HEI, NMSS 2012

RF_HEI	Coef.	95% CI		Robust Std. Err.	t	P>|t|
Cheaper healthy foods	3.49	0.48	6.50	1.53	1.53	0.023
Knowing more about cooking	-3.22	-5.34	-1.10	1.08	1.08	0.003
Ability to buy more healthy food snacks	-2.45	-4.63	-0.27	1.11	1.11	0.028
Unhealthy foods had a coloured symbol	2.81	0.12	5.49	1.37	1.37	0.041
Constant	44.46	41.09	47.83	1.72	1.72	<0.0001

Table 7.33 Beliefs about making things easier to eat healthy associated with the DF_HEI, NMSS 2012

DF_HEI	Coef.	95% CI		Robust Std. Err.	t	P>|t|
Ability to buy more healthy food snacks	-1.49	-2.70	-0.27	0.62	-2.40	0.017
Constant	18.92	18.00	19.97	0.53	35.60	<0.001

The total number of ways of making it easier to eat healthy were also tested in a regression for the RF_HEI and the DF_HEI but was not significant. Higher RF_HEI scores were associated with cheaper foods and having unhealthy foods labeled with a symbol. For both the RF_HEI and the DF_HEI, the availability of healthy snack was associated with lower scores.

7.2.13 Other variables associated with the RF_HEI and the DF_HEI

The final set of variables entered considered are those that have face validity in terms of being likely to be associated with healthy eating. These are having responsibility for shopping or cooking/preparing food; cooking skill; whether or not someone in the household went without food and there was no money to buy more; BMI; and an overall attitude to the health aspects of diet. Table 7.34 shows the correlation between the responsibility for food shopping, responsibility for food choice/preparation, cooking skills and attitude towards health aspects of diet. As the correlation between food responsibility and food preparation were so high, the coefficients and Bayesian Information Criteria (BIC) informed which would be retained in the model, which was the responsibility for the choice and/or preparation of food.

Table 7.34 Spearman correlation matrix responsibility for food shopping, choice/preparation, cooking skills and attitude towards health aspects of diet, NMSS 2012

	Responsibility for food shopping	Responsibility for food choice/ preparation	Cooking skill
Responsibility for food choice/preparation	**0.74**		
Cooking skill	-0.29	-0.33	
Attitude toward health aspects of diet	0.12	0.11	-0.20

The mean RF_HEI and DF_HEI scores described above are found on Table 7.35. Every variable is statistically significantly associated with the mean RF_HEI scores and all but BMI and running out of food with the DF_HEI.

Table 7.35 Mean scores for RF_HEI and DF_HEI by food responsibility, cooking skills, BMI and overall attitude to the health aspects of diet, NMSS 2012

Responsibility for food shopping				
Sole	47.98[46.66,49.30]		18.81[18.10,19.52]	
Shared	45.86[44.39,47.33]		17.52[16.65,18.40]	
None	41.24[38.19,44.30]	<0.0001	15.72[14.14,17.29]	<0.0001
Responsibility for food preparation/cooking				
Sole	48.07[46.93,49.22]		18.62[17.92,19.33]	
Shared	45.60[43.97,47.22]		17.79[16.93,18.64]	
None	40.86[37.98,43.73]	<0.0001	14.92[13.31,16.54]	<0.0001

Cooking skills				
Can't cook	35.61[27.29,43.92]		16.61[11.67,21.56]	
Can boil egg/BBQ meat/heat frozen	37.34[33.46,41.21]		14.62[12.04,17.20]	
Can cook basic meat and 3 veg	41.27[39.00,43.54]		16.28[14.88,17.67]	
Can cook a wide variety of meals	48.50[46.96,50.04]		17.91[17.11,18.71]	
Can cook almost anything	47.06[45.55,48.57]	<0.0001	18.91[18.00,19.83]	<0.0001
BMI Category				
BMI 8.5 to 24.9	46.50[44.60,48.41]		16.97[15.89,18.05]	
BMI between 25 and 29.9	46.44[44.81,48.06]		18.20[17.37,19.02]	
BMI 30 or more	44.25[42.52,45.97]	0.048	17.74[16.71,18.77]	ns
Ran out of food in last twelve months				
No	45.67[44.36,46.98]		17.71[16.98,18.43]	
Yes	39.07[33.71,44.43]	0.015	17.09[13.29,20.88]	ns
Overall attitude to health aspects of diet				
Pay a lot of attention	51.47[50.21,52.72]		19.23[18.46,20.00]	
Pay a bit of attention	43.17[41.86,44.49]		16.68[15.86,17.49]	
Don't think about it	33.13[28.93,37.33]	<0.0001	16.00[13.98,18.02]	<0.0001

The results for the regression models for the RF_HEI are shown on Table 7.36 and for the DF_HEI on Table 7.37.

Table 7.36 Food responsibility, cooking skills, BMI and overall attitude to the health aspects of diet and interactions associated with the RF_HEI, NMSS 2012

RF_HEI	Coef.	95% CI		Robust Std. Err.	t	P>|t|
Either can't cook or can only cook basic/BBQ/reheat	-6.45	-9.60	-3.31	1.60	-4.03	<0.001
Someone in home didn't have enough to eat	-4.80	-10.06	0.45	2.68	-1.79	0.073
Body Mass Index (per unit increase)	-0.23	-0.41	-0.05	0.09	-2.53	0.012
Pay a bit of attention to health aspects of diet	-6.09	-8.45	-3.73	1.2	-5.07	<0.001
Don't think about health aspects of diet	-1.60	-23.34	-8.66	3.74	-4.28	<0.001
Constant	57.90	52.77	0.00	2.61	22.15	<0.001

The RF_HEI model had an r^2 of 0.16 and the DF_HEI model had an r^2 of 0.03. For both the RF_HEI and the DF_HEI lower scores were associated with not thinking about the health aspects of diet.

Table 7.37 Food responsibility, cooking skills, BMI and overall attitude to the health aspects of diet and interactions associated with the DF_HEI, NMSS 2012

DF_HEI	Coef.	95% CI		Robust Std. Err.	t	P>|t|
No responsibility for food choice or preparation	-2.63	-4.37	-0.89	0.89	-2.97	0.003
Pay a bit of attention to health aspects of diet	-2.32	-3.44	-1.21	0.57	-4.08	<0.001
Don't think about health aspects of diet	-2.41	-4.69	-0.14	1.16	-2.08	0.038
Constant	19.42	18.64	20.2	0.4	49.07	<0.001

The association was particularly strong for the RF_HEI. For the RF_HEI lower scores were also associated with higher BMI and having minimal cooking skills. There was a marginal association with lower scores and running out of food. Paying only a bit of attention to the health aspects of diet and not having any responsibility for cooking or preparing food were associated with lower scores on the DF_HEI.

7.2.14 Assessing direction and strength of associations for the two healthful eating indicators

To assess the direction and strength of associations for the two healthful eating indicators all the variables from the regression models for each healthful eating indicator were entered into a final regression model. The final models will be used to test whether or not using standardized coefficients from regression models make it possible to identify relative importance of diet related outcomes to dietary behaviour indicators.

The final RF_HEI model is based on 1453 respondents as 95 respondents did not provide enough information to estimate BMI (93.6% of the total sample). The variables entered into the final model for the RF_HEI final are taken from Table 7.2, Table 7.5, Table 7.10, Table 7.17, Table 7.2, Table 7.20, Table 7.23, Table 7.27, Table 7.32 and Table 7.36. The results are shown on Table 7.38.

Table 7.38 Final model for associations with the RF_HEI, NMSS 2012

RF_HEI	Coef.	95% CI		Robust Std. Err.	t	P>|t|	Beta
Already eats enough fruit	11.66	8.52	14.79	1.60	7.30	<0.001	0.39
Is trying to eat more fruit	8.14	4.74	11.54	1.73	4.69	<0.001	0.22
Is thinking about trying to eat more fruit	5.89	2.55	9.22	1.70	3.46	0.001	0.16
Total number of health problems with excess weight	0.90	0.32	1.48	0.30	3.04	0.002	0.09
Knows recommended serves of fruit	5.46	1.53	9.39	2.00	2.73	0.006	0.08
Knows recommended serves of vegetables	2.28	0.54	4.03	0.89	2.56	0.01	0.08
If food was cheaper	3.33	0.92	5.74	1.23	2.71	0.007	0.07
Already eats enough vegetables	2.06	0.13	3.99	0.98	2.09	0.037	0.07
Can save some money each pay period	1.96	0.02	3.90	0.99	1.98	0.047	0.06
Don't think about health aspects of diet	*-9.41*	*-13.30*	*-5.52*	*1.98*	*-4.75*	*<0.001*	*-0.17*
Pay a bit of attention to health aspects of diet	*-3.95*	*-5.76*	*-2.15*	*0.92*	*-4.31*	*<0.001*	*-0.13*
Either can't cook or can only cook basic/bbq/reheat	*-3.76*	*-5.76*	*-1.76*	*1.02*	*-3.68*	*<0.001*	*-0.11*
Total number of difficulties trying to eat more fruit	*-2.06*	*-3.29*	*-0.83*	*0.63*	*-3.29*	*0.001*	*-0.10*
Is thinking about trying to decrease fat/fatty foods	*-2.51*	*-4.78*	*-0.24*	*1.16*	*-2.17*	*0.031*	*-0.06*
Total number of difficulties eating less fat/fatty foods	*-1.11*	*-2.24*	*0.01*	*0.57*	*-1.94*	*0.052*	*-0.06*
Body Mass Index	*-0.11*	*-0.22*	*0.01*	*0.06*	*-1.85*	*0.065*	*-0.05*
Constant	31.93	25.19	38.67	3.43	9.30	<0.001	

The model has an r^2=0.29 (f=27.91 p<0.0001). The table is sorted by the standardized coefficient (beta) for the variables with lower scores on the R_HEI (these are in italics).

The model shows only one socio demographic indicator remained in the model which is one associated with the ability to save some money from each pay received, independent of income. This has the lowest beta (the least important driver) for the variables associated with increased RF_HEI scores. All the other variables are about intentions, beliefs and attitudes with the exception of BMI which is associated with a decrease in mean RF_HEI per unit increase in BMI. The greatest influence for increased RF_HEI scores were the intentions related to fruit and the greatest influence for decreased RF_HEI scores were not thinking about the health aspects of diet.

The variables for the final DF_HEI model are those identified in Table 7.3, Table 7.6, Table 7.8, Table 7.11, Table 7.13, Table 7.18, Table 7.21, Table 7.28, Table 7.33 and Table 7.37. The final DF_HEI model is based on the full 1548 respondents with an r^2=.09 (f=12.19 p<0.0001). The results are shown on Table 7.39. As with the RF_HEI, the table is sorted by the standardized coefficient (beta) for the variables associated with better scores on the DF_HEI and then by variables which are associated with lower scores on the DF_HEI (shown in italics).

Table 7.39 Final model for associations with the DF_HEI, NMSS 2012

DF_HEI	Coef.	95% CI		Robust Std. Err.	t	P>|t|	Beta
Already eats enough vegetables	1.52	0.43	2.62	0.56	2.72	0.007	2.62
Pay a bit of attention to health aspects of diet	*-2.39*	*-3.48*	*-1.30*	*0.56*	*-4.31*	*0.000*	*-1.30*
Living in SEIFA Quintile 1 (most socially disadvantaged)	*-2.70*	*-4.24*	*-1.17*	*0.78*	*-3.46*	*0.001*	*-1.17*
Already eats enough cereal foods	*-2.26*	*-3.35*	*-1.16*	*0.56*	*-4.05*	*0.000*	*-1.16*
No responsibility for choosing or preparing food	*-2.40*	*-4.15*	*-0.66*	*0.89*	*-2.71*	*0.007*	*-0.66*
Male	*-1.52*	*-2.63*	*-0.40*	*0.57*	*-2.66*	*0.008*	*-0.40*
Not thinking of trying to lose weight	*-1.33*	*-2.37*	*-0.29*	*0.53*	*-2.51*	*0.012*	*-0.29*
Doing home duties	*-1.86*	*-3.51*	*-0.20*	*0.84*	*-2.20*	*0.028*	*-0.20*
Total number of difficulties trying to eat more fruit & vegetables	*-0.62*	*-1.06*	*-0.17*	*0.23*	*-2.71*	*0.007*	*-0.17*
Don't think about health aspects of diet	*-2.02*	*-4.19*	*0.15*	*1.11*	*-1.82*	*0.068*	*0.15*
Constant	22.76	21.21	24.31	0.79	28.85	0.000	

In contrast to the RF_HEI model only one variable is associated with higher DF_HEI scores, which is the perception that vegetable consumption is sufficient. The rest of the variables are associated with lower DF_HEI scores. The greatest influences for decreased RF_HEI scores were paying only a bit of attention to the health aspects of diet and living in one of the areas in WA categorised as the most socially disadvantaged.

These fuller models explained more of the variance but was still modest for the RF_HEI ($r^2 = 0.29$) and low for the DF_HEI ($r^2=0.09$).

7.3 Discussion

This series of models show that there are a range of influences to eating choices. Some are influences that lead to healthier eating and some are influences that lead to less healthy eating. The analysis of the RF_HEI interactions and the DF_HEI interactions confirms the initial findings in Chapter six that there are not many overlapping associations between the two indicators. Three of the associations that are significantly associated with scores on both the RF_HEI and the DF_HEI are the overall attitude to the health aspects of diet with paying more attention to the health aspects associated with higher scores; higher number of perceived difficulties with increasing fruit and vegetable consumption associated with higher scores; and thinking enough vegetables already eaten associated with higher scores. All three of these suggest a level of knowledge or perception about food choices that may be indicating an underlying orientation to health mediating decisions about foods (Beydoun & Wang, 2007, 2008; Wardle, Parmenter, & Waller, 2000). This finding is in line with previous research which showed that concern about health was associated with eating fruit and vegetables (Ball et al., 2006).

No direct questions were asked about choosing food on the basis of taste in the NMSS but in the open ended multiple response questions disliking fruit and vegetables were associated with lower scores on both the RF_HEI and the DF_HEI. This association was also noted for liking foods high in fat. These could be taken as a proxy for taste with higher RF_HEI and DF_HEI scores associated with people who didn’t report liking as a difficulty which would be in line with the literature on food preference (Glanz, Basil, Maibach, Goldberg, & Snyder, 1998).

The total number of difficulties (barriers) related to increasing consumption of fruit and vegetables and to decreasing consumption of fats and fatty food that were part of the full RF_HEI and DF_HEI supported evidence from a qualitative study that found the decisional balance between pros and cons associated with foods were one of the strongest themes in decisions about choice of foods (Daivadanam, Wahlstrom, Ravindran, Thankappan, & Ramanathan, 2014).

The food choice process model posits many levels in the decisions about food (Sobal & Bisogni, 2009). The relatively low explanation of variance achieved by the full model of associations with the RF_HEI and the DF_HEI could mean that some of these levels are not being measured, such as the influence of social and cultural norms (Cruwys et al., 2015). Another consideration is the use of r squared as the sole measure of a model's goodness of fit. While r squared describes the amount of variance explained by the effect of the independent variables on the dependent variable (Darlington, 1968; Snedecor & Chochran, 1989; Vittinghoff, McCulloch, V., & Shiboski, 2011) its absolute importance in interpreting multiple regression results has been questioned (Nathans, Oswald, & Nimon, 2012). There is also some debate about what constitutes an acceptable r squared (Christensen-Szalanski & Willham, 1991).

The results from the full models of associations with the RF_HEI and the DF_HEI confirm the importance of attitudes and intentions in relation to food choices as predicted by the theory of planned behaviour (Riebl et al., 2015). The identification of the two independent healthful eating components suggests that people are making choices about what to eat depending on the foods or attributes of foods being considered; one in line with dietary guidelines about eating from recommended core food groups and one in line with dietary guidelines about recommendations about limiting discretionary foods and having more than the recommended amount of any food group. This means that the same person could eat well on one component (eating the recommended serves from the core food groups) but not on the other (that is, not eating within the upper limits of additional serves and limiting discretional foods); well on both components or not well on either component.

This approach to conceptualising healthful eating indicators provides information that is intrinsically different from but complementary to other research examining dietary quality and patterns (Imamura et al., 2015). The more usual analytic methods found to identify patterns of Australian dietary intake were cluster analysis as used to identify an eating pattern relatively high in fat and meat compared with an eating pattern higher in fruit and vegetables (Grieger et al., 2012); or a combination of factor analysis, cluster analyses or ranked regression conducted on data that has not been pre-scored against any standard such as dietary guidelines (Moeller et al., 2007). These methods identified eating patterns and then explored associations with: health indicators (Amini et al., 2012; Li et al., 2014; Xu et al., 2012); who is eating in line with particular patterns (Elstgeest et al., 2012; Kant, 2004); how changes in individuals' dietary patterns affect obesity over time (Elstgeest et al., 2012; Pachucki, 2012); and mortality (Kant et al., 2000). The different approach taken in this research offers a unique and rich source from which to explore important interactions between the psycho social aspects of diet such as attitudes, perceptions and intentions with knowledge and behaviours associated with healthy dietary patterns (Grunert et al., 2012).

The results show that different drivers are associated with whether or not one is eating in line with recommended food group serves and types and also with associations with higher and lower scores on healthful eating indicators. These results can be used to inform the type and content of health promotion interventions.

8 IMPROVE THE CHARACTERISATION AND THUS PREDICTION OF THOSE LIKELY TO UNDERTAKE CERTAIN DIETARY BEHAVIOURS: ADDRESSING OBJECTIVE FIVE

The fifth objective was to evaluate the relative importance of dietary quality indicators. Running out of food at least once in the previous twelve months was chosen to illustrate the relative importance of dietary quality because it has been shown to be adversely related to eating a good diet (Hanson & Connor, 2014; Jones, Ngure, Pelto, & Young, 2013; Robaina & Martin, 2013); because the two cross sectional surveys, the NMSS and the HWSS, had reported prevalence of either running out of food or not having enough food to eat with no money to buy more but with very different possible independent measures; and because it is a dichotomous outcome which can be used to test direction and strength of associations. This allowed for comparison of the prevalence and associations between the two surveys and, using the HWSS, the construction of a path diagram using a dataset which had enough statistical power to allow for this analysis and a subsequent investigation of possible causal links.

Food insecurity has been widely investigated and associations between socio economic disadvantage and wellbeing established particularly in parts of the world designated as low income countries (Barrett, 2010). While food insecurity is a bigger problem in low income countries compared with high income countries, it not restricted to these although the severity of the insecurity and its effects are mitigated in higher income countries (Australian Bureau of Statistics, 2012b; Foley et al., 2010; Loopstra & Tarasuk, 2013). There are links between food insecurity and mental health (Hernandez, Marshall, & Mineo 2014; Melchior et al., 2012; Muldoon, Duff, Fielden, & Anema, 2013; Whitaker, Phillips, & Orzol, 2006; Young et al., 2014) and both under nourishment as well as obesity (Crawford & Webb, 2011; Larson & Story, 2011; Metallinos-Katsaras, Must, & Gorman, 2012).

Running out of food without money to buy more is only one component of the complex concept of food security and measurement of this is still being evaluated and validated (Jones et al., 2013; Marques, Reichenheim, de Moraes, Antunes, & Salles-Costa, 2014). Whatever its limitations, in

Australia it is part of two questions used by the ABS in the AHS to assess food insecurity, the other being going without food and unable to afford more (Australian Bureau of Statistics, 2014b). The complexity of food insecurity in relation to obesity as well as under nourishment, urban food sources and possible interventions has been discussed in relation to school programs (Ashe & Sonnino, 2013) and more generally at a public health level in a high income countries (Bastian & Coveney, 2012; Rideout, Seed, & Ostry, 2006). In WA in 2013, based on the reported prevalence of 3.7% [95% CI 2.7,3.7] (Radomiljac & Joyce, 2014) and the projected estimate of 856,000 households in WA by 2011 (Australian Bureau of Statistics, 2004), between 23,355 and to 40,655 households reported at least one episode of running out of food in the previous twelve months and being unable to afford more. This statistic indicates that even if food insecurity is not fully present, at least some elements are. The purpose of this investigation is to show that the use of two cross sectional data sources, the HWSS and the NMSS make it possible to evaluate the relative importance of a wide range of associations with running out of food or not having enough to eat at least once in the previous year and being unable to afford more; and using the HWSS with its larger sample size and health outcome measures, construct a possible path to running out of food.

8.1 METHODOLOGY

8.1.1 Measures

The question about not being able to afford food asked in the HWSS was based on the Australian Bureau of Statistics National Health Survey question: “In the past 12 months, was there any time when you ran out of food and couldn't afford to buy more?” with the response categories, No, Yes, Unsure, Refused. The question asked in the NMSS surveys was worded “In the last 12 months, has anyone in your household eaten less than they should because you couldn't afford enough food? “with the response categories, No, Yes, Unsure.   While the questions are not identical, the prevalence of the population reporting that they had run out of food from the years when both surveys were being conducted (2009 and 2012) were not statistically significantly different. The estimates were also similar to those found in the 2011 2012 National Nutrition and Physical Activity survey for WA (4.8%), where these questions are used to indicate food security (Australian Bureau of Statistics, 2014a). While the same concept may not be measured by the two different questions, it can be argued that they are both indicators of the latent variable food insecurity which is the assumption underlying their use in the ABS AHS.

The socio-demographic variables collected in both surveys include: age, gender, highest level of education attained, living arrangements, area of residence, annual household income, perceived discretional income (2009 & 2012 NMSS – all years HWSS), country of birth and employment status. For the HWSS, a geographic area based index that reflects socio-economic advantage and disadvantage (SEIFA) was also available (Commonwealth of Australia, 2013). Respondents from the NMSS were asked about a number of personal factors including their body weight and height which was used to estimate BMI using a correction for over reporting height and under-reporting weight (Hayes et al., 2008). They were also asked how concerned they were about the health aspects of their diet as well as what made it difficult to eat fruit and vegetables as well as what would make it easier to eat a healthy diet. Respondents from the HWSS were also asked about their weight and height along with a number of health related questions including a general health rating, a comparison of their health with twelve months ago, the level of their psychological distress based on their responses to the Kessler 10 and some selected questions about health conditions and risk factors. Tables of the variables used in the analysis are provided in Appendix two.

8.1.2 Analysis

Prevalence estimates for the NMSS and the HWSS were estimated using the survey data weighted using IPF described in Chapter three, Section 3.3.1. Tables of prevalence include 95% Confidence Intervals. Pearson Chi Square tests were used to determine statistically significant differences for nominal data. Separate logistic regressions were conducted on each dataset with the reference group, those who did not run out of money to buy food. All the variables that were statistically significant at *p*<=.1, which are shown in the univariable analysis tables, were entered into multivariable logistic regression analyses. Post estimation tests for the models were conducted (Hosmer & Lemeshow, 2000) and estimates of the probability of reporting running out of food were made using predictive margins. Robust measures were used to estimate standard errors for the regression analyses and results at *p*<.05 were considered to be statistically significant. Regression results show unadjusted and adjusted odds ratios and the probability of being reported with confidence intervals. Using the regression results from the HWSS a path analysis was conducted with Akaike Information Criteria (AIC) (Akaike, 1987; Bozdogan, 1987) and Bayesian Information Criteria (BIC) (Burnham & Anderson, 2004) used to determine whether or not an association preceded or came after running out of food. The treatment effects module was used to control for potential confounding from the covariates in the path analysis for each variable being tested for causality. Those that were statistically significantly associated with the variable being tested were retained. In this investigation, “treatments” are operationally defined as the variables in the path leading to the outcome of either running out of food or not (Little & Rubin, 2000).

8.2 RESULTS

Table 8.1 shows the pooled NMSS estimate of the prevalence of the population who answered “yes” to the question “In the last 12 months, has anyone in your household eaten less than they should because you couldn't afford enough food?” by socio demographic measures. Less than one percent either didn’t remember or refused.

Over the six years the prevalence varied significantly but has remained just under 4% since 2009. This is consistent with recent estimates from the ABS which is 3.2% for all Australians (Australian Bureau of Statistics, 2012). The highest prevalence estimates of food insecurity were for adults aged 18 to 34 years and for adults with household incomes less than $60,000.

Table 8.1 Prevalence of eating less because they couldn’t afford enough food by sociodemographic indicators, NMSS 1995,1998,2001,2004,2009 & 2012

Demographic Variables NMSS	% (95% CI)	*p*
Persons	**3.7[2.6,5.6]**	
Female	5.4[4.5,6.4]	
Male	5.2[4.3,6.3]	0.817
Age group		
35-64	3.8[3.3,4.5]	
18-34	7.6[6.3,9.2]	<.0001
Annual household income		
Over $60,000	2.5[1.8,3.5]	
Up to $60,000	8.3[7.1,9.7]	<.0001
Employment status		
In paid employment	4.9[4.2,5.7]	
Not in paid employment	6.5[5.2,8.1]	0.039
Highest education level attained		
Tertiary	3.5[2.7,4.6]	
Less than tertiary	6.2[5.3,7.1]	<0.001

Table 8.2 shows the percent eating less than they should because they couldn’t afford to buy more by selected attitudes and perceptions.

Table 8.2 Prevalence of eating less because they couldn’t afford enough food by attitudes and perceptions, NMSS 1995,1998,2001,2004,2009 & 2012

Attitudes and Perceptions	% (95% CI)	*p*
Best describes how you feel about your diet and nutrition		
Pay a lot of attention to the health aspect of food	4.7[3.7,5.8]	
Take a bit of notice of the health aspect of food	5.2[4.4,6.2]	
Don’t think about the health aspect of food	9.1[6.6,12.6]	0.003
Difficulty increasing consumption of fruit due to cost		
No	4.8[4.2,5.6]	
Yes	9.6[7.5,12.3]	<.0001
Difficulty increasing consumption of vegetables due to cost		
No	5.1[4.4,5.8]	
Yes	14.7[10.6,20.1]	<.0001
Easier to eat a healthy diet if food was cheaper		
No	3.1[2.1,4.5]	
Yes	5.8[5.1,6.7]	0.002

Overall attention to diet with regard to health was inversely associated with prevalence with those not thinking of the health aspect of food almost twice as likely to report that someone in the household has eaten less than they should because they couldn't afford enough food compared with those who paid a lot of attention to the health aspect of food (9.1% vs 4.7%). The cost of fruit and vegetables and food being cheaper were associated with someone in the household eating less than they should because they couldn't afford enough food.

A logistic regression was conducted using the variables in Table 8.1 and Table 8.2. and obesity as covariates of "someone in the household had eaten less than they should because they could afford enough food". Table 8.3 shows the variables that remained statistically significant in the model along with the probability of reporting that of someone in the household eaten less than they should because they couldn't afford enough food. The logistic regression found statistically significant associations with the outcome being: people who were less than 34 years, people earning less than $60,000, people who perceived vegetables to be expensive, people who thought that it would be easier to eat a healthy diet if healthy food were cheap and people who didn't think about the health aspects of their diet.

A question about perceived discretional income was introduced in 2009 and 2012. In these years, it was the only variable to be significantly associated with someone in a household who had eaten less than they should because they couldn't afford to buy enough food. Those who reported having just enough/not enough income per pay were more than twenty times more likely to report eating less than they should (OR=20.5, $p<0.0001$).

Table 8.3 Associations with someone in the household eaten less than they should because they couldn't afford enough food, NMSS 1995, 1998, 2001, 2004, 2009 & 2012

	Crude Odds Ratio§	Adjusted Odds Ratio	*p* for Adjusted	Probability of reporting %#	95 % CI	
Age Group						
35-64 years	1	1		3.8	3.1	4.5
18-34 years	2.1	2.5	<0.0001	8.6	6.9	10.4
Annual household income						
Over $60,000	1	1		1.9	1.2	2.7
Up to $60,000	3.5	4.2	<0.0001	7.4	6.3	8.5
Difficult to eat more vegetables due to cost						
No	1	1		4.8	4.1	5.6
Yes	3.2	2.8	<0.0001	12	7.9	16.2
Easier to eat healthy if healthy foods cheaper						
No	1	1		3.6	2.1	5.1
Yes	2	1.6	0.045	5.7	4.8	6.5
Attitude towards health aspects of diet						
Pay at least some attention to health aspects	1	1		5.1	4.3	5.8
Don't think about health aspects	1.9	1.6	0.028	7.9	5.1	10.7
Perceived discretional income*						
Can save a lot or can save regularly	1	1		Unable to be estimated		
Spend what left over or save a bit occasionally	4.7	4.7	0.003	3.6	1.4	5.8
Not enough to get by or just enough to get by	20.5	11.6	<0.0001	10.1	5.7	14.5

§ All categories with Adjusted Odds Ratios of 1 are the reference categories
# This is percentage expected to report that someone in the household has eaten less than they should because they couldn't afford to buy enough food
* This question was introduced in 2009 and asked only in that year and 2012 and in those years also interacts with income.

Table 8.4 shows the pooled HWSS estimate of the prevalence of the population who answered “yes” to the question worded “In the last 12 months, were there any times that you ran out of food and couldn't afford to buy more? “by sociodemographics.

Table 8.4 Prevalence of running out of food and not being able to afford more by sociodemographic indicators, HWSS 2009 - 2013

Demographic Variables	%	95% CI	p
Age group			
18-24	8.0	[6.5,9.9]	
25-34	4.9	[3.8,6.2]	
35-44	3.2	[2.6,4.0]	
45-54	2.4	[1.9,2.9]	
55-64	1.6	[1.3,2.0]	<0.0001
Highest education level attained			
Tertiary	1.9	[1.3,2.6]	
Less than tertiary	4.7	[4.1,5.3]	<0.0001
Main employment status			
Employed	2.9	[2.5,3.4]	
Unemployed	12.3	[8.7,17.3]	
Home duties	5.2	[3.9,6.8]	
Student	6.8	[4.6,9.8]	
Unable to work	17.3	[12.8,22.9]	<0.0001
Annual household income			
Over AUD $40,000	2.4	[2.0,2.9]	
AUD $20,001- AUD $40,000	9.6	[7.6,12.2]	
Up to AUD $20,000	17.8	[14.2,22.2]	<0.0001
Perceived spending power per pay			
Spend left over or save some	1.6	[1.4,2.0]	
Just enough to get by	12.5	[10.7,14.5]	
Not enough to get by	19.0	[15.1,23.6]	<0.0001
Aboriginal			
No	3.8	[3.4,4.2]	
Yes	15.0	[9.8,22.1]	<0.0001
Household structure			
Adults living with others	3.7	[3.3,4.2]	
Adults living alone	6.4	[5.2,7.8]	<0.0001
Country of birth			
Outside Australia	2.9	[2.3,3.7]	
Australia	4.4	[3.9,5.0]	0.002
SEIFA Quintiles using SLA level data 2009-2013			
Quintile 5 (least disadvantaged area)	2.9	[2.3,3.6]	
Quintiles 3,4 (less disadvantaged areas)	4.5	[3.9,5.3]	
Quintiles 1,2 (most disadvantages areas)	5.2	[4.2,6.4]	<0.0001

Table 8.5 shows the estimates by selected health conditions and chronic disease risk factors.

Table 8.5 Prevalence of running out of food and not being able to afford more by health conditions and chronic disease risk factors, HWSS 2009 - 2013

Health-related variables (compared with those who are not in the group)	**%**	**95% CI**	**p**
Has a health care card	11.30	[9.7,13.2]	<0.0001
Doesn't have private health insurance	8.30	[7.2,9.6]	<0.0001
Self-reported doctor diagnosed health conditions			
Has asthma	6.30	[4.7,8.4]	0.0011
Some cardiovascular condition	7.40	[4.9,11.0]	0.0022
Has cancer	7.00	[4.3,11.3]	0.0167
A mental health problem (depression/anxiety/other)	9.70	[8.3,11.4]	<0.0001
Rating of general health			
Excellent/very good/good	3.40	[3.0,3.9]	
Fair/poor	8.90	[7.2,11.0]	<0.0001
Always or often feel a lack of control over health			
Yes	13.90	[11.0,17.3]	<0.0001
Rating of health compared with 12 months ago			
Somewhat/much worse	9.40	[7.6,11.6]	<0.0001
Kessler Psychological Distress Scale(K10)			
High/very high	14.80	[12.4,17.6]	<0.0001
Body Mass Index Range			
BMI 30 or more (in obese range)	5.20	[4.4,6.1]	<0.0012
Smoker			
Currently smoking	8.50	[7.0,10.3]	<0.0001
Physical Activity			
Does no leisure time physical activity	5.50	[4.0,7.5]	0.0447
Time spent sitting			
Spends four or more hours sitting in leisure time	7.60	[5.8,9.8]	<0.0001
Fast food			
Eats three or more times a week compared with less	11.90	[8.3,17.0]	<0.0001
Fat content of milk usually used			
Uses full fat milk compared with using reduced fat	5.70	[4.9,6.7]	<0.0001
Fruit usually eaten daily			
Doesn't eat any fruit	6.40	[4.5,9.1]	
Eats less than two serves daily	4.20	[3.6,4.9]	
Eats two or more serves daily	3.30	[2.8,4.0]	0.003
Vegetables usually eaten daily			
Doesn't eat any vegetables	14.90	[6.5,30.4]	
Eats less than five serves daily	4.00	[3.6,4.5]	
Eats five or more serves daily	2.60	[1.7,3.9]	<0.0012

As with the NMSS, younger adults were more likely to run out of food and be unable to afford more but higher prevalence estimates were found for adults who were unable to work, earned less than $20,000, who reported that they didn't have enough money to get by from pay to pay and for adults reporting they were of Aboriginal and/or Torres Strait Islander origin.

Adults who didn't have a health care card, who felt a lack of control over their health, who high or very high psychological distress, who ate fast food more than twice a week and who didn't eat vegetables were all associated with higher prevalence estimates than those who were not in these groups. Table 8.6 shows the logistic regression results conducted using the variables in Table 8.4 and Table 8.5.

The logistic regression shows that people under 35 years, those earning less than $40,000, just getting by pay to pay or can't get by, and having no private health insurance are more likely to report running out of food and not being able to afford more. Not having a tertiary education was also associated but just failed to reach statistical significance (adjusted OR 1.6, p=0.059). Running out of food is also associated with the life style variables of smoking, being obese and eating fast food more than three times a week.

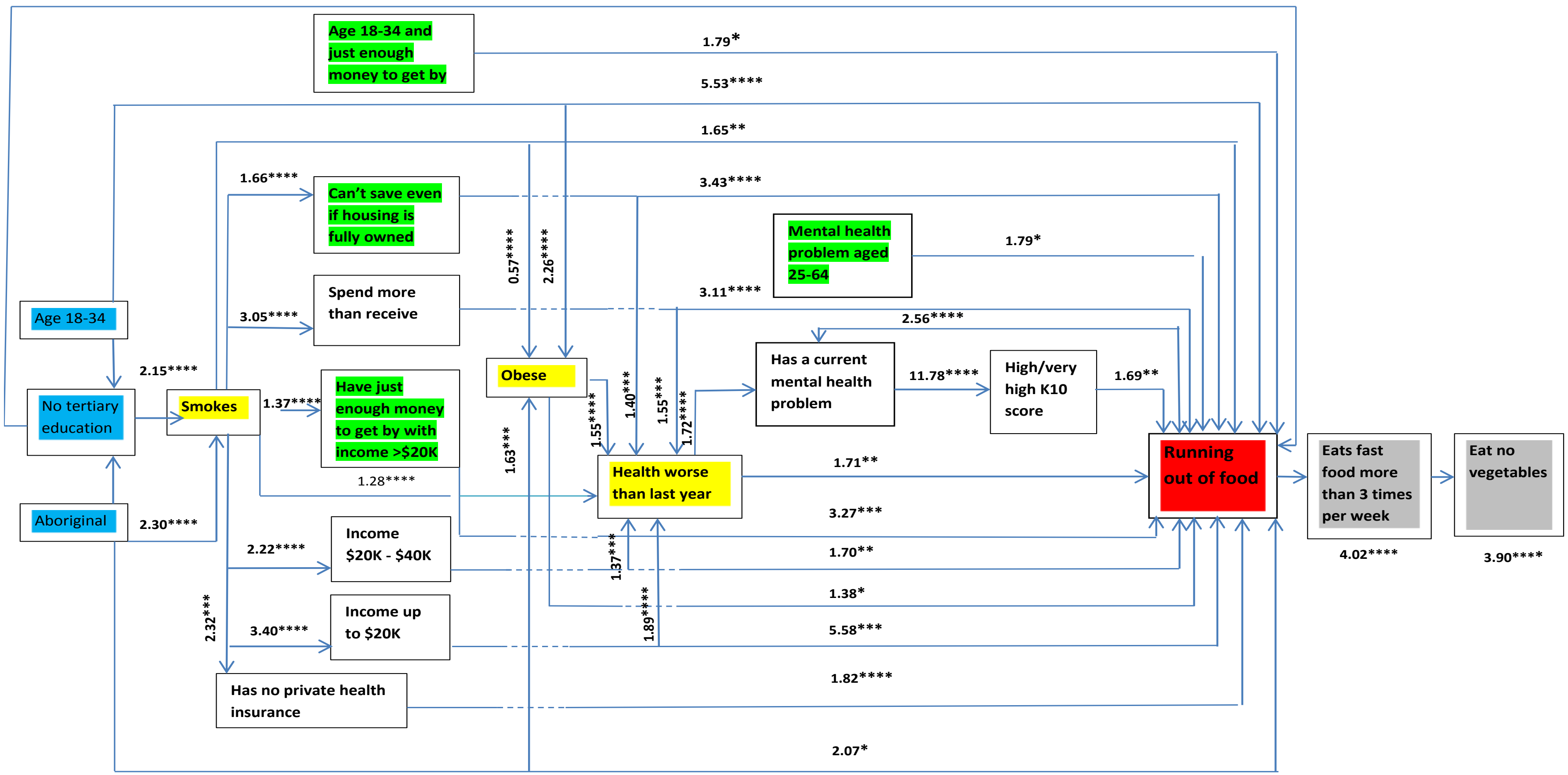
Larger adjusted odd ratios are shown for indicators of mental wellbeing with the increased likelihood is 3.6 times that of people who do not have a current mental health problem, 4.7 time that of people who feel they have control over health and 5.8 times that of people who have low/moderate psychological distress. The latter finding is in line with research carried out in New Zealand although the effect there was smaller with an adjusted odd ratio of 1.8 (Carter, Kruse, Blakely, & Collings, 2011).

Using the information from this logistic regression, the path to running out of food was constructed. This path explored interactions between variables and is shown on Figure 8.1.

Table 8.6 Logistic regression results: Associations with running out of food, HWSS 2009-2013

	Crude OR	Adjusted OR	p	Probability %#	95 % CI	
Age group						
55-64	1	1		1.5	1.1	1.9
45-54	1.5	1.7	0.012	2.4	1.8	2.9
35-44	2.1	2.7	<.0001	3.5	2.7	4.3
25-34	3.1	5.5	<.0001	5.9	4.5	7.4
18-24	5.3	8.8	<.0001	8.2	6.0	10.5
Perceived spending power per pay						
Spend left over or save some	1	1		3.7	2.2	5.3
Just enough to get by	10.1	6.6	<.0001	6.3	4.9	7.8
Not enough to get by	16.3	8.6	<.0001	7.9	5.2	10.6
Annual household income						
$40,001- $60,000	1	1	0.841	2.3	1.7	2.9
$20,001- $40,000	5.8	1.7	0.034	3.5	2.5	4.5
Up to $20,000	11.7	3.3	<.0001	5.9	4.1	7.6
Health related cover						
Has private health insurance	1	1		2.2	1.8	2.7
No private health insurance	4.1	2.0	<.0001	3.9	3.3	4.6
Highest education level						
Tertiary	1	1		2.2	1.4	3.0
Less than tertiary	2.6	1.6	0.059	3.2	2.8	3.6
Kessler 10						
Low or moderate	1	1		2.5	2.1	2.9
High or very high	5.8	2.0	0.001	4.6	3.3	5.8
Always or often feel a lack of control over health						
No	1	1		2.7	2.3	3.1
Yes	4.7	1.8	0.022	4.5	2.9	6.0
Doctor diagnosed health condition						
No mental health problem	1	1		2.6	2.2	3.0
A mental health problem	3.6	1.6	0.008	3.8	3.0	4.7
Risk factors						
Not obese	1	1		2.7	2.3	3.1
Obese	1.5	1.4	0.040	4.5	2.9	6.0
Doesn't currently smoke	1	1		2.7	2.3	3.1
Currently smokes	3.0	1.5	0.018	3.8	3.0	4.6
Fast food < 3 times a week	1	1		2.9	2.6	3.2
Fast food >= 3 a week	3.6	1.8	0.045	4.7	2.6	6.7

§ All categories with Adjusted Odds Ratios of 1 are reference categories.



Legend: blue boxes indicate 'fixed' variables, green boxes indicate interactions; yellow boxes indicate significant mediators; grey boxes indicate possible outcomes; straight lines indicate a relationship between the variables; the dotted lines indicate that the association is not directly related to the lines it crosses (e.g. income $20K-40 K is not directly related to obesity (yellow box 2) which is indicated by the dotted line; and income up to $20K is nor directly related to income $20K-40 K or obesity indicated by dotted lines); The figures above each of the lines are the odds ratios for those associations. One star indicates statistical significance at p<0.05; two stars p<0.01; three stars p<0.001 and four stars p<0.0001.

Figure 8.1 Path diagram showing associations with running out of food, HWSS 2009-2013

The rationale for the construction of the path diagram is as follows. The ‘red’ box is the outcome measure, running out of food at least once in the previous twelve months; the ‘blue’ boxes are sociodemographics that are not able to be changed or are not easily changed; the ‘yellow’ boxes are associations which interact with other variables on the path to running out of food as well as being directly associated; and the ‘grey boxes’ are the hypothised outcomes of running of food. For each of the associations in the path, the odds ratios are provided above the lines to which they refer. For example, the blue tertiary education box is directly associated with whether or not someone smokes (the yellow box) with an odds ratio of 2.15 more likely to occur compared with those who do have tertiary education. This association is statistically significant at $p<.0001$.

Of the variables that we regarded as fixed at the time of the survey, only three age group (age 18-34 compared with age 35-64, OR 5.53, $p<0.0001$), prior education level (no tertiary education compared with tertiary education OR=1.92, $p<0.01$) and aboriginality (of Aboriginal or Torres Strait Islander origin compared with not).

There were three variables which acted as powerful effect modifiers in the path. These were smoking, obesity and worsening health over time. Smoking, influenced by aboriginality and education, has a main effect and also acts as an effect modifier for money problems, income, private health insurance and worsening health status.

Obesity, influenced by smoking, aboriginality and younger age, has a main effect and acts as an effect modifier for worsening health. Worsening health is influenced by smoking, obesity, low income, discretional income, money problems. It has a main effect and acts as an effect modifier on mental health.

Independent interactions between young age and spending power; low income and spending power; spending and money problems; and mental health problem for older respondents are directly associated with running out of food. Other direct effects include not having private health insurance, low income, discretional income, mental health. Mental health also has an indirect effect mediated by high psychological distress score measure by the K10.

Respondents who are younger or who have very low incomes are more than five times as likely to report running out of food compared with older age respondent and those with higher incomes. Respondents with money problems, low discretional income, those with both low income and low discretional income are more than three times as likely to report running out of food compared with respondents who don't have money problems and higher income as well as higher discretional spending power.

8.3 USING PROPENSITY SCORING TO ASSESS POSSIBLE CAUSAL LINKS

Using propensity scoring described in section 3.3.6, three areas of the path were tested for possible causality with regard to running out of food. These were having a low annual household income; perceived discretional income and obesity and each one of these is used as the "treatment" in the propensity analysis for that variable. Two other areas were tested for possible causality *because* of running out of food were eating fast food more than twice a week and not eating any vegetables, which were the "treatments" for those two propensity analyses. To illustrate how the model works with propensity scoring, Table 8.7 shows the results for the link between having an annual household income up to $20,000 or not (the "treatment") and running out of food. The table shows that there is a statistically significant 'treatment' effect associated with having a low income and running out of food. The first line of the Table 8.7 shows the probability for reference higher income group running out of food. The second line of the table shows the difference in the probability of running out of food for the population with low income compared with those with a higher income.

Table 8.7 Estimate of probability of running out of food by income adjusted using propensity scores

	Coef.	95% CI		Robust Std. Err.	z	*p*
Probability of running out of food if income > $20,000	0.028	0.025	0.030	0.001	19.330	<0.001
Average effect when income is < $20,000	0.038	0.013	0.063	0.013	3.020	0.003

The overall probability of running out of food for the low income group is the sum of the two coefficients (e.g. 0.038+0.028=0.066). The rest of Table 8.7 shows the model for the covariates of not running out of food and running out of food and the 'treatment model' which shows which variables are associated with having an annual household income up to $20,000.

Covariates for not running out of food	**Coef.**	**95% CI**		**Robust Std. Err.**	**z**	***p***
Can save regularly vs can save lots	0.217	-0.687	1.122	0.462	0.470	0.638
Can save a bit sometimes vs can save lots	1.160	0.303	2.017	0.437	2.650	0.008
Some left but spent vs can save lots	2.262	1.397	3.126	0.441	5.130	<0.001
Just enough to get by vs can save lots	2.990	2.159	3.821	0.424	7.050	<0.001
Spending more than getting vs can save lots	3.514	2.659	4.369	0.436	8.060	<0.001
Of aboriginal origin vs not	0.825	0.286	1.363	0.275	3.000	0.003
Male vs female	-0.167	-0.405	0.071	0.122	-1.370	0.170
Age In years	-0.055	-0.066	-0.045	0.005	-10.380	<0.001
Rented from government vs paying mortgage	-0.047	-0.553	0.459	0.258	-0.180	0.856
Rented privately vs paying mortgage	0.368	0.081	0.654	0.146	2.510	0.012
Fully owned vs paying a mortgage	-0.067	-0.357	0.223	0.148	-0.450	0.650
Other living arrangement vs paying mortgage	-0.181	-0.874	0.512	0.354	-0.510	0.609
Doesn't have a tertiary education vs does	0.524	0.193	0.855	0.169	3.100	0.002
Doesn't have private health insurance vs does	0.690	0.457	0.924	0.119	5.790	<0.001
Has a mental health condition vs doesn't	0.469	0.202	0.735	0.136	3.450	0.001
Moderate psychological distress vs low	0.637	0.351	0.923	0.146	4.370	<0.001
High psychological distress vs low	1.115	0.773	1.456	0.174	6.390	<0.001
Very high psychological distress vs low	1.180	0.733	1.626	0.228	5.170	<0.001
Smokes	0.421	0.179	0.664	0.124	3.400	0.001
Is obese	0.307	0.083	0.530	0.114	2.690	0.007
Constant	-4.555	-5.507	-3.603	0.486	-9.380	<0.001
Covariates for running out of food						
Can save regularly vs can save lots	-2.233	-2.233	1.816	1.033	-0.200	0.840
Can save a bit sometimes vs can save lots	-2.206	-2.206	1.691	0.994	-0.260	0.795
Some left but spent vs can save lots	-2.077	-2.077	2.088	1.063	0.010	0.996
Just enough to get by vs can save lots	-0.864	-0.864	2.871	0.953	1.050	0.292
Spending more than getting vs can save lots	-0.117	-0.117	3.622	0.954	1.840	0.066
Of aboriginal origin vs not	-0.431	-0.431	1.137	0.400	0.880	0.378
Male vs female	-0.717	-0.717	0.102	0.209	-1.470	0.141
Age In years	-0.042	-0.042	-0.009	0.008	-3.070	0.002
Rented from government vs paying mortgage	-0.406	-0.406	0.725	0.289	0.550	0.580
Rented privately vs paying mortgage	-0.195	-0.195	0.962	0.295	1.300	0.194
Fully owned vs paying a mortgage	-1.015	-1.015	0.068	0.209	-1.470	0.141
Other living arrangement vs paying a mortgage	-0.840	-0.840	1.055	0.483	0.220	0.824
Doesn't have a tertiary education vs does	-0.157	-0.157	0.350	1.510	0.131	-0.157
Doesn't have private health insurance vs does	0.275	0.275	1.131	0.218	3.220	0.001
Has a mental health condition vs doesn't	0.463	0.463	1.271	0.206	4.210	<0.001
Moderate psychological distress vs low	0.292	0.292	1.273	0.250	3.130	0.002
High psychological distress vs low	0.523	0.523	1.558	0.264	3.940	<0.001
Very high psychological distress vs low	0.720	0.720	1.851	0.289	4.460	<0.001
Smokes	-0.054	-0.054	0.717	0.197	1.680	0.092
Is obese	-0.003	-0.003	0.733	0.188	1.940	0.052
Constant	-1.340	-5.410	-1.340	1.038	-3.250	0.001

Covariates for running out of food after adjustment based on propensity scoring	Coef.	95% CI		Robust Std. Err.	z	*p*
Can save regularly vs can save lots	0.724	0.261	1.188	0.236	3.060	0.002
Can save a bit sometimes vs can save lots	1.687	1.234	2.140	0.231	7.300	<0.001
Some left but spent vs can save lots	1.848	1.352	2.344	0.253	7.300	<0.001
Just enough to get by vs can save lots	2.700	2.246	3.154	0.232	11.660	<0.001
Spending more than getting vs can save lots	3.204	2.723	3.685	0.245	13.070	<0.001
Male vs female	-0.333	-0.471	-0.195	0.070	-4.730	<0.001
Age In years	0.038	0.030	0.046	0.004	9.250	<0.001
Rented from government vs paying mortgage	2.054	1.810	2.297	0.124	16.540	<0.001
Rented privately vs paying mortgage	1.113	0.892	1.334	0.113	9.880	<0.001
Fully owned vs paying mortgage	1.208	1.026	1.389	0.093	13.040	<0.001
Other living arrangement vs paying mortgage	1.327	0.902	1.752	0.217	6.120	<0.001
Doesn't have a tertiary education vs does	0.521	0.327	0.715	0.099	5.270	<0.001
Doesn't have private health insurance vs does	1.128	0.990	1.266	0.070	16.000	<0.001
Has a mental health condition vs doesn't	0.188	0.018	0.359	0.087	2.160	0.031
Moderate psychological distress vs low	0.294	0.125	0.464	0.086	3.400	0.001
High psychological distress vs low	0.707	0.484	0.930	0.114	6.220	<0.001
Very high psychological distress vs low	0.926	0.640	1.211	0.146	6.360	<0.001
Constant	-8.160	-8.788	-7.532	0.320	-25.470	<0.001

For each of the next four “treatments” separate propensity scores were computed using the same covariates for each model (shown on Table 8.7). The next four tables will only show the top panel of the table which are the estimates of the possible causal effect. They show the difference between the population and the reference category(ies) with which they are being compared for each of the following independent variables: perceived discretional income (the “treatment”) (Table 8.8); obesity (the “treatment”) (Table 8.9); fast food consumption (the “treatment”) (Table 8.10) and not eating vegetables (the “treatment”) (Table 8.11). First comes eating fast food three or more times a week which precedes eating no vegetables.

Table 8.8 Estimate of probability of running out of food by spending power adjusted using propensity scores

Outcome: running out of food	Coef.	95% CI		Robust Std. Err.	z	*p*
Difference between spend left over vs able to save	0.023	0.014	0.033	0.005	4.85	<0.001
Difference between just enough vs able to save	0.056	0.046	0.067	0.005	10.48	<0.001
Difference between not enough vs able to save	0.066	0.048	0.083	0.009	7.38	<0.001
Average probability of outcome for those able to save	0.012	0.009	0.014	0.001	9.05	<0.001

Table 8.9 Estimate of probability of running out of food by obesity adjusted using propensity scores

Outcome: running out of food	Coef.	95% CI		Robust Std. Err.	z	p
Difference in probability when obese	0.008	0.003	0.013	0.003	3.15	0.002
Average probability of outcome if not obese	0.029	0.026	0.032	0.002	17.88	<0.001

Table 8.8 and Table 8.9 show variables that in the path preceded running out of food as assessed by the BIC previously described in Section 8.1.1. The next two tables (Table 8.10 and Table 8.11) show the variables that follow running out of food rather than precede it.

Table 8.10 Estimate of probability of eating fast food more than twice a week by running out of food adjusted using propensity scores

Outcome: Fast food more than three times a week	Coef.	95% CI		Robust Std. Err.	z	p
Difference in probability of running out of food vs not	-0.007	0.042	-0.013	0.003	-2.03	0.042
Average probability of outcome when didn't run out	0.019	<0.001	0.017	0.001	17.83	<0.001

Table 8.11 Estimate of probability of eating no vegetables by eating fast food more than twice a week adjusted using propensity scores

Outcome: Eats no vegetables	Coef.	95% CI		Robust Std. Err.	z	*p*
Difference in probability of fast food eaten >2 times weekly	0.029	0.007	0.051	0.011	2.61	0.009
Average probability of outcome when fast food <3 times weekly	0.006	0.005	0.007	0.001	10.32	<0.001

8.4 Discussion

The main results of this investigation confirm the frequently reported finding that those who have fewer economic resources are also those most likely to run out of food and be unable to afford more. However, the story is more complex than that. What this research shows is that income per se doesn't necessarily predict either whether or not you can save or whether or not you run out of food and further that running out of food has consequences for the quality of diet as after running out of food people tend to eat more fast food and stop eating vegetables.

The hypothesis that this investigation seems to support is that running out of food probably indicates a relatively poor quality of diet leading to that outcome and then it appears that the quality of diet gets even worse. This hypothesis needs further investigation. Previous Australian research suggested that some of the increased risk of running out of money for food may be due to bills associated with unexpected events (King et al., 2012) but there may be other factors that influence running out of money for food. A recent study has shown that spending more money on diet, independent of income resulted in higher fruit and vegetable consumption (Mackenbach et al., 2015) suggesting that attitudes towards health and diet may be a factor when allocating funding for food. The results from this research suggest that it is possible that people who are able to save no matter what their income may be managing their money better than those with the same income who either cannot save or who overspend. There is some evidence that attitudes towards how people manage money and cope are underpinned cultural beliefs (Lofters, Slater, Kirst, Shankardass, & Quiñonez, 2014). Support for this hypothesis is the increased odds of reported smoking, eating fast food more than three times a week and obesity which are also associated with running out of money to buy food, independent of income level.

This current research points to complex interactions between attitudes and running out of food. Two attitudes have been shown to be related to perceived cost: people who report that it is difficult to eat more vegetables due to cost are almost three times more likely to report running out of food; and people who believe that it would be easier to eat a healthy diet if healthy food were cheaper were 60% more likely to report running out of food. These attitudes may make sense as they are associated with the already demonstrated link to low income. But the evidence that people who report that they don’t think about the health aspects of their diet are 60% more likely to report not having enough to eat at least once in the previous twelve month is not. The results from the HWSS analysis provide some indications that this attitude may underpin the observed related variables of smoking, obesity and fast food consumption. In addition, there are significant associations with not having private health insurance and feeling a lack of control over one's own heath both of which have adjusted odds ratios of 1.9. Other than income and attitudes, there is the increased likelihood of reporting running out of food associated with social, mental and physical disadvantage as noted in other studies (Stuff et al., 2004). The evidence also shows that quantification of the degree and direction of effects associated with running out of money is possible.

It is not the intention of this case study to attribute causality to the components of the path to food insecurity but there is some evidence for a causal relationship within the path that warrants further investigation. According to the theory underlying propensity score methodology as developed by Rosenbaum and Rubin (Rosenbaum & Rubin, 1983), adjustment for propensity scoring removes the influence of confounding by multiple covariates as well as unobserved covariates. They argue this provides sufficient evidence for causation for cross sectional studies. Consistent results from similar studies or randomised controlled studies would lend support for a causal link. In this case randomised controlled studies to investigate such links would not be feasible or ethical but as demonstrated there are now tools to use with observational data which lend strong support for causal attribution. Evaluation of research systems may need to consider observational data, less as being only valuable as descriptive studies and more as potential sources of important causal relationships. That attribution depends on the quality of the data, the quality of the collection methodology and the robust and appropriate statistical analyses. Application of a set of criteria in relation to observational data collections and outputs can mean that previously untested information can re-examined. The results suggest evidence of a causal relationship within the path for the variables presented and warrants further investigation. According to the theory underlying propensity score methodology as developed by Rosenbaum and Rubin (Rosenbaum & Rubin, 1983), adjustment for propensity scoring removes the influence of confounding by multiple covariates and provides sufficient evidence for causation for cross sectional studies. Randomised controlled studies to investigate such links would not be feasible or ethical.

These findings corroborate the advantage of investigating both datasets together. Each survey on its own provides a restricted perspective but when analysed in tandem they provide greater breadth and have allowed a previously unexplored area to be identified.

9 DISCUSSION OF RESULTS FROM THE FIVE INVESTIGATIONS

The objectives of the thesis were to investigate what adults in WA were thinking, believing, and doing about their dietary choices with the ultimate goal of finding pathways to support development of interventions designed to shift the distribution of the population in the direction of better diet and nutrition. If planning interventions about food choices requires knowledge of the how people make choices, possible causes for unhealthy eating, evidence about some of the motivators for decisions that either increase healthy eating or decrease healthy eating, knowledge of what has worked before and for how long as well as what has not worked, then the results of this present research provides a basis for planning. Using recently developed statistical methods for survey data, the data have yielded results that provide a range of contexts from which to further study how choices about food are made; and an evidence base from which to plan health promotion, health education and interventions that are specifically targeted to segments of the population to achieve healthy eating on all of the levels, the intrapersonal, community and policy level. This has been achieved by interrogating two data sets more comprehensively than is traditional with cross sectional data. The research questions and subsequent statistical analyses provide a platform from which other similar data can be re-examined in a systematic manner.

9.1 FINDINGS ARISING FROM RECENTLY DEVELOPED STATISTICAL METHODS USED ON SEQUENTIAL CROSS SECTIONAL SURVEY DATA RELATED TO FOOD CHOICES

> "Influencing eating behaviour requires more than addressing nutrition knowledge and perceptions of healthy eating – it requires addressing the very context within which individual choices are made" (Raine, 2010, p 23C)

The objectives of the thesis were to investigate what adults in WA were thinking, believing, and doing about their dietary choices with the ultimate goal of finding pathways to support development of interventions designed to shift the distribution of the population in the direction of better diet and nutrition. If planning interventions about food choices requires knowledge of the how people make choices, possible causes for unhealthy eating, evidence about some of the motivators for decisions that either increase healthy eating or decrease healthy eating, knowledge of what has worked before and for how long as well as what has not worked, then the results of this present research provides a basis for planning. Using recently developed statistical methods for survey data, the data have yielded results that provide a range of contexts from which to further study how choices about food are made; and an evidence base from which to plan health promotion, health education and interventions that are specifically targeted to segments of the population to achieve healthy eating on all of the levels, the intrapersonal, community and policy level. This has been achieved by interrogating two data sets more comprehensively than is traditional with cross sectional data. The research questions and subsequent statistical analyses provide a platform from which other similar data can be re-examined in a systematic manner.

Large amounts of information around breastfeeding, the beginning of the life cycle of eating, were reduced to manageable information so that evaluation of self-reported behaviours could be made against the ADG. The investigation used factor analysis to show patterns in perceptions around benefits, barriers and enablers and who held these perceptions.

How the adult community of WA rated the importance of breastfeeding was a relatively poor indicator of support for breastfeeding. However, perceived importance of breastfeeding was a major predictor of factors in relation to the benefits of breastfeeding and what would make it easier but was not related to perceived difficulties.

Evidence from this research found that there were important gender differences in what were perceived as benefits, difficulties with breastfeeding (barriers) and what would make it easier (enablers) although neither gender had a high knowledge of breastfeeding from any perspective. A higher percent of females reported immunity, social bonding and the convenience of breastfeeding as benefits of breastfeeding compared with males; whereas a higher percent of males reported the naturalness and chemical free nature of breast milk compared with women. Also a higher percentage of females compared with males reported that needing to work was a barrier to breastfeeding and not having to work would make it easier.

Generally, people who knew a lot of enablers and benefits of breastfeeding were also most likely to know a lot of barriers. The perceived length of time a baby should be breastfed varied with the number of benefits and enablers reported but not with the number of barriers, for which the major covariate was whether or not people thought babies should be breastfed.

The key finding of this investigation were that males apparently do not perceive breastfeeding in the same way as females. Males differ not only in what they perceive as the benefits of breastfeeding but also how breastfeeding might affect a woman’s ability to work and/or manage other family members. In particular, the males in this investigation appeared to be less aware of the effect of breastfeeding on how a female sees returning to work both in terms of the need to and the effect that might have on being able to continue to breastfeed. These results would support an education program for males about how to support and assist the management of breastfeeding in relation family and work. For females, the evidence suggests that an education program would focus on how to ameliorate perceived problems with milk supply, breast soreness and how to manage breastfeeding in public places.

The time series analysis of the consumption of fruit, vegetables and fast food as well as the tracking of BMI showed that the population was not getting better at healthy eating. The consumption of fruit and vegetables showed that there were changes over time but that these were not stable and that overall, there has been a decline in consumption since 2007. In the time series period April 2002 to December 2013, fruit and vegetable consumption rose at the same time as a major multi mass media health promotion campaign (*Go for 2&5®)* was running from April 2002 to June 2005. Regression analysis confirmed that there was a positive significant association between fruit and vegetable consumption consistent with this campaign when costs of both were controlled for in the temporal model. The increases of consumption appeared to remain reasonably stable until 2007, possibly assisted by a brief burst campaign in 2006 which was running long enough to show any association in the regression. In 2007, the consumption, particularly of vegetables, started to decrease and although the decrease has started to slow down, the forecast for the next five years suggested that with no further interventions, the decline would continue. Females generally consumed more vegetables than males but showed a similar decrease pattern as seen for males. There were also differences in consumption by age group with adults aged sixteen to twenty-five years and adults aged over sixty-four years generally consuming less compared with those aged twenty-five to sixty-four years. As this latter group was the targeted group for the Go for 2&5® health promotion campaign, the higher consumption may be partly due to that.

For fruit, the consumption pattern showed that the mean consumption of fruit over time was not too far off the recommended two serves and as for vegetables, females consumed more fruit than males. There was little difference in consumption by age and the forecast indicates that the consumption level will stay about the same as it has been over the time period. What appears to be one of the major temporal drivers of fruit consumption is the price of fruit, which is not the case for vegetables. The two big dips in fruit consumption coincided with major weather incidents in key fruit growing areas of Australia and to a lesser extent there was a decrease in vegetable consumption associated with the big price increase in 2008-2009 but whereas in the temporal regression analysis the price of fruit was significantly associated with consumption, the price of vegetables was not significantly associated with consumption.

The regression analyses showed that for vegetables over the time period of 2002 to 2013, temporal events such as health promotion campaigns and costs accounted for a large part of the variance for both males (r^2.69) and females (r^2.51). This was not true for fruit (males and females combined

r^2.19). This may be because, other than costs, fruit consumption was already approaching the recommended serves of two per day.

The time series analyses showed that there was a need to try to identify how people were eating and to relate eating habits to characteristics in the population that could be addressed by public health interventions. The time series shows that for vegetables, the Go for 2&5® campaign was associated with an increase in consumption for the first campaign conduced from March 2002 to June 2005 using a full media strategy. Previous studies on changes in smoking due to campaigns found a similar outcome with the more intense programs reporting the largest effect (Bala, Strzeszynski, Topor-Madry, & Cahill, 2013). The subsequent campaigns using the Go for 2&5® theme did not show the same effect which may be due in part to the sporadic nature of times and the parts of the campaign being used. The campaign run over 2008 and 2009 was associated with a decrease in consumption with no obvious explanation as there was no interaction effect with the GFC. For females, the campaign run in 2011 had a marginal effect with increase in consumption but this was not true for males. These findings suggest that to effect change health promotion campaigns need to be wide ranging and long term.

The times that fast food was consumed over a week remained relatively stable over time since about 2008 with a slowing down of the decline which is forecast to continue. Young people and males consume more fast food and for females cost is associated with the number of times they consume fast food.

BMI showed a linear increase over time for both genders with males showing higher BMI over the time 2002 to 2013. The forecasts however show a continued linear upward trend for females but a plateauing of the trend for males. When BMI was examined by area of residence grouped by relative social disadvantage, the middle quintile was the only one which showed a continued linear upward trend over the time period while the other quintiles showed a slowing down, plateau and then decline. Those living in the two most disadvantaged quintiles were also those with the highest BMI scores which would have been predicted from the literature. However, when the means were forecast, it was the upper three quintiles (those who are relatively LESS disadvantaged) that showed a continued upward trend and it appears that they will catch up with the lower two quintiles within the next five years. This is an unexpected finding and one that requires further investigation. It may be that increasing food costs mean less discretional income to use in the purchase of less healthy foods. It could also mean that health promotion and health education messages were reaching those quintile populations but as none of the campaigns aimed at reducing BMI was statistically associated with decreases in BMI over time, it seems to be unlikely.

The five year forecasts shows that without any interventions or changes in pricing there is high probability that the daily serves of vegetables consumed will continue to decrease and that BMI will increase. Fast food consumption and daily fruit consumption appear to be stable with minimal decreases predicted for both. This is the case even with the release of the updated ADG suggesting that more campaigns like the effective first Go for 2 and 5 full media campaign are necessary if the trends are to be changed.

The findings from the time series analysis confirmed the need for an indicator of healthy eating that could be used to track how the population was adhering to the ADG and identify associations with attitudes, perceptions, beliefs and behaviours. Using a model based on a full dietary intake assessment, but adapted for use with short dietary questions, factor analysis revealed that there were clear and independent patterns for two types of eating. The first was eating from recommended food groups (RF_HEI) and the second was eating in relation to recommendations on discretional foods and additional serves over the recommended for any age and gender group (DF_HEI). Many scales have been constructed to measure eating patterns, but this investigation was the first to identify two eating patterns based on short dietary questions although a study of twins using a full dietary intake measure had found two similar patterns (van den Bree et al., 1999).

Apart from the two clear healthful eating indicators, a key finding was that the two indicators were independent. This meant that people could eat in one of four eating patterns: eating well on both, eating well on neither, or eating well on one but not the other. Associations for the healthful eating indicators were also different so not only did people eat in different patterns but that what predicted the particular pattern was different both in terms of socio demographics and also in terms of attitudes. This finding was made possible through the use of factor analysis with confirmatory structural equation modelling.

Regression analysis identified that having less education, low income and the inability to save any money were all associated with lower scores on the healthy eating indicator associated with recommended food group consumption (RF_HEI). Being male, not living alone and living in the most socially disadvantaged areas of WA were all associated with lower scores on the healthy eating indicator associated with discretionary foods (DF_HEI).

The key finding from the associations with healthy eating patterns were that paying a great deal of attention to the health aspects of diet, independent of education or income was a significant predictor of healthy eating for both the RF_HEI and the DF_EHI. Conversely paying no attention to the health aspects of diet was associated with poorer diet patterns on both indicators.

A staged regression analysis revealed that when sociodemographic indicators, beliefs, intentions and behaviours are modeled against the Recommended Food Healthy Eating Indicator (RF_HEI) the final model shows that people who feel that they eat enough fruit or have intentions to increase consumption, who have knowledge of health problems association with excess weight, who know the recommended daily serves of fruit and vegetables, who feel they eat enough vegetable, who think that if healthy food was cheaper and who have the ability to save money all tend to have higher scores on the RF_HEI. There are more predictors of poor scores on the RF_HEI with the most important predictors not thinking about health aspect s of a diet or only paying a bit of attention to it. These are followed by not being able to cook well, thinking there are many difficulties associated with eating more fruit and vegetables and trying to cut down on fatty foods. Increasing BMI is associated with increasingly poor RF_HEI scores.

When sociodemographic indicators, beliefs, intentions and behaviours are modeled against the Discretionary Food Healthy Eating Indicator (DF_HEI) the final model shows quite a different pattern. Those who think that they already eat enough vegetables were the only group positively associated with higher DF_HEI scores. All the other associations are negatively associated with higher scores. The most important predictors of low DF_HEI scores are living in areas which are classified as being the most socially disadvantaged and people who don't have responsibility for preparing or buying food. Being male, not thinking of trying to do anything about weight, doing home duties, thinking that there are many difficulties associated with eating more fruit and vegetables and not thinking about the health aspects of diet were all associated with poorer DF_HEI scores.

A key finding from the investigations into healthy eating patterns was that overall less than ten percent of the population eats well on both the healthy eating indicators while two thirds of the population don't eat well on either. This finding arose from the adaption of quiz to assess how well the population was doing with regard to meeting the ADG described in Chapter six, section 6.3.2. The results suggested that population groups within each of the four eating patterns identified by the healthy eating indicators needed to be targeted specifically.

The investigation of food insecurity used two different datasets, the NMSS and the HWSS each of which had a question about having insufficient food at least once in the previous twelve months, to provide a clearer picture of the path to this outcome.

A key finding from the NMSS showed that running out of food was associated with the overall attitude of paying attention to the health aspects of diet, which had not previously been identified. The relatively small percent of people reporting that they had run out of food and the relatively small sample sizes of the NMSS surveys meant that there was not enough statistical power to explore this finding in any greater detail. The HWSS with its much longer data collection period and large sample sizes provided enough statistical power to allow for the development of a path to running out of food associated with socio demographics, health risk factors and health conditions.

Three areas of evidence were provided by using the two cross sectional surveys. The first was that it was not only actual income that was associated with running out of food but also perceived ability to use that income. The second was that attitudes towards food and health were related to running out food. The third was that quantification of the risk of food insufficiency within a population could be estimated with the relative effects of associated outcomes or precursors. The path showed the expected associations with low income and mental health problems but it also showed that how money was being spent was relatively more important in the path than income per se. The path also provided information about what happens after running out of food. Evidence showed that eating fast food more than three times a week followed by not eating vegetables are consequences associated with running out of food. This has not been previously identified or quantified.

Overall respondents who are younger or who have very low incomes are more than five times as likely to report running out of food compared with older age respondent and those with higher incomes. Respondents with money problems, low discretional income, those with both low income and low discretional income are more than three times as likely to report running out of food compared with respondents who don’t have money problems and higher income as well as higher discretional spending power. There appear to be complex interactions between attitudes and running out of food. Thinking that it is easier to eat healthy if food were cheaper and costs related to vegetables were associated with running out of food and both of these are associated with low income and inability to save. However, independent of income, people who report that they don’t think about the health aspects of their diet are 60% more likely to report not having enough to eat at least once in the previous twelve month suggesting that underlying money issues is a fundamental attitude toward diet. Thinking about the health aspects of diet may underpin the observed related variables of smoking, obesity and fast food consumption.

A key finding from this investigation was that the use of propensity scoring for some of the variables on the path showed that statistically significant ‘treatment’ effects associated with running out of food can be established and quantified. Further this kind of analysis identified precursors and consequences of running out of food at least once in the previous twelve months. Results from this research showed that incomes less than $60,000 and not having enough discretional income to be able to save any were both precursors of running out of food and these findings are consistent with the literature. What was also illustrated was that two of the apparent consequences of running out of food were the increased use of fast food and subsequently eating no vegetables. This finding has not been previously shown

9.2 LIMITATIONS OF THE RESEARCH

As with all cross sectional studies, the information is based on self-reported data. An assumption is made that the data is a reasonably accurate reflection of the population’s attitudes, beliefs and actions in relation to dietary behaviour, lifestyle and demographics. There has been work conducted on test-retest reliability and comparisons against other surveys of a similar nature which show that data used in this research produces estimates which are, in the main, very similar (Daly, Parsons, Wood, Gill, & Taylor, 2011; National Public Health Partnership, 2003, 2004).

9.2.1 Coverage

Another limitation is how representative the data is of the population it seeks to describe. There are two aspects to this limitation. The first relates to the sample frame from which the sample is drawn (Eastwood, Gregor, MacLean, & Wolf, 1996; Thomas, Heck, & Bauer, 2005). In the case of the surveys used in this research, the sample frame was the Electronic White Pages (EWP). The main problems with using the EWP as a sample frame are that the may not have the most recent additions to the land line telephone base and they won’t be up-to-date on the mobile only households. A comparison of different sample frames and random digit dialing (RDD) showed that there were no consistent differences (unpublished report prepared for the Commonwealth Department of Health) which supported earlier findings from a comparison of RDD and EWP conducted in South Australia earlier (Wilson, Starr, Taylor, & Dal Grande, 1999). Also, for data collected prior to 2004, the use of land lines in Australia was predominant.

The second limitation is the way in which the sample frame is used. In this thesis for most of the investigations, probability sampling stratified by geographic area is used to extract the sample. Random sampling allows for adjustment for the probability of selection and for post estimation weights based on the structure of the population. For the years prior to 2009, random digit dialing and quota sampling were used which potentially provide more complete coverage but don't allow for any estimation of the effect of non-responders or unselected responders. To address issues related to coverage, weighting was applied to all datasets in accordance with the sampling strategy. The importance of weighting in estimating prevalence at a population level has been acknowledged in the literature (Kalsbeek & Agans, 2009; Thomas et al., 2005) and the way in which the data are weighted can significantly affect some estimates (Kolenikov & Hammer, 2015; Mokdad, Stroup, & Giles, 2003). In this research, raking was the method adopted and a full description of this can be found in Appendix two.

A comparison of response rates for the NMSS and the HWSS with the Australian Health Survey (AHS) found that even though the AHS uses a cluster sampling technique and interviews all members (WA: 2847) in a selected household (WA: 2144) and the HWSS and NMSS use random sampling with only one member of a household interviewed (2011 HWSS: 6920 and NMSS: 2832 for 2009 & 2012 combined), all three surveys had comparable response rates (AHS WA 89.9% and 2011 HWSS 82.1 with a participation rate 89.8%; NMSS 2009 & 2012 82% with a participation rate 88.9%).

9.2.2 Social desirability bias

Social desirability, the propensity to provide answers that are socially acceptable, has been found to influence responses in surveys, particularly when a response may have some perceived social consequence or be a response to a question that is sensitive in nature (Gittelman et al., 2015). This bias has been recognized as a potential source in surveys about dietary intake (Hebert, Clemow, Pbert, Ockene, & Ockene, 1995). However, although questions about food and food habits are asked in the NMSS and the HWSS, most of the responses are unlikely to be biased as the respondents would need to be aware of all of the dietary guidelines in formulating their answers to questions about knowledge or support for particular policies, funding or interventions. Further, in this research, the information about food is not being represented as being any indication of nutrient intake. Rather the information is used to indicate healthy eating habits and as such is considered an acceptable for such cross sectional data (Subar et al., 2015).

9.2.3 Measurement bias, validity and reliability

Self-reported information can affect validity, reliability and accuracy. There may be errors arising from those recording the self-reported information in terms of incorrect transcription or errors in computer entry; and there are errors related to analysis in terms of confounders, measurement errors, ignoring assumptions underlying specific analytical techniques and incorrect use of statistics (Cadmus-Bertram & Patterson, 2012; Kerr, Schap, & Johnson, 2012). A comparison of prospective, cross sectional surveys and case control studies found all three had some response bias in estimates of prevalence and odds ratios but that “case-control studies appear to be especially vulnerable “ (Criqui, 1979, p 399).

There may also be reliability and validity biases in relation to some of the food consumption questions asked in the NMSS and the HWSS. For telephone surveys, particularly surveys which are mainly quantitative and close ended in question format, assessment against a major face-to-face survey is considered validation against a ‘gold standard’. For the HWSS, the gold standard is the Australian Health Survey (AHS) conducted every three to five years. Although not undertaken in this research, comparisons of HWSS prevalence estimates for chronic conditions and quality of life indicators have consistently showed good congruence with it. For this research a direct comparison of responses to short dietary questions collected in the 2011, a year when both surveys were being conducted and the same questions asked, was used as an indicator of validity. The short dietary questions used were based on those used in the National Health Survey 1995 which were validated against 1995 National Nutrition Survey (Marks et al., 2001). The comparison between the AHS and the HWSS shows a reasonable good match with very few statistically significant differences across the age groups by gender (Appendix five).

The 1995 NMSS dietary questions were validated against the 1996 Perth Dietary Survey using a Food Frequency Questionnaire. The validation showed that the NMSS dietary questions had good congruence with the estimates of consumption based on the Perth Dietary Survey[3]. Consistency of responses to open-ended multiple response questions over the years in the NMSS supports face validity. As long as the data are not represented as being accurate in terms of nutrient intake then cross sectional data for investigating associations of dietary attitudes and behaviours is an acceptable source (Subar et al., 2015).

In terms of reliability of the HWSS, responses to fruit and vegetable consumption and height and weight have been previously reported (Daly, Parsons, Wood, Gill, & Taylor, 2010). Using ranges of acceptable reliability as defined by Landis and Koch, fruit, height and weight all demonstrated reliability estimates in the ‘good’ range with vegetable having a ‘fair’ reliability. However, the questions used to estimate serves of vegetables consumed have been used in Australia nationally for at least twenty years as to date none have been found that yield better reliability in large population based studies (Landis & Koch, 1977). A range of other questions used in the HWSS were assessed for test-retest reliability and found to be within the

[3] This is an unpublished work.

good to excellent range (National Public Health Partnership, 2003, 2004). The NMSS has not been assessed by any formal test-retest reliability studies. As a proxy indication, the consistency of estimates on similarly worded questions using surveys with similar modes of administration and sampling suggest that the data are likely to be reasonably reliable. A comparison of estimates between the HWSS and the NMSS with AHS comparisons from the 2011 2012 survey showed good congruence given the different collection times, samples and methods (Appendix five).

In the cross sectional surveys used in this present research there was under representation of males relative to females suggesting a non response bias for males (Galea & Tracy, 2007). In cases where there is over or under representation of a particular sub group of the population, weighting or raking techniques can be used to make the sample more representative of the population. The calculation of standard errors with methods such as bootstrapping and jackknifing can also be used to address non response within groups (Rust & Rao, 1996). This is particularly important when a total population estimate is been calculated (DeVoe, Krois, & Stenger, 2009; Johansen, Rognerud, Sundet, & Aarø, 2012).

9.2.4 CATI data collections

CATI data collections have the limitations described above in section 9.1.1 regarding coverage in telephone surveys and there are ways in which this can be addressed. One is to use a more complete sample frame, such as the Integrated Public Number Database, currently in use in South Australia. This database contains every telephone number in use in Australia but is subject to many restrictions which would need to be addressed. While the database is complete, no geocoding of addresses is permitted even with the permission of the owner of that address. This means that targeted sampling for geographic areas is not possible and analysis using geocoding is also not possible. The tradeoff between coverage and ability to do specific geographic analysis has not been investigated and needs to be addressed. What CATI surveys do offer is a cost saving compared to the use of Computer Assisted Personal Interviews, as used by the ABS in their cross sectional health and nutrition surveys. CATI allows for a much large sample and in WA the HWSS sample size is twice that of the ABS national survey sample for WA. The concordance of prevalence estimates as shown in Appendix five provides evidence that one system is not necessarily superior to the other and no research has been conducted using the same sampling techniques and comparing the two modes of administration. This needs to be addressed,

9.2.5 Monitoring and Surveillance data and data collected for research purposes

When data is collected for monitoring and surveillance the research questions are generally about trends over time and the ability to identify emerging issues quickly and in a timely manner. The data is generally not designed to address a specific research question (Campostrini, McQueen, Taylor, & Daly, 2015) which is the opposite of a data collected designed to address a specific research question. Differences between the two types of data collections lie in the degree and breadth of coverage of a specific area and may also use different modes of administration and statistical techniques to analyse the data. Specifically, a research data collection will cover a topic in more depth and will be more detailed and specific in the focus to address the hypothesis being tested. The sample selection may also be more targeted. The statistical analysis will use techniques to identify and quantify differences between ‘treatments’ or interventions consistent with the hypothesis. Monitoring and surveillance data collections aim for a broader coverage of areas with less depth. They are not based on any hypothesis and analysis of their data is often limited to descriptive statistics. Results are generally used to describe what population groups are doing, thinking or feeling over a range of issues and to provide estimates of the prevalence of variables such as chronic health conditions and risk factors for chronic disease. However, this does not mean that surveillance data cannot be used to investigate research questions as has been demonstrated in this thesis. In this instance, the aim is less to address specific focused hypotheses but rather to interrogate the data using broad research questions and more inferential statistics to produce results which then can be used to identify gaps and/or emerging issues. Results from these inferential statistics may produce results that appear to indicate a relatively poor goodness of fit, such as a low r squared for a multiple regression. The use of r squared as the best measure of model fit has been questioned (Nathans et al., 2012) and there is the further issue of what . There is the further issue of what constitutes an acceptable r squared, with evidence for relatively low r square values showing meaningful results (Christensen-Szalanski & Willham, 1991) versus relatively high r squared values which don't (Department of Statistics Online Programs, 2016) .These results can then guide the formation of hypotheses for further investigation. Surveillance data collections offer the ability to do time series statistical analysis as shown in Chapter 5 which no other data collection type can do with the same degree of statistical power as time series analysis depends on the number of measurements made consistently over time.

9.2.6 Issues with quantifying response to short dietary questions

Twenty-four hour recall of the consumption of a small number of food groups, by type and amount, is inadequate for any assessment of diet in terms of nutrients and total diet for the day. There is even evidence that any self-reported dietary intake has under-reporting of caloric intake and is of limited value (Mitka, 2013). In many ways, the reporting errors are similar to those associated with measuring obesity at a population level under-reporting of weight and over-reporting of height are common (Gorber, Tremblay, Moher, & Gorber, 2007). For these errors it has been possible to use algorithms to make adjustments to the self-reported data (Hayes, Clarke, & Lung, 2011; Hayes, Kortt, Clarke, & Brandrup, 2008). Given the complexity of nutrition, it is unlikely that this will be possible for under reporting dietary intake. At this point in time, self-reported dietary intake is the only feasible way to assess dietary intake at a population level (Ioannidis, 2013; Subar et al., 2015). For that purpose, detailed dietary records and questions about frequency and variety of foods consumed over time are needed to provide some measure of total diet and nutrient intake. Even with the measurement errors, evidence shows that, at a population level, such data has provided valuation information about dietary patterns and their effects on health outcomes

(Hebert et al., 2014; Kirkpatrick & Collins, 2016) and that short dietary questions can used to a general high level indication of general adherence to a dietary pattern or a set of guidelines (Thompson & Subar, 2012).

These limitations notwithstanding, the cross sectional surveys used in this provide the only data available on attitudes, beliefs, perceptions and behaviours about the adult WA population across and within time. As such they provide a unique set of data from which to explore the inter-relationships and interactions between such variables with regard to dietary choices and behaviour. The results from such investigations can inform policy and practice but they can also provide insight about the WA population social norms around eating, eating choices, influences to change and community support for government policies, support and interventions.

10 CONCLUSIONS AND RECOMMENDATIONS

The evidence presented in the preceding chapters demonstrate that statistical techniques not generally used on sequential cross sectional population survey data yielded previously unknown information and/or provided quantification for hypothesized but to date, uninvestigated associations for diet related behaviours and outcomes. This information, obtained through the use of statistical methods that are designed to provide evidence of change over time and indications of causality, has provided context and quantification of the importance and direction of motivators in food choices. The use of two different survey datasets with similar questions has provided a more complete picture about how and why people run out of food than the attribution of social disadvantage.

Statistical and methodological approaches have been applied to WA cross sectional survey data to investigate adherence to Australian recommendations for a healthy diet. However, they can be applied to any survey dataset with samples large enough to provide estimates that are reasonably robust (in a statistical sense) and representative of the population they are attempting to describe. This chapter summarises the main conclusions with recommendations for cross sectional survey methodology and for further research follows.

10.1 THE MAIN CONCLUSIONS FROM THE INVESTIGATIONS

The evidence presented in this thesis demonstrates that cross sectional data can benefit from a more rigorous approach both in its collection and its statistical analysis. The results supports the premise that cross sectional data are a potentially powerful source of information provided the questions asked of respondents and subsequently of the data are embedded in a theoretical, epidemiological or empirical basis, or a combination of these.

Each of the analyses showed the important drivers within the variable set being investigated thereby providing evidence to support behaviour change theories in line with a taxonomy approach. The fuller models developed from the outcome of a series of staged regressions provide evidence of the complexity of the interactions and can be used to modify and refine system approaches to behaviour change.

Granger causality tests used with time series auto regression analysis identified important time related precursors associated with environmental events and healthy eating behaviors as well as providing evidence for the effects of health promotion campaigns. It also confirmed, for the first time, a reciprocal temporal causality between fast food and BMI.

By using two different cross sectional data sets the evidence showed that quantification of the degree and direction of effects associated with running out of money is possible. The quantification lends support that there may be causality between some of the variables on the path. The use of the more sophisticated propensity scoring with path analysis provided a tool with which to explore importance and direction of precursors along paths to running out of food as well as identifying for the first time possible consequences of that.

While direct translation of results from this thesis to policy or health promotion is not made, they can be used to for that purpose. For example, tables similar to insurance league tables to pinpoint the most ‘at risk’ groups for intervention purposes can be constructed. Visual representations of important relationships between variables in the decision making process can be developed such as the path diagram (Chapter 8 section 8.2). Although many of the graphs in this thesis are complex, simple graphs to illustrate relationships between attitudes and behaviours can be made such as the one showing how attitude towards the health aspects of diet is associated with the RF_HEI (Chapter six, results section).

The findings described in this thesis support the value of continuous monitoring of a population on important determinants of health and wellbeing. The examination of the impact of interventions over time, the early warning of changes that are not in a direction towards better health, the identification of stability in desired behaviours or attitudes, and the description the knowledge, beliefs, perceptions and behaviours in relation to achieving a healthy population all depend on the existence of valid, reliable and consistent data sources. In WA, the NMSS and the HWSS provide this information and are good models for sequential cross sectional data collection at a population level.

10.2 Recommendations

Evaluation of research systems may need to consider cross sectional data, less as being only valuable as descriptive studies and more as potential sources of important causal relationships which need to be studied under more controlled situations and where randomised studies are not possible. This type of attribution depends on the quality of the data; the quality of the collection methodology; and robust appropriate statistical analyses (Rikkers, Lawrence, Hafekost, Mitrou, & Zubrick, 2013). Application of a set of criteria in relation to the analysis of cross sectional data collections offers an opportunity to re-examine previously untested information. Such investigations can be used as proof of principle for the case that in-depth statistical analysis of cross sectional data is necessary and provides information not obtainable by other methods.

There are a number of recommendations arising from the results presented in the chapters above. There are recommendations that pertain to the methodology of survey data collection and there are recommendations for further investigation.

10.2.1 Future cross sectional monitoring and surveillance surveys

The methodology recommendations arising from the current studies (pertinent to all objectives) center around the sampling methodologies used and to a lesser extent the modes of administration.

1. Probability sampling should be used for all future surveys. This will allow for weighting to be applied adjusting for the sampling methodology, such as over sampling in remote areas or over sampling particular sub populations such as young adults or older adults.

2. All samples for population based surveys should be stratified by age, gender and area of residence given the specific population groups which are under represented in the respondent profiles. This will mean

that sampling expertise will be required to advise on the best practice methods to achieve valid results.

3. Sufficient sample should be estimated to address the objectives of the survey and provide reasonable confidence intervals around estimates. If population subgroup segmentation is required, then larger samples are also required. Power analysis should be conducted to show the sample size necessary to produce robust estimates of the desired outcomes.

These three recommendations will ensure the data which is collected can be properly weighted and that the estimates and models derived from these data can be relied upon.

The next set of recommendations is related to the training and resource allocation for the analysis of cross sectional data. To date almost all monies are allocated to data collection and little to data analyses and research translation. Outcomes from the investigations in this thesis demonstrate that these data can be sources of valuable insights but these will remain unexplored and underutilised unless there is a trained workforce. These are recommendations in line with this issue:

1. Allocate resources, both in terms of time and support, to interrogate and analyse data that is already available, such as the NMSS, the HWSS, and the AHS.

2. Provide training in the recently developed methods of statistical analysis, that can be used with cross sectional data, to those working in the field of public health.

3. Provide access to statistical advice and support to public health professionals who are planning and designing research.

4. Provide workshops on how to use the outcomes of studies such as those outlined in this thesis to health care professionals.

5. Develop courses on translational research

6. Upskill of workers in data collection, data dissemination, health promotion and health education.

The finding that people appear to eat differently depending on what the foods has been extensively examined in this thesis for drivers and predictors with little success. None of the areas examined yielded an r squared high enough to provide a strong basis to support interventions. While a low r squared value is not of itself necessarily a problem it may, given the large number of variables tested, suggest that there are areas which are more important in explaining what we eat than those measured in the existing monitoring systems. Evidence from studies conducted in the US provide information about how context and norms play a large part in decisions about what to eat. It is recommended that the NMSS:

1. Incorporate some questions that tap into social norms and contexts surrounding eating.

2. Include questions about cultural background.

Evidence has been provided to show that the use of propensity scoring and standardized coefficients can identify the major drivers of running out of food and has provided grounds for testing causal links resulting in running out of food or resulting from running out of food, which results in a poorer quality diet.

1. Investigate methods to more directly examine two different datasets. Methods such as multiple imputations of missing data and propensity scoring offer starting points. Being able to link datasets that explore different aspects of behaviour, attitudes and perceptions have the potential to expand our understanding of what drives people's dietary choices and behaviour.

10.3 RECOMMENDATIONS ARISING OUT OF THE RESULTS FOR FURTHER INVESTIGATION

The following recommendations for further investigation arise out of the results from the five studies. Some are in the form of questions that appear to be unanswered, either in this thesis or in the literature. Some are hypotheses which can be tested and some are recommendations for extensions of the studies described in the chapters above.

10.3.1 Breastfeeding

The whole area of breastfeeding, while extensively researched, appears to have gaps. These are mainly the way in which characteristics, attitudes and social norms interact to influence whether or not to breastfeed; how long to do it; what constitutes a 'good' reason not to breastfeed; and what is necessary to support the recommendations with regard to six months of exclusive breastfeeding. The following are some of the questions that arise:

1. How do general attitudes towards the health effects of diet affect decisions to breastfeed?

2. What is the role of income versus discretional income in the decision to breastfeed?

3. How does education interact with income in the decision to breastfeed?

4. How is information about breastfeeding communicated? What is the relative contribution of community norms and more personal beliefs?

5. How do social norms versus immediate family influences and previous breastfeeding history interact?

6. Is the reported inconvenience of breastfeeding as a barrier perceived in relation to work and/or other children if there isn't enough family and/or work support? If so, what is the nature of this complex interaction?

10.3.2 Assessing temporal changes and trends in diet related events

The time series raised a number of issues around the influences that can affect public health interventions. These include:

1. What is the difference between campaign success in terms of outcome and impact?
2. How long is long enough to decide that a health promotion campaign is successful?
3. What is the optimal lag between campaigns?

Evidence from this investigation suggests:

1. Health promotion campaigns need to be evaluated not only in terms of immediate success but also in terms of long term impact.

2. Health promotion campaigns should be evaluated both in terms of types of media employed and length of campaign.

3. There is a need to investigate how long the effects of campaigns last and how these relate to the types of campaigns.

4. The decrease in vegetable consumption with the predicted continuation of this trend suggests that some immediate interventions should be considered.

5. The plateauing in BMI forecast for the SEIFA quintiles with the highest relative social disadvantage suggests that perhaps there is a cost factor involved which might be exploited further.

10.3.3 Food choices, drivers and predictors

While the staged analysis did not provide a strong basis from which to provide insight about drivers and predictors of food choices, some suggestions for further investigation can be made.

1. Investigate how to make the health aspects of diet more salient to people as a way to influence their food choices .The amount of attention paid to the health aspects of diet was a significant predictor of healthful eating patterns and the results indicate the groups with the

lowest healthy eating patterns were those who did not give the health aspects of their diet any thought.

2. Investigate the four eating patterns aimed at providing better information to improve the quality of diet and eating that is appropriate for each pattern.

3. Investigate of risk factors associated with poor health and the four eating patterns aimed at identifying ‘at risk’ groups.

4. Investigate how the information in the survey can be used to create an indication of social norms around dietary patterns.

5. Investigate how best to illustrate and use the results of this study to design programs and interventions specifically to fit with the profiles of designated population subgroups.

The other side of the coin is the lack of many choices with regard to food because of a lack of money. The path analysis showed that the effects of running out of food (or being food insecure) are many. They range from deprivation in the physical environment all the way through to detriment of health and wellbeing. Some questions arising from this are:

1. Where does food insecurity start in a high income country with a reasonable welfare system? For example, not having a tertiary education is associated with the probability of running out of food and not having any money to but more but getting such an education is expensive. Similarly living in areas that do not have many support systems, such as some of the remote areas of WA, may contribute to the development of behaviours that leads to food insecurity.

2. Which comes first, mental health problems or being food insecure? Evidence shows that those who are food insecure are also likely to be depressed and unhappy but is this antecedent or consequent?

3. Why do people think that eating fast food is a solution to having little money? In WA the evidence is that it is not but is it more satisfying? If so why? How can this we addressed?

4. Exploration of the role of attitudes in running out of food needs to be conducted as this is an area where not much has been identified but which appears to be a potentially valuable area.

5. Confirmatory investigation that eating fast food more than three times a week followed by not eating vegetables are consequences and not precursors of running out of food.

6. Continue testing other parts of the part for probable causation so that these can be investigated.

The recommendations above are some of the areas that need further investigation as suggested by the results in this thesis. The recommendations demonstrate that cross sectional data, adequately analysed, provides a rich source of information which, of itself, is useful but is also an invaluable source of hypotheses. Results from these further investigations can be used to inform public health interventions which make real and lasting differences to the diet and health of the WA population.

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Appendices

APPENDIX 1

TABLE SHOWING THE SEARCH STRATEGY FOR THE LITERATURE REVIEWS

Table A Search strategy table showing databases, search terms and how the information was used for the literature reviews in this research

Databases searched	Search terms	Results/Comments
Topic: Diet and Health – no date filter	**The first set of terms included:** attitude to health, health behavior, health communication, health education, health food, health knowledge, attitudes, practice, health literacy, health planning, health policy, health priorities, health promotion, nutrition policy, public health, poor health, health effects, depression, diet quality, diet density, dietary patterns, mental health, wellbeing, capacity building, environment and public health, health care economics organizations, health care quality, access & evaluation, health communication, health promotion, healthy people programs, outcomes, phenomena and processes, population characteristics, successful outcomes	**There were then refined as the searches progressed and the major terms used in the second search are described in the following pages.**
Topic: Diet and Health – no date filter	**The effect of diet on different aspect of health Limiters: human; review; meta analysis; systematic review**	**Systematic and other reviews were chosen to represent the field**
Pub Med, Global health, Medline, Web of Science	Nutrition* & health, Poor nutrition* & health Diet* & health, Poor diet* & health	Filtered by diseases outlined in the 2003 Australian Dietary Guidelines
Topic: Measuring diet – no date filter	**Different methods of assessing diet Limiters: human**	**The search was not restricted to Australian measures although these were used in the review**
Pub Med Global health Medline	Measuring diet quality ,Measuring diet density, Healthy Eating Index, Diet Quality Index, Recommended Food Score, Mediterranean Diet, Dietary Guideline Index, Food Index	The search was used to identify the primary ways in which diet indices were developed and/or measured. .
Topic: Translating research to policy	**Using research in policy decision and translational research**	
Pub Med Global health Medline	Diet* & policy, Research & policy Translational research, Health communication &/or promotion	These were filtered by relevance to the areas of investigation and by frameworks or formats
Topic: Types of data	**Characteristics of data source and methods of measuring the data**	**Authors were the primary source of information**
	Nutritional epidemiology, Observational, Cross sectional, Cohort, Case control, Population	There are many books on data collection and data types. These were sourced for references as well as known authors in nutrition and health

Databases searched	Search terms	Results/Comments
Medline PsychINFO	Health & attitudes & theories, Health & beliefs & theories, Diet* & attitudes & theories, Diet* & beliefs & theories, The Health Belief Model, Theory of Planned Behaviour, Social Cognitive Theory, Transtheoretical Theory, Stages of Change, Reasoned action, Theory of self determination, Theory of Triadic Influence, Systems based , Taxonomy	These were filtered by the major theories about how to change behaviour and then the major theories were extracted and used in the literature review. Each of the theories listed were also searched for the primary sources.
Topic: Statistical information	**Statistical procedures that have been or could be used on cross sectional data focusing on nutrition/diet**	**Many of the references are taken from seminal books on the topics**
Pub Med Medline Web of Science	Iterative Proportional Fitting, Raking &/or weighting, Principal Component Analysis Factor &/or Cluster Analysis, Latent Class Analysis, Ranked Ratio Regression, Path Analysis &/or Structural Equation Modelling, Bayesian Information Criterion, Multivariable spline regression, Holt-Winters smoothing, Time series &/or interrupted Granger Causality, Propensity scoring	Statistical books and journals were the primary sources of information of the statistics and then a search was done on these terms and diet. The relevant articles were retrieved and used in the literature review.

The numbers of articles originally identified as potential sources for the literature review by each of the databases are included to show the strength of interest, relevance and importance of the areas under review.

APPENDIX 2

QUESTIONS USED IN THE ANALYSES

Table of questions used in developing the healthful eating indicators, Chapter six taken from the NMSS 2012

Question	Response recorded
How many pieces of fruit did you eat yesterday? A piece of fruit would be, for example, an apple, a small bunch of grapes, 3 prunes, a quarter of a rock melon or half a cup of stewed, pureed or canned fruit.	The responses are recorded as a number, less than one serve as 991 (recoded to .5) with provision for don't know and refused.
How many different types of vegetables, did you eat yesterday? Please remember to include salad, fresh, frozen, canned, raw and cooked vegetables.	The responses are recorded as a number with provision for don't know and refused.
How many serves of vegetables do you usually eat each day? A serve of vegetables is equal to half a cup of cooked vegetables or 1 cup of salad.	The responses are recorded as a number, less than one serve as 991 (recoded to .5) with provision for don't know and refused.
Did you eat any bread yesterday, don't include rolls?	0 No 1 Yes 998 Can't remember 999 Refused
How many slices of bread did you eat?	The responses are recorded as a number, less than one serve as 991 (recoded to .5) with provision for don't know and refused.
Did you eat any bread rolls yesterday?	0 No 1 Yes 998 Can't remember 999 Refused
Were they large rolls or small rolls?	1 Large rolls 2 Small rolls 3 Both 998 Can't remember 999 Refused
How many rolls did you eat yesterday?	The responses are recorded as a number, less than one serve as 991 (recoded to .5) with provision for don't know and refused.
What type of bread or bread rolls did you mainly eat yesterday? Was it brown, wholemeal, multigrain, wholegrain, white, white with extra fibre, or another type?	1 Brown or wholemeal 2 Multigrain or wholegrain 3. White with extra fibre 4 White 5. Other 998 Can't remember 999 Refused
Did you eat any bread muffins?	0 No 1 Yes 998 Can't remember 999 Refused
How many muffins did you eat?	The responses are recorded as a number with provision for don't know and refused.
Did you eat any flat bread like pita bread, lavash bread or bread wraps?	0 No 1 Yes 998 Can't remember 999 Refused
How many pieces of flat bread did you eat?	The responses are recorded as a number with provision for don't know and refused.
Did you eat any crumpets?	0 No 1 Yes 998 Can't remember 999 Refused
How many crumpets did you eat?	The responses are recorded as a number with provision for don't know and refused.
Did you eat any scones?	0 No 1 Yes 998 Can't remember 999 Refused
How many scones did you eat?	The responses are recorded as a number with provision for don't know and refused.
Did you eat any rice cakes?	0 No 1 Yes 998 Can't remember 999 Refused
How many rice cakes did you eat?	The responses are recorded as a number with provision for don't know and refused.
Did you eat any large crackers?	0 No 1 Yes 998 Can't remember 999 Refused
How many large crackers did you eat?	The responses are recorded as a number with provision for don't know and refused.
Did you eat any small crackers?	0 No 1 Yes 998 Can't remember 999 Refused
How many small crackers did you eat?	The responses are recorded as a number with provision for don't know and refused.
Did you eat any damper? (Damper is an Australian bread baked over a camp fire)	0 No 1 Yes 998 Can't remember 999 Refused
How many slices of damper did you eat?	The responses are recorded as a number with provision for don't know and refused.
How many cups of cooked rice did you eat yesterday?	The responses are recorded as a number. None is recorded as 0; less than one serve as 991 (recoded to .5) with provision for don't know and refused.

Question	Response recorded
What type of rice did you eat?	1 White 2 Brown 3 Both 998 Can't remember 999 Refused
How many cups of cooked pasta or spaghetti did you eat yesterday?	The responses are recorded as a number, less than one serve as 991 (recoded to .5) with provision for don't know and refused.
What type of pasta or spaghetti was it?	1 White 2 Brown 3 Both 998 Can't remember 999 Refused
How many different types of breakfast cereal did you eat yesterday?	The responses are recorded as a number with provision for don't know and refused.
What type of breakfast cereal did you eat? For each type of breakfast cereal they mention eating they were asked to specify what it was.	1 Oats and porridge 2 All bran or other fibre based without fruit 3 Fruit based with any combination 4. Mixed grain 5. Muesli or granola 6. Cornflakes or wheat flakes 7. Sweet cereal, e.g. Honey oats 8. Cheerios, Rice puffs rice based 9. Wheat Bix, Vita Brits, other biscuits 10. Other such as gluten free
How many cups of any type of milk did you have or use yesterday? Include milk used in cereal, tea, coffee, other drinks or cooking, including powdered milk.	Record I didn't use any milk as 0 and fractions of a cup as 1/4=.25; 1/3=.33 1/2=.5 2/3=.66 3/4=.75). If the respondent says that they only used milk in tea or coffee record that a .1, don't know as 998 and refused as 999)
What was the main type of milk that you used yesterday - this includes milk in tea or coffee?	1 Cows milk 2 Soy milk 3 Other 998 Don't Know/Can't remember 999 Refused The other category is specified and recoded back to existing categories.
Was the milk	1 Skim/non fat 2 Low fat/2% fat 3 Whole milk/ full fat 998 Don't Know/Can't remember 999 Refused
Was the milk mainly?	1 Flavoured 2 Plain 3 Both 998 Don't Know/Can't remember 999 Refused
How many cups of yoghurt did you have or use yesterday?	Record I didn't use any yoghurt as 0 and fractions of a cup as 1/4=.25; 1/3=.33 1/2=.5 2/3=.66 3/4=.75). If the respondent says that they only used milk in tea or coffee record that a .1, don't know as 998 and refused as 999)
What type of yoghurt did you eat yesterday?	1 Cow's milk yoghurt 2 Sheep's milk yoghurt 3 Soy milk yoghurt 4 Other type 998 Don't Know/Can't remember 999 Refused The other category is specified and recoded.
What was the yoghurt?	1 Skim/non fat 2 Low fat/2% fat 3 Whole milk/ full fat 998 Don't Know/Can't remember 999 Refused
Was the yoghurt mainly?	1 Flavoured 2 Plain 3 Both 998 Don't Know/Can't remember 999 Refused
How much soft cheese such as ricotta, cottage, brie, camembert, castello, cream cheese, did you eat yesterday? A serve of soft cheese is equal to one rounded tablespoon.	Record I didn't eat any as 0 and fractions of a cup as 1/4=.25; 1/3=.33 1/2=.5 2/3=.66 3/4=.75) 998 Don't Know/Can't remember 999 Refused
How much hard cheese such as cheddar, edam did you eat yesterday? A serve of hard cheese is equal to one slice or a 2.5 cm cube.	Record I didn't eat any as 0 and fractions of a cup as 1/4=.25; 1/3=.33 1/2=.5 2/3=.66 3/4=.75) 998 Don't Know/Can't remember 999 Refused

Question	Response recorded
How much grated cheese yesterday such as grated cheddar, mozzarella, parmesan or Romano did you eat yesterday? A serve of grated cheese is equal to a rounded tablespoon.	Record I didn't eat any as 0 and fractions of a cup as 1/4=.25; 1/3=.33 1/2=.5 2/3=.66 3/4=.75) 998 Don't Know/Can't remember 999 Refused
Was the cheese you ate yesterday mainly regular, reduced fat or low fat cheese?	1 Low fat, like ricotta or cottage 2 Reduced fat cheese 3 Regular cheese 998 Don't Know/Can't remember 999 Refused
Did you eat any beef, lamb or veal yesterday?	0 No 1 Yes 998 Can't remember 999 Refused
How much beef, lamb or veal as a piece of steak did you eat yesterday? A steak serve is a piece of steak that is about the size on your palm.	Record fractions of a serve as 1/4=.25; 1/3=.33 1/2=.5 2/3=.66 3/4=.75) 998 Don't Know/Can't remember 999 Refused
How many beef, lamb or veal chops did you eat yesterday? 1 serve is 2 small chops	The responses are recorded as a number with provision for don't know and refused.
How much roast beef, lamb or veal did you have yesterday? 1 serve is 3 slices of roast meat.	The responses are recorded as a number with provision for don't know and refused.
How many beef, lamb or veal, hamburger patties did you eat yesterday? 1 serve is 1 ½ patties	The responses are recorded as a number with provision for don't know and refused.
How much beef, lamb or veal, mince did you eat yesterday? 1 serve is ½ cup of mince	The responses are recorded as a number with provision for don't know and refused.
Thinking only of fish fillets or tinned fish such as tuna or salmon, how much fish did you eat yesterday? 1 serve of fish weighs 115 grams or 1 100 gram tin	The responses are recorded as a number with provision for don't know and refused.
How many sweet biscuits did you eat yesterday?	The responses are recorded as a number with provision for don't know and refused.
In total, how many cans, bottles, glasses or cups of soft drink, energy drinks, sports drinks, flavoured mineral water or vitamin water, did you drink yesterday? Please say how large the container was in your answer, for example, 2 can of 375 ml RedBull or 1 litre bottle of Coke.	Responses are recorded as number of cans ,cups, glasses, 300ml bottles, 600 ml bottles, 1 litre bottles, 2 litre bottles
How much diet soft drink did you drink yesterday? Please say how large the container was in your answer, for example, 375 ml can	Responses are recorded as number of cans ,cups, glasses, 300ml bottles, 600 ml bottles, 1 litre bottles, 2 litre bottles
How many cups, glasses, mls or litres of plain water did you drink yesterday?	Responses are recorded as number of cups, glasses, millilitres or litres
How many cups, glasses, mls or litres of plain water did you drink yesterday?	Responses are recorded as number of cups, glasses, millilitres or litres

Sociodemographic variables used in Chapter six taken from the NMSS 2012

Persons n=1548
Male
Female
Age group in years n=1548
18-24
25-34
35-44
45-54
55-64
Highest level of education attained n=1545
Up to Year 12
Year 12
TAFE/Trade/Diploma
Tertiary
Aboriginality[1] n=1547
No
Yes
Country of Birth n=1548
Australia
UK or Ireland
Other country
Current Employment Status n=1547
Employed
Unemployed
Home Duties
Student
Retired
Unable to work
Living Arrangements n=1541
Living with my parent(s)
Living with other family
Living with friends
Living with a partner/kids
Living with a partner/no kids
Living alone
Sole parent
Residential area n=1548
Metropolitan Perth
Rest of State
SEIFA[2] n=1548
SEIFA Quintile 1 (most disadvantaged)
SEIFA Quintile 2
SEIFA Quintile 3
SEIFA Quintile 4
SEIFA Quintile 5 (least disadvantaged)

Annual household income[3] n=1370
Under $20,000
$20,000 - $40,000
$40,000 - $60,000
$60,000 - $80,000
$80,000 - $100,000
$100,000 - $120,000
$120,000 - $140,000
More than $140,000
Unsure/Dont know/Cant remember
Refused read out
Perceived discretional income n=1514
Spending more money than received
Just enough money to next pay
Some money left over but spend
Can save a bit every now
Can save regularly
Can save a lot

1 Only 1.54% of the sample identified themselves of ATSI origin (n=22)
2 Socio-Economic Indexes for Areas (SEIFA) which is an area based indication of relative socioeconomic disadvantage developed by the Australian Bureau of Statistics (Australian Bureau of Statistics, 2013d).
3 This is the only variable where there were more than 2% in the don't know and refused categories combined. For this household income variable, 10% said that they didn’t know and 4% refused to answer the question. The don’t know category was included in the anlaysis as a separate variable. No other don’t know or refused categories were part of the analysis.

Questions used in the staged analysis Chapter 7: Description of behaviours and intentions that best describe current use/intentions and comparison to the previous twelve months, NMSS 2012

Fruit n= 1548
I already eat enough
I am not thinking about increasing
I am thinking about increasing
I am currently trying to eat more
Vegetables n=1548
I already eat enough
I am not thinking about increasing
I am thinking about increasing
I am currently trying to eat more
Cereal foods n=1541 (1 don't know)
I already eat enough
I am not thinking about increasing
I am thinking about increasing
I am currently trying to eat more
Calcium rich foods n=1532 (5 don't know 2 refuse)
I already eat enough
I am not thinking about increasing
I am thinking about increasing
I am currently trying to eat more
Fats and fatty foods n=1546 (2 don't know)
I already eat a low fat diet
I am not thinking about cutting
I am thinking about cutting down
I am currently trying to eat less fat
Losing weight n=1548
Not thinking or trying to lose
Thinking of trying to lose
Trying to lose
Cooking skill n=1548
Cook anything
Cook wide range
Cook basic
Can BBQ/boil egg
Can't cook

Fruit n=1547 (1 don't know)
Eat less
Eat about the same
Eat more
Vegetables n=1548
Eat less
Eat about the same
Eat more
Cereals n=1544 (4 don't know)
Eat less
Eat about the same
Eat more
Calcium rich foods n=1544 (4 don't know)
Eat less
Eat about the same
Eat more
Fat and fatty foods n=1546 (2 don't know)
Eat less
Eat about the same
Eat more
Weight n=1526 (22 pregnant so not asked)
Weigh less
Weigh about the same
Weigh more

The next questions were asked either as a single response answer which was the case for what would make healthy eating easier (enabler indicated by #) or as a multiple response answers to what makes it difficult to eat healthy and what are the health problems associated with eating healthy (barriers indicated by *). For the multiple response questions, no suggestions or examples were provided but prompts for more possible answers were given.

Perception and intentions in relation to dietary choices and changes, NMSS 2012

Make it easier to eat healthy (enablers) #	Difficulty in changing to better eating or controlling weight (barriers) *	Health beliefs/knowledge about foods and having excess weight. *
Cheaper healthy foods	Nothing /already eat enough *(all)*	Doesn't cause health problems *(all)*
More healthy food options in fast food outlets	No time to cook /prepare/too busy *(all)*	Cancer (unspecified) *(all)*
Knowing more ways to prepare healthy foods	Don't like / lack of interest / get bored /children don't like *(all)*	Bowel/Colon Cancer (all)
Knowing quicker ways to prepare healthy foods	Cost/too expensive *(all)*	Heart disease/heart attack/heart problems *(all)*
More information to decide which foods are healthy	Difficult to change eating habits *(control weight, fruit, vegetables, fatty foods)*	Diabetes/high blood sugar/sugar problems *(all)*
Knowing more about cooking	The effort it takes to prepare vegies to eat/ I'm not organised enough *(vegetables, cereals, fatty foods)*	Lethargy/low energy/fatigue/low stamina/tired/run down/sluggish *(all)*
My family/partner enjoyed healthy foods	Enjoy my food /food helps me get through *(control weight)*	Obesity/gaining weight/overweight *(fatty foods, excess weight, cereals)*
Ability to buy more healthy food snacks	No time to exercise /work long hours *(control weight)*	General health problems/unwell/sick/run down *(fruit & vegetables, cereals, excess weight)*
Healthy food easier to find in supermarket	Don't like exercise *(control weight)*	Constipation/poor irregular bowel movements/lack of regularity *(fruit & vegetables, cereals)*
Detailed & understandable information on food labels	Eat out regularly/have take aways *(control weight)*	Digestion problems (unspecified)/acid reflux *(fruit, cereals)*

Knowledge about recommended daily serves	Knowledge about recommendations for amount and type of fat *
Daily serves of fruit	Eat less-don't eat fatty take away foods/eat home cooked meals
Less than recommended or don't know	Use less fat/oil in cooking
More than recommended	Eat less cakes/biscuits/chocolates /nuts/potato chips/cool drinks
Correct number daily serves	Choose lean meat/trim fat from meat/remove skin from chicken
Daily serves of vegetables	Use less butter margarine on bread
Less than recommended or don't know	Avoid fatty meats (sausages, salami, bacon
More than recommended	Switch to low fat milk/cheese/yoghurt
Correct number daily serves	Use low fat cooking methods (Grill, steam, microwave, drain fat)
Daily serves of cereal foods	Eat buy more low fat foods (ie bread, cereals, fruit, vegetables, legumes)
Less than recommended or don't know	Eat less red meat/meat in general/shift to white meat
More than recommended	Eat less saturated fat/animal fats
Correct number daily serves	Choose polyunsaturated fats (polyunsaturated margarine/vegetable oils)
	Check the fat content in packaged/ precooked/processed foods
	Eat less Trans fats
	Eat mono unsat fats/olive oil
	Eat less saturated fat/animal fats
	Choose polyunsaturated fats (margarine, vegetable oils)
	Don't eat any fat/avoid all fats
	Eat low cholesterol foods
	Follow Heart Foundation recommendations
	Omega 3 fats/eat essential fats from fish

Other variables associated with food choices and weight, NMSS 2012

Responsibility for food shopping n=1548
Sole
Shared
None
Responsibility for food choice and/or preparation n=1548
Sole
Shared
None
Which of the following statements would best describe how you feel about your diet? n=1548
I pay a lot of attention to the health aspect of the food I eat to make sure diet is as healthy as possible
Take a bit of notice of the health aspect of the food I eat to make sure I have a fairly good diet
I don't really think much about the health aspect of food I eat
Body Mass Index Category based on WHO cut points[a] n=1460[b]
Not overweight (BMI less than 25)
Overweight (BMI between 25 and 29.99)
Obese (BMI 30 or more)

a BMI was estimated from self-repoted height and weight. A calculation adjusting for over-reporting of height and under-reporting of weight was applied and then the resultant BMI divided into categories based on the WHO cut points (Alison J. Hayes et al., 2008; World Health Organization, 1995)
b The 22 pregnant women were not included in the estimate and of the 1526 eligible only 1460 gave a height and weight.

Variables used in Chapter eight taken from the HWSS 2009-2013

Demographic Variables – HWSS 2009-2013
Female
Male
Age group
18-24
24-34
35-44
45-54
55-64
Highest education level attained
Tertiary
Less than tertiary
Main employment status
Employed
Unemployed
Home duties
Student
Retired
Unable to work
Annual household income
Over $60,000
$40,001-$60,000
$20,001-$40,000
Up to $20,000
Perceived spending power per pay
Can save some at least occasionally
Some left over but spend it
Just enough to get by
Not enough to get by
Aboriginal
No
Yes
Household structure
Adults living with others
Adults living alone
Country of birth
Outside Australia
Australia
SEIFA Quintiles using SLA level data 2009-2013
Quintile 5 (least disadvantaged area)
Quintiles 3,4 (less disadvantaged areas)

Health related cover and self-reported doctor diagnosed health conditions[a]
Doesn't have a health care card
Has a health care card
Has private health insurance
Doesn't have private health insurance
Doesn't have asthma
Has asthma
No cardiovascular condition
Some cardiovascular condition
Doesn't have cancer
Has cancer
No current mental health problem
A mental health problem (depression, anxiety or other)
Self-reported ratings of wellbeing and risk factors
Rating of general health - Excellent/very good/good
Rating of general health - Fair/poor
Always or often feel a lack of control over health- No
Always or often feel a lack of control over health- Yes
Rating of health compared with 12 months ago – Not any worse
Rating of health compared with 12 months ago - Somewhat/much worse
Kessler Psychological Distress Scale[b]- Low/moderate
Kessler Psychological Distress Scale - High/very high
BMI less than 30 (not in the obese range)
BMI 30 or more (in obese range)
Not currently smoking
Currently smoking
Does at least some leisure time physical activity
Does no leisure time physical activity
Spend less than four hours sitting in leisure time
Spends four or more hours sitting in leisure time
Fast food - Eats up to twice a week
Fast food - Eats three or more times a week
Doesn't use milk
Uses reduced fat or skim
Uses full fat milk
Doesn't eat any fruit
Eats less than two serves daily
Eats two or more serves daily
Doesn't eat any vegetables
Eats less than five serves daily
Eats five or more serves daily

a These health conditions were associated with running out of food
b The Kessler 10 is a measure of levels of psychological stress and the cut points used are those used by the Australian Bureau of Statistics based on recommendations from Kessler(Australian Bureau of Statistics, 2003; Kessler et al., 2002)

Table of questions used in the path analysis to running out of food in Chapter eight taken from the NMSS 1995, 1998, 2001, 2004, 2009 & 2012

Demographic Variables NMSS
Gender
Female
Male
Age group
35-64
18-34
Annual household income
Over $60,000
Up to $60,000
Employment status
In paid employment
Not in paid employment
Highest education level attained
Tertiary
Less than tertiary
Perceived discretional income[a]
Can save a lot or can save regularly
Spend what left over or save a bit occasionally
Not enough to get by or just enough to get by
Attitudes and Perceptions
Pay a lot of attention to the health aspect of food
Take a bit of notice of the health aspect of food
Don’t think about the health aspect of food
Difficulty eating fruit due to cost - No
Difficulty eating fruit due to cost - Yes
Difficulty eating vegetables due to cost - No
Difficulty eating vegetables due to cost - Yes
Easier to eat a healthy diet if food was cheaper - No
Easier to eat a healthy diet if food was cheaper - Yes

a This question was introduced in 2009 and asked only in that year and 2012

APPENDIX 3

COMPARISONS BETWEEN PREVALENCE ESTIMATES USING DIFFERENT WEIGHTING PROCEDURES

Decisions about the appropriate statistical analysis assume some knowledge of the data, the circumstances under which it was collected and the research question being investigated (Bartholomew, 2010; Edwards & Allenby, 2003). For the production of prevalence estimates describing a population, weighting methods to correct for sampling strategy and to adjust for under or over representation of population groups need to be applied (Lu & Gelman, 2002; Mokdad & Remington, 2010). SAS, SPSS and have statistical modules that offer survey based prevalence estimates incorporating such adjustments. For inferential statistics the use of weights within the survey modules preclude most post estimation tests that assess goodness of fit for the model (Archer & Lemeshow, 2006). Tests considered necessary when results are going to be used to generalise to a larger population are tests for departures from assumptions under which the statistical analysis was performed (Krasker, Kuh, & Welsch, 1983; Rabe-Hesketh & Skrondal, 2006); the effects of missing data (Heckman, 1979); whether or not the data meets the assumptions underlying the statistical analysis (Durbin, 1970), goodness of fit for models (Archer & Lemeshow, 2006) and possible treatment effects (Rosenbaum & Rubin, 1983). Raking weights were computed using Stata 13 IPF raking (StataCorp, 2013). The raking method applied a basic adjustment for the probability of selection and then used marginal proportional totals for age group and sex and for area of residence as the basic raking computation and estimates with and without post stratification are computed.

For purposes of weighting with extra socio demographic variables, the marginal proportions for the raking groups for age, sex, country of birth, aboriginality, house tenure, regions employment status and Socio Economic Indexes For Areas (SEIFA) (Australian Bureau of Statistics, 2013d) were extracted from the 2011 census data (Australian Bureau of Statistics, 2012a); the marginal proportions for education and number in household were extracted from the National Health Survey 2011-2012 (Australian Bureau of Statistics, 2013c) using Table Builder. The Census 2011 data was used to extract the marginal totals:

1. For age and sex, an age group and sex combined variable was constructed using 18-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75+ for males and females. For the NMSS using 18-24, 25-34, 35-44, 45-54, and 55-64 for male and females.

2. For country of birth four groups were able to be compared: 1) Australia 2) England, Ireland and Scotland 3) New Zealand and 4) Other countries.

3. For household tenure three groups were extracted 1) Home owned 2) Home mortgaged and 3) Rented

4. Three geographic regions were extracted; 1) metropolitan Perth, 2) the Kimberley and Pilbara regions and 3) the rest of the state.

5. For employment status three groups were extracted: 1) Employed 2) Unemployed and 3) Other

6. For SEIFA, quintiles were extracted.

The Australian Health Survey 2011-2012 data was used to extract the marginal totals:

1. For education four groups were extracted: 1) Less than year 12 2) Year 12 3) TAFE/Certificate or Diploma and 4) Tertiary

2. For number in household, six categories were extracted ranging from 1 through to six or more

Table A shows that the unweighted estimate is higher than any weighted estimate which is to be expected as, relatively speaking, the younger age groups and males were both under-represented. Previous evidence has shown that both of these groups are the less like to know or meet food consumption recommendations (Pollard, Daly, et al., 2008).

Of the three different ways of determining robust estimates, the bootstrapping method produces the smallest confidence interval with the other two methods providing almost identical confidence intervals. The results suggest that, while weighting is important to produce an estimate that is representative of a population, the method of applying that weight is less so.

Table A Comparison of the HWSS and NMSS for fruit and vegetable consumption and running out of food using different weighting procedures with estimates from the AHS where comparisons were possible

	Percent of the population (usually-HWSS) eating two serves yesterday (NMSS)				Percent of the population usually eating five serves of vegetables				Percent of the population following fruit and vegetables guidelines for daily consumption				Percent of the population who ate less/ran out of food & couldn't afford to buy more			
	HWSS		NMSS		HWSS		NMSS		HWSS		NMSS		HWSS		NMSS	
Unweighted	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI
2009	51.3	[48.4,54.2]	68.3	[65.7,70.8]	13.0	[13.1,17.0]	15.0	[13.1,17.0]	9.0	[7.6,10.9]	11.6	[10,13.5]	4.2	[3.2,5.5]	4.0	[3.0,5.1]
2012	49.8	[45.8,53.7]	67.3	[65.0,69.7]	10.9	[10.8,14.0]	12.4	[10.8,14.0]	7.0	[5.3,9.4]	9.6	[8.3,11.2]	2.1	[1.2,3.6]	4.6	[3.3,6.0]
Age, sex and area standardised to 2011 ERP																
2009	49.8	[46.0,53.6]	66.2	[62.5,69.6]	11.0	[8.4,14.3]	12.4	[10.2,14.9]	7.5	[5.8,9.6]	9.6	[7.9,11.6]	3.8	[2.6,5.6]	3.9	[2.7,5.6]
2012	49.0	[41.7,56.5]	61.8	[58.1,65.5]	10.0	[5.9,16.6]	12.2	[9.6,15.4]	3.5	[2.4,5.1]	9.2	[7.2,11.8]	1.7	[0.8,3.4]	3.2	[1.9,5.2]
Weighted for probability of selection and post estimation adjusted to age, sex and area using 2011 ERP																
2009	48.8	[44.7,52.9]	65.5	[61.9,69.0]	10.2	[8.1,12.9]	12.6	[10.6,15.0]	7.1	[5.4,9.4]	9.1	[7.5,11.0]	3.8	[2.5,5.5]	3.8	[2.6,5.7]
2012	50.6	[45.0,56.2]	63.1	[59.7,66.4]	7.8	[5.6,10.7]	11.3	[9.3,13.6]	4.4	[3.0,6.4]	8.9	[7.1,11.0]	2.1	[1.0,4.3]	3.3	[2.2,5.0]
Robust Bootstrap SE																
2009	48.8	[45.0,52.6]	65.5	[62.1,68.7]	10.2	[8.3,12.5]	12.6	[10.7,14.9]	7.1	[5.6,9.1]	9.1	[7.5,11.0]	3.8	[2.5,5.6]	3.8	[2.6,5.6]
2012	50.6	[45.4,55.9]	63.1	[60.0,66.2]	7.8	[5.6,10.6]	11.3	[9.4,13.5]	4.4	[3.1,6.3]	8.9	[7.2,10.8]	2.1	[0.9,4.6]	3.3	[2.1,5.1]
Robust Jacknife SE																
2009	48.8	[44.6,53.0]	65.5	[61.8,69.1]	10.2	[8.1,12.9]	12.6	[10.5,15.1]	7.1	[5.4,9.4]	9.1	[7.5,11.0]	3.8	[2.5,5.7]	3.8	[2.6,5.7]
2012	50.6	[44.7,56.5]	63.1	[59.6,66.5]	7.8	[5.5,10.8]	11.3	[9.3,13.6]	4.4	[3.0,6.5]	8.9	[7.1,11.0]	2.1	[1.0,4.3]	3.3	3.3
Raked using Jacknife estimates of SE																
2009	49.2	[45.5,52.8]	67.0	[64.2,69.7]	10.8	[8.8,13.3]	12.7	[10.7,15.0]	7.8	[6.0,10.0]	9.3	[7.5,11.3]	2.9	[1.8,4.4]	4.3	[3.4,5.6]
2012	51.1	[46.0,56.1]	62.8	[60.1,65.4]	7.8	[5.5,11.0]	12.2	[10.6,14.1]	4.3	[2.5,7.2]	9.1	[7.6,10.8]	2.0	[0.9,4.8]	3.9	[2.8,5.3]
ABS Health Survey 2011-2012			**46.3**				**12.3**				**9.5**					
ABS Health Survey Nutrition and Physical Activity 2011-2012			**54.6**				**7.3**				**8.9**					**4.1**

Table B shows the estimates produced when only one extra characteristic is added to the basic age, sex and area weighting. The estimates range from 2.64 to 2.80 with the biggest difference in estimates made by adding the number in the household (2.77). However, there were no significant differences between any of the estimates.

These results suggest that the estimates are robust with weighting for probability of selection and adjusting to marginal totals for age and sex using IPF or by adjusting using post estimation weighting.

Table C shows the effects of IPF raking on derived estimates for the mean number of daily serves of food eaten which represent the five good groups, fluids and additional/discretional foods.

Table B Estimates of mean serves of vegetables usually eaten assessing the impact of each additional raking characteristic, HWSS 2003-2012

	No weight	Raking weight using only age, sex and area	Raking weight using age, sex, area and aboriginality	Raking weight using age, sex, area and employment status	Raking weight using age, sex, area and SEIFA	Raking weight using age, sex, area and education	Raking weight using age, sex, area and household status	Raking weight using age, sex, area and number in household
2003	3.21 (3.17,3.25)	3.06 (3.00,3.12)	3.06 (3.00,3.12)	3.01 (2.93,3.08)	3.05 (2.99,3.11)	3.06 (3.00,3.12)	2.96 (2.87,3.04)	3.05 (2.99,3.11)
2004	3.13 (3.09,3.17)	2.99 (2.93,3.04)	2.98 (2.92,3.04)	2.96 (2.88,3.04)	2.99 (2.93,3.05)	2.98 (2.92,3.05)	2.95 (2.87,3.04)	2.97 (2.91,3.03)
2005	3.06 (3.02,3.1)	3.00 (2.93,3.06)	2.99 (2.93,3.06)	2.94 (2.85,3.03)	2.98 (2.92,3.05)	2.99 (2.93,3.06)	2.90 (2.81,3.00)	2.97 (2.91,3.04)
2006	2.90 (2.86,2.93)	2.80 (2.75,2.85)	2.80 (2.74,2.85)	2.81 (2.74,2.88)	2.78 (2.72,2.83)	2.80 (2.74,2.85)	2.76 (2.69,2.84)	2.79 (2.73,2.84)
2007	2.83 (2.8,2.86)	2.70 (2.66,2.74)	2.69 (2.65,2.73)	2.71 (2.65,2.76)	2.69 (2.65,2.73)	2.70 (2.65,2.74)	2.66 (2.60,2.72)	2.67 (2.63,2.71)
2008	2.92 (2.89,2.96)	2.82 (2.77,2.87)	2.82 (2.77,2.87)	2.83 (2.76,2.89)	2.81 (2.76,2.86)	2.82 (2.77,2.87)	2.79 (2.72,2.86)	2.81 (2.76,2.86)
2009	2.84 (2.81,2.88)	2.73 (2.68,2.78)	2.72 (2.67,2.77)	2.77 (2.71,2.84)	2.71 (2.66,2.77)	2.73 (2.68,2.78)	2.69 (2.60,2.78)	2.68 (2.63,2.74)
2010	2.80 (2.77,2.84)	2.69 (2.64,2.74)	2.68 (2.63,2.73)	2.77 (2.70,2.84)	2.68 (2.63,2.73)	2.69 (2.63,2.74)	2.69 (2.62,2.77)	2.64 (2.58,2.69)

Table C The effect of using IPF raking on the mean number of serves for food groups, NMSS 2012

Serves used in the calculation of the healthful food indicator	Unweighted	IPF raking with age, sex and area
	Mean (95% CI)	Mean (95% CI)
Serves of fruit eaten yesterday	2.09 (2.02,2.17)	1.96 (1.87,2.05)
Serves of vegetables usually eaten	2.76 (2.68,2.83)	2.72 (2.62,2.82)
Serves of cereal foods eaten yesterday[1]	4.27 (4.08,4.47)	4.61 (4.34,4.88)
Serves of dairy foods eaten yesterday[2]	2.52 (2.43,2.62)	2.64 (2.48,2.80)
Serves of meat or fish eaten yesterday[3]	1.30 (1.23,1.37)	1.41 (1.25,1.58)
Cups of fluids consumed yesterday[4]	6.00 (5.87,6.14)	6.41 (6.23,6.60)
Serves of additional foods consumed yesterday	4.74 (4.52,4.95)	4.47 (4.19,4.74)

1 Cereal foods includes all types of breads, pasta, rice and breakfast cereal foods.
2 Daily foods include milk, yoghurt and cheese
3 Only 698 of the sample reported eating any meat or fish the previous day, this estimate is for those who did eat some.
4 Cups are 250 ml size and include any fluids consumed the previous day.

The HWSS and NMSS surveys are biased in favour of older age groups and females and the unweighted estimates in Table C reflect that bias. The lower means for the weighted estimates for vegetables and fruit are produced when the data are adjusted for the probability of selection and for the under-representation of males and younger people and are therefore more representative of the whole population. In terms of the serves, the weighted estimates suggest that fruit, vegetables and additional food serves are less likely to be consumed by males and by younger people whereas cereals, dairy foods, meat or fish and fluids are more likely to be consumed by these groups.

APPENDIX 4

MEANS OF THE DIFFICULTIES AND HEALTH PROBLEMS ASSOCIATED WITH THE RECOMMENDED HEALTHY EATING INDICATOR (RF_HEI) AND THE DISCRETIONARY HEALTHY EATING INDICATOR (DF_HEI)

Mean scores for RF_HEI and DF_HEI by the NMSS 2012 barriers to increasing consumption of fruit

Difficulties increasing fruit consumption*	RF_HEI Mean (95% CI)	*p**	DF_HEI Mean (95% CI)	*p**
There are no barriers	48.48[47.12,49.83]	<0.0001	17.83[17.02,18.64]	ns
Don't really like fruit/lack of interest	40.36[36.76,43.95]	<0.0001	17.27[15.41,19.14]	ns
Cost/ fruit too expensive	44.07[41.35,46.78]	ns	16.73[15.00,18.46]	ns
Difficulty in changing eating habits	42.21[38.86,45.55]	0.016	18.23[16.03,20.42]	ns
Too busy/ no time to buy/no time to prepare	45.12[40.72,49.52]	ns	16.21[14.50,17.92]	0.020
Hard to find good quality fruit	42.55[39.36,45.74]	0.006	17.58[15.89,19.27]	ns
Not enough variety/fruits too seasonal	43.40[40.57,46.23]	0.037	18.22[16.67,19.78]	ns
Doesn't appeal in cold weather	42.19[36.80,47.58]	ns	17.47[13.90,21.04]	ns
Health problems	43.82[38.08,49.56]	ns	16.23[13.49,18.98]	ns
Access to fruit difficult	55.20[51.12,59.29]	0.048	21.36[14.30,28.41]	ns

Mean scores for RF_HEI and DF_HEI by the NMSS 2012 barriers to increasing consumption of vegetables

Difficulties increasing vegetable consumption*	RF_HEI Mean (95% CI)	*p**	DF_HEI Mean (95% CI)	*p**
There are no barriers	46.92[45.73,48.11]	<0.001	18.11[17.40,18.83]	0.023
Don't really like vegetables/lack of interest	34.43[30.27,38.59]	<0.0001	14.87[12.69,17.05]	<0.001
Cost/ vegetables too expensive	47.91[44.56,51.25]	ns	19.24[17.15,21.34]	ns
Difficulty in changing eating habits	37.97[32.71,43.23]	<0.0001	17.97[14.08,21.86]	ns
Too busy/ no time to buy/no time to prepare	47.64[44.77,50.52]	ns	17.88[16.34,19.42]	0.020
The effort it takes to prepare them/not organised	43.25[39.53,46.98]	ns	18.69[16.12,21.26]	ns
Hard to find good quality vegetables	47.33[44.06,50.61]	ns	17.99[16.18,19.79]	ns
Not enough variety/vegetables too seasonal	45.17[40.76,49.59]	ns	15.63[13.04,18.21]	0.018
Health problems	36.75[13.14,60.35]	ns	14.11[5.01,23.20]	ns
Access to vegetables difficult	47.62[39.02,56.22]	ns	23.14[18.34,27.94]	0.015

* Compared with not saying this as a barrier

Mean scores for RF_HEI and DF_HEI by the NMSS 2012 barriers to increasing consumption of cereal foods

Difficulties increasing cereal food consumption	RF_HEI Mean (95% CI)	p*	DF_HEI Mean (95% CI)	p*
There are no barriers	47.4[46.23,48.56]	<0.0001	17.68[16.99,18.36]	ns
Don't really like vegetables/lack of interest	42.93[39.60,46.26]	0.007	18.45[16.99,19.91]	ns
Cost/ vegetables too expensive	37.67[32.02,43.33]	0.002	14.27[11.09,17.46]	0.025
I don't like eating in the morning/don't eat breakfast	43.09[38.85,47.33]	ns	18.68[16.50,20.85]	ns
The time it takes to prepare	41.23[37.26,45.20]	0.003	17.68[15.27,20.09]	ns
The effort it takes to prepare them/not organised	43.59[33.42,53.76]	ns	15.24[12.43,18.05]	ns
Don't have time for breakfast	45.23[38.68,51.79]	ns	16.10[13.10,19.09]	ns
Cereal sugars and possible weight gain	45.65[40.29,51.01]	ns	18.89[14.80,22.98]	ns
Health problems	42.55[36.39,48.72]	ns	18.17[13.97,22.36]	ns

Mean scores for RF_HEI and DF_HEI by the NMSS 2012 barriers to decreasing consumption of fat and fatty foods

Difficulties decreasing consumption of fat/fatty foods*	RF_HEI Mean (95% CI)	*p**	DF_HEI Mean (95% CI)	*p**
There are no barriers	46.97[45.57,48.37]	0.016	17.86[16.97,18.76]	ns
Person buying/preparing buys/uses fat/fatty foods	44.9[39.87,49.92]	0.007	17.54[15.59,19.49]	ns
Fat/fatty food is tempting/enjoyable	44.94[42.91,46.98]	ns	16.82[15.57,18.08]	0.040
Difficult to change eating habits/families habits	42.86[39.34,46.39]	0.020	17.57[15.52,19.62]	ns
The time it takes to prepare/shop for low fat foods	40.92[37.52,44.31]	<0.0001	17.66[16.06,19.25]	ns
The effort it takes to prepare them/not organised	38.39[34.01,42.77]	<0.0001	16.38[13.67,19.1]	ns
Low fat foods not readily available	46.97[43.12,50.82]	ns	17.74[15.92,19.57]	ns
I eat out/ have takeaways a lot	45.76[42.42,49.1]	ns	17.88[16.1,19.65]	ns

* Compared with not saying this as a barrier

Mean scores for RF_HEI and DF_HEI by the NMSS 2012 barriers to losing excess weight

Difficulties losing weight*	RF_HEI Mean (95% CI)	*p**	DF_HEI Mean (95% CI)	*p**
There are no barriers	45.82[44.01,47.63]	ns	17.16[16.18,18.14]	ns
Enjoy food/food helps me get through	45.29[43.16,47.42]	ns	18.70[17.40,20.00]	0.050
Difficult to change eating habits	45.72[42.78,48.66]	ns	17.07[15.60,18.54]	ns
Don't like exercise	41.60[37.36,45.83]	0.048	17.21[14.16,20.26]	ns
No time to exercise/work long hours	47.03[44.79,49.27]	ns	17.57[16.35,18.78]	ns
Eat out regularly/have take away	45.72[39.93,51.5]	ns	18.05[15.02,21.08]	ns
No will power to eat better	42.7[38.74,46.67]	ns	21.65[19.14,24.16]	<.001
No will power to exercise	43.55[39.79,47.31]	ns	18.53[16.14,20.91]	ns
Shift work/work long hours/work commitments	44.3[40.47,48.13]	ns	18.05[16.04,20.05]	ns
I don't like exercise	45.24[40.11,50.37]	ns	16.96[14.45,19.47]	ns
I like fattening food/have a sweet tooth	47.83[43.57,52.08]	ns	17.39[14.66,20.12]	ns
Medical problems	43.97[40.42,47.52]	ns	18.50[16.58,20.43]	ns
Like alcohol/beer/wine	44.47[40.84,48.10]	ns	17.67[17.10,18.24]	ns
No time to shop for healthy food	40.32[29.47,51.16]	ns	17.73[17.16,18.29]	0.051
No time to cook	37.98[31.68,44.29]	0.017	17.72[17.16,18.29]	ns
Eat what given	48.46[38.95,57.98]	ns	17.65[17.08,18.22]	ns

* Compared with not saying this as a barrier

Mean scores for RF_HEI and DF_HEI by the NMSS 2012 health problems associated with not eating enough fruit and vegetables

Not enough fruit and vegetables*	RF_HEI Mean (95% CI)	*p**	DF_HEI Mean (95% CI)	*p**
None	36.84 (32.11,41.56)	<0.001	22.01 (18.97,25.05)	0.000
Bowel or colon cancer	48.45 (45.89,51.01)	0.004	17.46 (16.07,18.85)	ns
Heart disease/problems/attack	46.94 (44.19,49.69)	ns	17.83 (16.54,19.11)	ns
Constipation	46.82 (44.30,49.34)	ns	17.39 (16.17,18.61)	ns
Digestive problems/Reflux	49.17 (46.10,52.25)	0.003	17.23 (15.52,18.94)	ns
Intestinal problems/bowel problems	46.55 (41.62,51.49)	ns	16.44 (14.05,18.83)	ns
Skin problems/acne	47.76 (44.55,50.97)	ns	18.02 (15.93,20.11)	ns
Scurvy/rickets/beriberi	48.21 (45.17,51.25)	ns	17.07 (15.25,18.89)	ns
Weight gain/obesity	48.70 (45.83,51.57)	0.020	17.21 (15.69,18.73)	ns
Vitamin and mineral deficiencies	45.69 (44.04,47.34)	ns	17.55 (16.56,18.54)	ns
Poor immunity/resistance to colds	49.13 (46.72,51.54)	<0.001	16.85 (15.57,18.12)	ns
Iron deficiency	46.44 (43.49,49.38)	ns	18.59 (16.80,20.38)	ns
Lack of fibre	46.57 (37.93,55.21)	ns	16.23 (11.88,20.57)	ns
Tired/no energy/sluggish	44.97 (41.03,48.91)	ns	15.59 (13.95,17.23)	ns
General health problems/feeling unwell	46.17 (42.94,49.40)	ns	16.40 (14.49,18.31)	ns
Cancer	49.83 (46.69,52.96)	0.030	15.94 (13.44,18.45)	ns
Diabetes	46.07 (42.67,49.46)	ns	17.35 (15.33,19.36)	ns

* Compared with not saying this as a health problem

Mean scores for RF_HEI and DF_HEI by the NMSS 2012 health problems associated with not eating enough cereal foods

Not enough cereal foods*	RF_HEI Mean (95% CI)	*p**	DF_HEI Mean (95% CI)	*p**
None	42.78 (40.33,45.23)	0.001	18.53 (16.90,20.16)	ns
Bowel or colon cancer	47.02 (44.33,49.70)	ns	17.88 (16.56,19.20)	ns
Heart disease/problems/attack	48.91 (44.36,53.45)	ns	16.28 (13.45,19.12)	ns
Constipation	46.49 (44.47,48.52)	ns	17.8 0(16.65,18.96)	ns
Digestive problems/Reflux	46.24 (43.37,49.11)	ns	17.55 (15.95,19.15)	ns
Intestinal problems/bowel problems	49.94 (47.15,52.73)	0.000	18.82 (17.09,20.56)	ns
Weight gain/obesity	46.18 (40.64,51.72)	ns	17.29 (14.49,20.09)	ns
Vitamin and mineral deficiencies	47.10 (42.81,51.38)	ns	17.03 (15.16,18.89)	ns
Lack of fibre	48.65 (45.93,51.37)	0.001	18.34 (16.85,19.84)	ns
Tired/no energy/sluggish	48.74 (46.01,51.48)	0.001	17.35 (16.01,18.70)	ns
General health problems/feeling unwell	48.61 (44.84,52.38)	ns	17.59 (15.37,19.81)	ns
Cancer	49.76 (43.81,55.72)	ns	15.56 (11.49,19.62)	ns
Diabetes	50.21 (45.56,54.85)	ns	16.09 (12.31,19.87)	ns

* Compared with not saying this as a health problem

Mean scores for RF_HEI and DF_HEI by the NMSS 2012 health problems associated with too much fat/fatty foods

Too much fat/fatty foods*	FR_HEI Mean (95% CI)	*p**	DF_HEI Mean (95% CI)	*p**
None	34.19 (24.11,44.27)	0.023	17.96 (7.83,28.09)	ns
Bowel or colon cancer	52.49 (46.49,58.49)	0.040	19.21 (15.7,22.71)	ns
Cancer unspecified	49.59 (47.17,52.00)	0.005	18.45 (16.64,20.25)	ns
Circulation problems unspecified	47.12 (43.46,50.78)	ns	17.09 (15.14,19.05)	ns
Stroke	49.37 (46.17,52.58)	0.008	19.05 (17.33,20.78)	0.076
Heart disease/problems/attack	46.09 (44.92,47.26)	ns	17.8 (17.18,18.41)	ns
Hardening of the arteries/atherosclerosis	43.9 (40.71,47.10)	ns	16.55 (14.74,18.37)	ns
High blood pressure	48.49 (46.53,50.45)	0.001	17.56 (16.39,18.73)	ns
High cholesterol	46.08 (44.21,47.95)	ns	17.69 (16.71,18.66)	ns
Diabetes	47.46 (46.07,48.84)	0.000	17.4 (16.55,18.24)	ns
Weight gain/obesity	46.21 (44.55,47.88)	<0.001	17.22 (16.34,18.09)	ns
Tired/no energy/sluggish	45.09 (41.85,48.32)	ns	17.46 (15.45,19.46)	ns
Feeling unfit	45.25 (41.39,49.12)	ns	17.51 (15.35,19.66)	ns

* Compared with not saying this as a health problem

Mean scores for RF_HEI and DF_HEI by the NMSS 2012 health problems associated with excess weight

Excess weight*	**RF_HEI Mean (95% CI)**	***p****	**DF_HEI Mean (95% CI)**	***p****
None	41.77 (31.57,51.98)	ns	15.32 (7.78,22.86)	ns
Circulation problems unspecified	44.73 (41.47,47.99)	ns	17.41 (15.76,19.06)	ns
Heart disease/problems/attack	45.99 (44.85,47.14)	ns	17.87 (17.24,18.51)	ns
High blood pressure	48.83 (47.07,50.59)	<0.001	17.88 (16.87,18.88)	ns
Respiratory/breathing problems	45.83 (43.04,48.62)	ns	18.01 (16.58,19.43)	ns
Joint/knee problems	47.57 (45.50,49.63)	0.016	18.43 (17.23,19.63)	ns
Back problems	48.29 (44.43,52.15)	ns	19.32 (17.29,21.34)	0.033
Strain on muscoskeletal frame/immobility	45.16 (42.56,47.76)	ns	18.08 (16.42,19.74)	ns
High cholesterol	45.47 (43.16,47.79)	ns	19.10 (17.87,20.33)	0.004
Weight gain/obesity	47.39 (45.42,49.36)	0.013	17.42 (16.43,18.40)	ns
Depression/low self esteem	48.85 (45.67,52.02)	0.001	18.10 (16.40,19.80)	ns
Tired/no energy/sluggish	46.32 (43.90,48.73)	ns	17.59 (16.29,18.89)	ns
Feeling unfit	45.77 (41.62,49.91)	ns	16.46 (14.52,18.41)	ns
General health problems/feeling unwell	49.73 (47.31,52.15)	0.000	15.76 (13.95,17.57)	0.003
Cancer	47.95 (44.00,51.91)	ns	18.00 (15.44,20.56)	ns
Bowel cancer	56.57 (52.07,61.08)	0.000	18.81 (14.78,22.85)	ns
Diabetes	46.70 (45.22,48.18)	ns	17.56 (16.62,18.51)	ns

* Compared with not saying this as a health problem

APPENDIX 5

COMPARISONS OF PREVALENCE ESTIMATES FOR THE AUSTRALIAN HEALTH SURVEY (AHS) WITH THE WA HEALTH AND WELLBEING SURVEILLANCE SYSTEM (HWSS)

Table B Comparison of the results from one of the questions of the AHS with the HWSS of the consumption of fruit and vegetables by females and age groups, AHS and HWSS 2011

	18-24		25–34		35–44		45–54		55–64		65+		18 years +	
	ABS	HWSS	ABS	HWSS	ABS	HWSS	ABS	HWSS	ABS	HWSS	ABS	HWSS	ABS	HWSS
Females														
Usual daily intake of fruit														
Does not eat fruit/Less than 1 serve	18.1	14.7	14.8	16.5	13.1	13.9	12.3	18.8	12.3	10.4	10.1	11.9	13.3	14.5
1 serve	43.0	43.5	37.8	38.1	37.1	36.9	35.8	31.1	27.7	26.8	23.6	25.0	34.1	33.4
2 serves	21.3	26.7	27.4	30.0	31.9	36.7	**25.2**	**36.5**	**35.3**	**41.3**	41.7	38.6	30.6	35.1
3 serves	8.3	13.5	16.3	11.5	14.3	10.6	17.8	11.5	18.8	14.8	18.4	18.6	15.9	13.3
4 serves	np	1.6	1.5	3.6	2.7	1.1	**7.3**	**1.1**	np	4.5	3.9	4.0	4.3	2.6
5 or more serves	np	0.0	2.2	0.4	1.0	0.7	1.5	1.0	np	2.4	2.4	1.9	1.8	1.0
2 or more serves (met guideline)	*38.9*	41.8	*47.4*	45.4	*49.8*	49.2	*51.9*	50.1	*60.1*	62.8	*66.3*	63.1	*52.5*	52.1
Total(a)	100.0		100.0		100.0		100.0		100.0		100.0		100.0	
Usual daily intake of vegetables														
Does not eat vegetables/Less than 1 serve	np	5.5	2.6	2.7	2.7	2.9	2.4	4.3	np	2.6	4.1	3.3	2.9	3.5
1 serve	28.8	22.6	**22.1**	**11.1**	16.8	9.8	18.7	11.2	16.7	9.0	16.8	10.3	**19.7**	**11.9**
2 serves	30.5	32.0	27.8	21.2	33.6	28.2	28.5	23.6	30.6	24.0	26.9	21.8	29.6	24.9
3 serves	22.4	20.7	27.6	30.9	23.8	29.7	30.2	27.3	25.7	26.8	23.5	26.2	25.7	27.3
4 serves	np	12.1	10.6	21.1	10.1	15.4	14.4	19.5	np	23.6	15.7	21.8	12.2	19.1
5 or more serves (met guideline)	np	7.1	9.2	12.9	13.0	14.1	**5.8**	**13.9**	np	13.9	13.0	16.5	9.9	13.3
Total(b)(c)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Dietary guidelines(d)(e)														
Adequate fruit and vegetable consumption	**4.8	*5.0*	*5.3	*8.8*	*8.1	*9.6*	***3.4**	***9.0***	11.1	*11.1*	9.2	*12.8*	6.9	*9.5*
Inadequate fruit and/or vegetable consumption	95.2	95.0	94.7	91.2	91.9	90.4	96.6	91.0	88.9	88.9	90.8	87.2	93.1	90.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Dietary guidelines(d)€ 2013		5.0		8.8		9.1		9.0		10.4		12.8		9.3
Adequate fruit and vegetable consumption		95.0		91.2		90.9		91.0		89.6		87.2		90.7
Inadequate fruit and/or vegetable consumption														
Total														

Table C Comparison of the AHS with the HWSS prevalence for four estimates common to both, AHS 2011 and HWSS 2011

	AHS 2011		HWSS, 2011	
Adults aged 18 years and over	%	95% CI	%	95% CI
Percent of population eating two serves of fruit yesterday	49.4	[46.7-52.1]	48.9	[47.9-49.9]
Percent of population usually eating five serves of vegetables daily	8.7	[7.5-9.9]	10.9	[9.7-12.1]
Percent of the population who met the 2003 Dietary Guidelines* for the consumption of fruit and vegetables	6.1	[5.0-7.2]	7.9	[6.9-8.9]
Percent of population who In last 12 months who ate less because they couldn't afford food	4.1	[3.6-4.6]	3.5	[2.7-4.4]

*The 2003 guidelines were used as these were in effect when the NHS and HWSS 2011 were conducted. The updated 2013 guidelines recommend slightly more serves of vegetables for young men and pregnant women compared with the 2003 guidelines .

APPENDIX 5

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