Too Disadvantaged to be Thin?

Socioeconomic Patterning of Obesity in an Australian National Cohort and the Interaction of Indigeneity

Billy Bragg

THESIS

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DECLARATION

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

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ABSTRACT

Obesity is one of the most pressing public health issues facing contemporary Australia. Its upsurging prevalence has reached epidemic proportions, and due to its deleterious effect on health outcomes, obesity is imposing increasingly immense social and economic costs on collective society year after year. Furthermore, obesity is associated with an additional public health predicament in Australia - the sparse differential or 'gap' in overall health and life expectancy present between the indigenous and non-indigenous populations, with the incidence of obesity being much higher among the indigenous population relative to the non-indigenous population.

This study sought to enhance the understanding of the environmental aetiology of obesity and contribute to the extant literature and existing scholarly knowledge by uncovering the socioeconomic, demographical and behavioural patterning of obesity in an Australian national cohort, and assess whether any of such variables impose a greater effect on obesity for the indigenous sample.

Multivariate logistic regression techniques were employed to collectively analyse a multitude of variables which were highlighted by the pre-existing literature to pertain to obesity. Interaction terms were then included for the variable of Indigeneity to highlight any factors for which the effect on the odds of being obese statistically differed with indigenous status.

It was found that the variables which each had a statistically significant positive association with the odds of being obese were age (1.35%, 0.000), being indigenous (80.29%, 0.000), being married (13.65%, 0.009), having children under 14 (11.76%, 0.031), being a current smoker (13.53%, 0.039) or an ex-smoker (30.15%, 0.000), occasional alcohol consumption (25.14%, 0.001), and being in paid employment (15.95%, 0.007). Conversely, a negative relationship with the odds of being obese was found for the variables of being physically active three or more times per week (43.2%, 0.000), consuming alcohol 1-2 times per week (19.3%, 0.006) and more than 2 times per week (18.6%, 0.002), having a university education (20.4%), having a mother who completed year 12 (18.0%, 0.001) , having a father who completed year 12 (13.3%, 0.017), and residing in an area rated in the middle (24.3%, 0.000) and upper tiers (41.0%, 0.000) of the SEIFA education and occupation index. While the variables of gender, year 12 and certificate/diploma education, household income, residence outside a major city, and SEIFA economic resources index rating of the area of residence were each not found to associate with the odds of being obese. The variables of mother completing year 12 and SEIFA economic resources index rating of the area of residence were found to

statistically interact with Indigeneity, with these two factors reducing the odds of being obese by a greater magnitude for indigenous people compared to non-indigenous people (52.2%, 0.029 versus 18.3%, 0.003 and 62.0%, 0.046 versus no statistical relation, respectively).

These results underscore the role of individual-level intermediary environmental variables as conduits for obesity prevalence in Australia, and highlight that some variables may impose a greater impact on the indigenous population. Such findings hold important information for the development of targeted resource-efficient public health policy, not only for the general population, but for 'close the gap' indigenous focussed campaigns as well.

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1 INTRODUCTION

Over the course of history, the human race has been subject to a diverse and dynamic range of threats to the health and wellbeing of the population. A case example of this is the epidemiological transitions in the causes of death that occurred between 1900 and 2010 for the United States population. A study by Jones, Podolsky, and Greene (2010) showcased that in the year 1900, tuberculosis and influenza were the two leading causes of death, together causing 36% of population deaths that year. Due largely to advances in modern medicine, by the year 2010, these conditions had become more of a hiccup in health than a genuine threat to life, making up a relatively low 2.7% of the total death rate. For 2010, it was non-communicable chronic conditions that had come to the fore, with the two leading causes of death in the USA in 2010 being heart disease and cancer, collectively causing 63% of population deaths that year, compared to 18.3% in 1900. One of the primary reasons for this markedly increased incidence of heart disease and cancer is the upsurge in prevalence of overweight and, in particular, obesity, that has occurred in recent decades (Flegal, Carroll, Kuczmarski & Johnson, 1998; Hubert, Feinleib, McNamara, & Castelli, 1983; Carroll, 1998).

Obesity is defined by the World Health Organisation as abnormal or excessive body fat accumulation that may impair health (WHO, 2006), and is most commonly classified as having a Body Mass Index (calculated as mass in kilograms divided by the square of height in metres) of greater than 30 kg/m^2, while a having Body Mass Index of more than 25 kg/m^2 is deemed as being overweight (U.S. Preventative Services Task Force, 2003). Body mass index as a measure of health risk is imperfect, as it fails to differentiate between fat mass and muscle mass. So for example, very muscular persons will have a high BMI and may be classed as overweight or obese, but be carrying low amounts of body fat and actually be relatively healthy. For the general population though, BMI is a good gauge of body fat accumulation. Research shows that BMI is strongly correlated with the gold-standard methods of measuring body fat across age, gender and ethnic groups (Gallagher et al. 1996). Due to this, and its simplicity in measurement and calculation, BMI is the standard method of body weight classification employed by clinicians and throughout the literature (Harvard School of Public Health, 2014).

Overweight and obesity is a pressing public health concern. It has been calculated that from 1980 to 2013, the global proportion of overweight adults rose from approximately 29% to 36%. Included in this statistic is the global obesity rate, which has almost doubled in the same time frame from 6% to 11%, meaning that in 2013 over 1.5 billion adults were overweight or obese globally (Ng et al. 2014).

These prevalence rates are set to only increase, with projections indicating that if current secular trends continue unabated, global overweight and obesity prevalence will rise to 38% and 20% respectively by the year 2030 (Kelly et al. 2008). For the case of Australia specifically, statistics show that 54% of the adult population is overweight, with more than 18% of this 54% being obese (Australian Bureau of Statistics, 2005). The obesity prevalence and corresponding health crisis is not only an issue for the developed or 'rich' world, but also for developing nations, even as these countries continue to struggle with malnutrition, which has resulted in a dual burden of disease (Caballero, 2005). Of the 188 countries analysed in one study, every single nation had exhibited increasing rates of overweight and obesity since 1980 (Ng et al. 2014). Overall, 65% of the global population reside in a nation where overweight and obesity kills more people than malnutrition (World Health Organisation, 2009). This is chiefly because being overweight or obese is a predisposing factor for two of the leading causes of death worldwide; both heart disease (Hubert, Feinleib, McNamara & Castelli, 1983) and certain cancers (Carroll, 1998). It is also a risk factor for mortality and/or morbidity from many other health ailments, including diabetes, hypertension (high blood pressure), dyslipidemia (such as high cholesterol), stroke, gallbladder disease, osteoarthritis, sleep apnoea, respiratory conditions such as asthma, as well as mental health issues stemming from social stigmatization and discrimination (National Institutes of Health, 1998; Mokdad et al. 2003). Given the increasingly high prevalence of overweight and obesity, and the deleterious impacts on population health that this entails, it is one of the most pressing public health concerns of today. So immense is the issue of overweight and obesity that in 1997 the World Health Organisation declared it a global health epidemic.

The exact impacts that the high prevalence of overweight and obesity has on society is difficult to quantify, but numerous attempts to calculate the grim scenario have been made. Given that obesity is a risk factor for the development of various chronic health conditions, an increased rate of obesity results in a greater incidence of disease, which in addition to the social toll incurred by individuals and their friends and families, an economic cost is also imposed through the drain on medical resources. Indeed, in 2010 the United States Congressional Budget Office reported that nearly 20 percent of the increase in national health care spending in real terms between 1987 and 2007 was due to overweight and obesity (Congressional Budget Office, 2010). Studies show that overweight and obese persons accrue on average a 41.5% greater medical bill per capita than persons of a healthy weight (Finkelstein, Trogdon, Cohen, & Dietz, 2009). Another study conducted in the United States, which is a population on which a plethora of obesity related research has been conducted, calculated that overweight and obesity raises annual national medical costs by $2741 (in 2005 US dollars) for each overweight or obese person (Cawley & Meyerhoefer, 2012). This translates to a calculated annual health care bill of $190.2 billion being directly attributable to overweight and obesity, nearly 21% of annual health spending in the United States. Looking ahead, it has been estimated that if overweight and obesity trends continue unabated, the corresponding healthcare costs would double each decade for the United States to approximately $800 billion US dollars by 2030 (Wang, Beydoun, Liang, Caballero, Kumanyika, 2008). For Australia, it is estimated that the direct medical cost of overweight and obesity is $21 billion annually, more than half of which is attributed to obesity alone (Colagiuri et al. 2010). This equates to 15% of annual health expenditure. In addition to the significant direct medical costs of overweight and obesity are the indirect costs.

The indirect costs of overweight and obesity specifically relate to reduced economic productivity and output due to absenteeism, presenteeism (on-the-job productivity losses), and premature death. Studies have shown that compared to healthy counterparts overweight workers exhibit 1.74 times greater absenteeism from the workplace due to illness (Tucker & Friedman, 1998), are 12% less productive while at work (Goetzel et al. 2010), and have a lower life expectancy (Berrington et al. 2010), all of which have a negative economic impact on society. In the case of Australia, the annual indirect costs of overweight and obesity are $35.6 billion, which in addition to the direct medical expenses results in an estimated overall total annual cost of $56.6 billion (Colagiuri et al. 2010). A major economic issue with this is that generally, these negative externalities of obesity are largely paid for by governments, insurance companies, or firms, not the overweight or obese individuals themselves. Thus, obesity is a case of market failure, where by the actions of one portion of society has created the negative externalities of obesity, which are imposed upon and paid for by collective society (tax payers) or third parties (firms) largely without compensation.

To curb the upsurge in overweight and obesity rates and the resultant social and economic burden, strategic government policies focussed on both management and prevention need to be developed and implemented. In order to develop effective policy though, the causes of the issue must first be known and understood. A challenge to this mission is that obesity is a multifaceted and complex issue with many underlying causes. Excess fat accumulation and, in turn, becoming overweight and obese, stems directly from caloric intake consistently exceeding energy expenditure over time. Unlike a problem such as smoking though, which is another major contemporary public health issue, one single product is not to blame, so policy makers cannot simply employ basic economics and tax the product itself. Thus, research that elucidates the deeper patterning and causes of obesity is an important endeavour.

Research suggests that obesity results from a multitude of genetic and environmental factors that may interact with, or correlate with, each other. It is posited that genetics affect the propensity for weight gain through an array of mechanisms, particularly the hormonal determination and regulation of appetite and metabolism. Indeed, there is substantial evidence for the heritability of obesity. Numerous genes have been shown to correlate with obesity (Rankinen et al. 2006), and significant measures of heritability for skinfold thickness (Selby et al. 1989), waist circumference (Katzmarzyk et al. 2000) and bodily fat accumulation (Malis et al. 2005) have been found. There is evidence that genes which contribute to greater fat storage and accumulation would once have had a selective advantage for persons who were at risk of experiencing infrequent meals and starvation, such as hunter-gatherer populations (Voight, Kudaravalli, Wen & Pritchard, 2006). Populations with a greater prevalence of these evolutionary 'hunter-gatherer' type genes in modern society where there is generally always an abundance of high-calorie food, would theoretically overreact and become overweight or obese. This notion provides one explanation for the disproportionately higher prevalence of obesity of many ethnic groups compared to Caucasians (Ogden et al. 2006; Diamond, 2003).

One of the most striking examples of differentials in obesity rates is that which exists between the indigenous and non-indigenous populations in nations such as the United States (Broussard et al. 1991), Canada (Tjepkema, 2006) and Australia (Australian Bureau of Statistics, 2005). In the case of Australia, the indigenous obesity rate is 34% versus 18% for non-indigenous. This disparity between the two populations is thought to partly explain and contribute to the health gap that exists between indigenous and non-indigenous Australians. Along with this 1.9 times greater prevalence of obesity than the non-indigenous population, the indigenous population suffers from a 3 times greater incidence of diabetes, 1.3 times higher rate of heart disease, 1.5 times greater prevalence of high blood pressure, 1.2 times higher onset of cancer, and in turn, a 12 year lower life expectancy than their non-indigenous peers (Penm, 2008). This is socially unjust, and forms the basis for the 'Close the Gap' campaign initiated and overseen by Australia's peak public health bodies. As a single risk factor, high body mass was the second leading cause of the burden of illness and injury among Indigenous Australians in 2003, accounting for 11% of the total burden of disease and 13% of all deaths (Vos, Barker, Stanley & Lopez, 2007). Indigenous people aged 35 years and over who were overweight/obese were more likely than those who were a healthy weight to have diabetes (22% compared with 10%) and/or cardiovascular disease (36% compared with 23%). Overweight/obesity was associated with poorer self-assessed health among Indigenous people as well.

This differential in health between the two Australians populations of course has economic consequences, with the indigenous population drawing on an average of $7995 per person annually, which is a per person public health expenditure of 1.47 times greater than the $5437 spent per non-indigenous person (Australian Institute of Health and Welfare, 2013).

While obesity has always existed in human populations, until recent decades it was comparatively rare (Hum, Mol & Genet, 2006). Crucially, in this relatively short time frame, the genetic patterning of the human race has obviously not changed, but the environment in which people live has evolved and changed in many ways. Furthermore, no matter the genetic make-up, not every individual is overweight or obese. The role of the environment is thus seen to be pivotal for the development of overweight and obesity.

Environmental factors are thought to affect the development of obesity through an independent influence on intermediary behaviour variables which affect caloric intake and/or expenditure. Environmental conditions related to diet and physical activity play a critical role in both the manifestation and degree of obesity (Bouchard, 1991). The view is that genetics operate within and are moderated by the environment. A case example of the impact of the environment on body weight is that of the Pima Indians, which are the indigenous population of Central America. Research shows that those residing in Arizona in the United States weigh significantly more on average (64.2 versus 90.2 kg) and exhibit a higher mean body mass index (24.9 versus 33.4 kg/m^2) than those living in Mexico (Ravussin et al. 1994). Similarly, a study comparing 247 London residents who migrated from India with 117 of their siblings who remained living in India, found that those living in London exhibited a significantly higher mean body mass index of 27.1 compared to 22.8 kg/m^2 (Bhatnagar et al. 1995). These studies showcase the impact that the environment has on body weight. It is the environmental factors that are of greatest interest to policy makers, as unlike genetics, these variables can potentially be altered so as to reduce the development and prevalence of obesity.

A theorised and somewhat blanket explanation for the environmental aetiology of the obesity epidemic is that economic and technological growth has resulted in an environment conducive to weight gain. Both the monetary and time cost of calories has decreased. And physical activity has become increasingly easy to avoid, due largely to the shift from a manufacturing-based economy to a more sedentary services-based economy (Lakdawalla and Philipson, 2002; Philipson and Posner, 2003). It is an environment where people can individually elect what, when, and how much to eat, as well as how much physical activity to undertake. This has been dubbed the 'obsogenic' environment. Economic theory states that individuals seek to maximise their utility for a given budget constraint. Given that eating calorie dense food (such as sweets) is generally seen as a utility maximising practice, and that exercise and physical exertion is generally not viewed in this way, it makes basic economic sense that people will eat as much as they can afford, while exercising as little as possible, so would thus be likely to gain weight and become overweight and/or obese. In their seminal paper, Philipson and Posner (1999) formalize this notion by modelling weight as the result of eating and exercise decisions made through a utility maximisation process. It is theorised that individuals' trade-off the disutility from excess weight with the utility of eating and a sedentary lifestyle, subject to a budget constraint. Later theoretical models such as that by Komlos (2004) added an intertemporal dimension, noting that the enjoyment from eating and sedentary activities occurs in the present, but the potential health costs occur in the future. Thus the behavioural economics notion of time inconsistent preferences comes into play, where economic agents instinctively place greater value on the present than the future. Such theories help to conceptualise the observed increase in overweight and obesity rates, however, they do not explain why some individuals are affected and some aren't.

Given that overweight and obesity is a lifestyle driven condition, and that diet and level of physical activity are not pre-selected for individuals, but largely chosen and decided upon by themselves on a day-to-day basis, factors influencing people's decisions in regards to diet and physical activity are, in turn, also factors that potentially influence the development of overweight and obesity. Research shows that individuals' dietary choices and their elected levels of physical activity are correlated with a broad array of factors, including demographical, lifestyle, and especially socioeconomic variables (Hernandez & Blazer, 2006). Identifying and quantifying the patterning of obesity amongst environmental factors is an avenue for potential public health policy formation, as particular predisposed demographics can be targeted specifically.

For the case of Australia, it is not only in health that indigenous people are disadvantaged relative to the non-indigenous population. Compared to non-indigenous Australians, the indigenous population experiences lower levels of advantage across a range of socioeconomic variables including education, employment, and income (Altman, Biddle & Hunter, 2005). There is evidence that low socioeconomic status is associated with an increased prevalence of health risk factors within developed nations (Blakely, Hales & Woodward, 2004; Turrell & Mathers, 2000), particularly the development of obesity (McLaren, 2007). This begs the research question of whether some of the disparity in the obesity rate between the indigenous and non-indigenous Australian population can be attributed to the differential in socioeconomic variables, or whether it is purely due to more innate and entrenched factors such as genetics and culture.

Overall, overweight and obesity is a public health issue of epidemic proportions which poses great social and economic costs. Statistics reveal that obesity affects the indigenous population of Australia disproportionately. Studies show the underlying indirect aetiology of obesity includes socioeconomic factors. This research venture aims to reveal the individual level socioeconomic as well as demographic and behavioural patterning of obesity among a nationally representative sample of the Australian population, and also, assess whether any of the variables analysed have a greater impact (interaction effect) on the indigenous population. From this it is hoped that some light can be shed on the reasons for the obesity differential that exists between the two populations, which may be used to spur on further research and/or for the basis of public health policy.

Chapter 2 of this paper showcases, discusses and contrasts the relevant literature pertaining to the socioeconomic patterning and aetiology of obesity. The primary aims of this study are listed as research questions in Chapter 3. The methodology employed is elucidated in Chapter 4. A description of the variables and data utilised in the analysis makes up Chapter 5. Descriptive statistics of the study sample are detailed in Chapter 6. Then, Chapter 7 showcases the findings, which are discussed at length in Chapter 8. Finally, Chapter 9 concludes and summarises the study, highlighting the implications of the findings, and offering suggestions for further research. A detailed reference list then follows.

2 LITERATURE REVIEW

Given the long-time recognized upward trend in overweight and obesity rates, and the immense social and economic costs this entails, there exists a plethora of scientific literature on the topic. A concise summary of the literature review that follows is presented in Table One.

One area of obesity-related research that has received a lot of attention by both academics and public health authorities is the patterning of obesity within populations, in a bid to uncover the underlying environmental causes of why some people become overweight and obese and why others do not. Macroeconomic level economic growth was once hypothesised to be an explanatory factor, given the premise that economic and technological growth has resulted in an environment in which food has become cheaper, more readily available, and more calorie-dense, while physical activity has become increasingly easy to avoid. Research shows a positive relationship between BMI and GDP per capita only up to $US3000, a level that is markedly lower than that of developed nations, and beyond this level, the two variables are not significantly correlated (Egger, Swinburn & Islam, 2012), suggesting that other more microeconomic level factors could be at play.

A microeconomic area that has been a focus of economic research on the obsogenic environment is the effect that the relative price of consumable products has on overweight and obesity prevalence. Chou, Grossman and Saffer (2004) looked at the effect of state level real prices of fast-food restaurants, full-service restaurants, and groceries (food to be prepared at home). It was found that the downward trends in the real price for each of these food groups accounted partly for the upward trend in body mass index seen in the nationally representative sample of the United States population for the period 1984 to 1999. The impact of the tax-lead increasing price of cigarettes was also looked at in this study, and it was found that this had a positive impact on state level overweight and obesity prevalence. This points to an unintended consequence of anti-smoking campaigns. Indeed, research demonstrates that individuals who quit smoking typically gain weight (Pinkowish, 1999; Courtemanche, 2009).

This same study by Chou, Grossman and Saffer (2004) incorporated not only the monetary cost of food, but the time-cost of food, by looking at the increasing number of fast-food stores per capita. The growth in fast-food restaurant prevalence over the last few decades has been dramatic. For example, in the United States, the per capita number of fast-food restaurants doubled between 1972 and 1997, while the per capita number of full-service restaurants rose by 35% (Bureau of the Census, 1976, 2000). This food is typically of a high caloric density (defined as calories per kilogram) to aid in palatability (Schlosser, 2001). The implication of this is that total calories consumed per meal will rise with caloric density if a reduction in the total quantity of food consumed does not take place in an amount to fully offset the increase in calorie density. Mela and Rogers (1998) report that typically this said reduction generally does not occur, and that people tend to even consume a larger quantity of food outside the home, as they have paid for it so see it as wasteful to not finish meals, even if their appetite has been sufficiently met. Thus, body fat mass is more likely to be gained over time. Indeed, fast-food restaurant prevalence was the strongest effecter on body mass index out of the variables analysed by Chou, Grossman, and Saffer (2004). The positive effect of restaurant prevalence highlights fast-food and full-service restaurants as culprits for the undesirable upward body weight trend, but the authors note the important interpretation that the growth in prevalence of these restaurants is largely in response to the consumer demand for them. This is in part due to labour market developments such as increased participation rates, particularly by females, which corresponds to decreased time availability for labour-intensive food preparation (Philipson, 2001; Anderson , Butcher & Levine, 2003). This increases the scarcity and in turn value of household or non-market time by consumers, which increases demand for more convenient methods of meal attainment. These findings by Chou, Grossman, and Saffer (2004) underscore the interesting notion that a price is being paid for by achieving some of collective society's goals. The social shift to an expanded labour market for women has resulted in significant increases in families' capacity for consumption of real resources and higher living standards. Additionally, cigarette smoking has long been the largest cause of premature death in developed nations, and declines in the rate of this behaviour would bear obvious health benefits. But research suggests that these two factors contribute to the rising prevalence of overweight and obesity. Whether public policies should be pursued to offset this consequence of previous actions depends on the relative costs and benefits.

The findings by Chou, Grossman and Saffer (2004) are mirrored in effect by those of Cawley (1999) who reported that BMI was negatively related to the real price of groceries for the period from 1981 to 1996 in the United States. Similarly, Lakdawalla and Philipson (2002) found a negative effect of the price of food, specifically in relation to technology-based reductions in grocery food price between 1976 and 1994 in the United States. The same findings in relation to the reduced time-cost of calories were also demonstrated by other studies, namely that by Currie et al. (2009) which looked at fast-food restaurant proximity, and that by Courtemanche and Carden (2009) who looked at Walmart supercentres per capita.

The real price of other consumables has also been shown to have a negative relationship to Body Mass Index, such as that of petrol. Courtemanche (2011) showed that a negative relationship exists between the two variables, and suggests that a permanent increase of $1 in the price of petrol would reduce the obesity rate by 10 percent and overweight rate by 7 percent within 7 years, as people shun the expensive option of driving for more physically active transpiration measures such as walking, biking, or public transport, which generally entails some level of walking to and from transit points. From a heightened petrol price it is also thought that people would eat out less frequently, instead opting to prepare meals at home, which has been shown to reduce the amount of calories consumed. It was estimated that from this $1 rise in petrol price in the United States alone collectively 16, 000 lives and $17 billion dollars would be saved annually. As well as these benefits, such a policy poses costs too, particularly on income inequality, as a society-wide absolute price increase will more adversely affect lower income earners than higher income earners.

Another variable that has been linked to heightened rates of overweight and obesity due largely to its impact on the incentive to walk is that of urban sprawl. The increasing rate of urban sprawl (reduction in population density) in metropolitan areas of the United States between 1970 and 2000 was found to have a positive association with obesity (Zhao and Kaestner, 2010). Areas of increased suburban sprawl are such that work, school, and social activities are less accessible by foot, leading to a decreased propensity to be physically activity, increasing the odds of weight gain and obesity (Vandegrift & Yoked, 2004).

Aggregate unemployment rates have also been documented to associate with obesity, however researchers have painted a mixed picture in the literature. Zhang, Lamichhane and Wang (2014) showed that in repeated cross-sections over the time period 2007 to 2011 in the United States, state level unemployment rates positively related to body mass. In contrast however, in analysing the relationship between economic climate and obesity for the period 1972 to 1991 in the United States, Ruhm (2000) found that cyclical variations in the economy affected the time cost of leading a healthy lifestyle, with economic downturns and consequent higher unemployment rates being associated with more time to exercise and in turn reduced obesity.

Each of the studies outlined thus far considered one or a few factors at a time. This is useful in identifying the presence of a relationship between variables, but does not hold practical meaning, as in reality numerous variables are at play simultaneously, and one cannot simply add up the degree of causation of each variable from separate studies to determine the overall influence of all factors. Courtemanche, Pinkston, Ruhm, and Wehby (2013) studied the effect of a range of changing economic conditions on obesity in the United States for the period of 1990 to 2010. In total, 27 state-level variables were analysed, relating to general economic indicators, labour supply, and the monetary and time costs of calorie intake and physical activity. It was found that changes in six of the variables analysed collectively explained 40.5% of the rise in obesity in the timeframe analysed. These six explanatory variables were a reduction in the 50/10 income inequality ratio, a reduction in the proportion of persons in an active job, and an increase in the per capita prevalence of restaurants, supermarkets, supercentres, and convenience stores. Given that Australia shares a similar food culture and general economic environment to the United States, these findings by Courtemanche and colleagues can be taken to be somewhat representative for the case of Australia too.

The research highlighted thus far demonstrates the impact of state level factors on the prevalence of overweight and obesity. Courtemanche and colleagues calculated that 40.5% of the rise in obesity was attributed to state-level variables, but there is 59.5% left unaccounted for. What the studies showcased thus far do not take into account or offer insight into is individual level social and economic variables, which may also have an effect on obesity development. In a study which analysed the body mass index of twins who had been reared apart, it was found that 30 percent of the variance in body mass index was due to environmental factors unique to the individual not shared by the respective family (Stunkard, Harris, Pedersen & McClearn, 1990). Similarly, studies in nations such as Indonesia, China, Brazil, Russia and the Kyrgyz Republic, show that 22%, 23%, 44%, 58% and 63% of households respectively have both an underweight person and overweight person in residence (Doak, Adair, Bentley, Monteiro, & Popkin, 2005), suggesting that individual level socioeconomic factors could be at play, not just aggregate ones.

A seminal review by Sobal and Stunkard (1989) looked at 144 published studies from 1960 to the mid-1980s on the relationship between socioeconomic status and obesity, showcasing the correlation that exists between the two variables. In the 144 studies reviewed, either individual income or education was used as the indicator of socioeconomic status, and the level of obesity was classified predominantly through Body Mass Index, but also skin-fold thickness at different sites. It is important to note that the strength and significance of the relationship between socioeconomic status and obesity may differ according to the indicators and body weight classifications used, but such a large scale review is useful in presenting the cumulative patterns in the literature. The review revealed a strong inverse relationship between socioeconomic status and obesity among women in developed societies, but not for men. While in developing nations, a strong direct relationship was seen to exist between socioeconomic status and obesity among both men and women. In 2007, McLaren updated the review by Sobal and Stunkard (1989) to include a total of 333 published studies. The overall pattern of results highlighted by this extended and updated review mirrored the findings of the initial work by Sobal and Stunkard (1989), in that a strong negative association was found for women in developed nations, but a strong positive relationship in developing countries, while the relationship between socioeconomic status and obesity for men was only significant in developing countries where it was positive. The overall pattern of the 333 studies was of an increasing proportion of positive associations and a decreasing proportion of negative associations between socioeconomic status and obesity as one moved from highly developed countries to medium and lowly developed countries (McLaren, 2007).

In another review, Ball and Crawford (2005) examined the relationship between socioeconomic status and weight gain over time, and paid added attention to the factor of ethnicity, specifically that of African-American heritage. As with the reviews conducted by Sobal and Stunkard (1989) and later by McLaren (2007), different studies included in the review by Ball and Crawford used different indicators as a proxy of socioeconomic status. In this case these were one of either income, education or employment status. In the 34 studies covered, Ball and Crawford noted the same relationships as those observed by Sobal and Stunkard (1989) and McLaren (2007) for the non-African American sample. That is, weight gain is inversely associated with socioeconomic status in developed countries among women, and less consistently among men; whereas, in developing nations, the association is direct for both sexes. For African-Americans though, support for a relationship between socioeconomic status and weight gain was only found when employment status was used as the indicator, which was inverse in nature. Overall, the authors noted a differential rate of weight gain by socioeconomic status, particularly early in life, suggesting that parental socioeconomic status may be influential (Ball and Crawford, 2005). This is supported by findings in the literature of parental education level having a negative effect on body mass index (Lamerz et al. 2005).

Several mechanisms could underlie the link between low socioeconomic status and obesity. The variable of education is thought to influence body weight and obesity in part due to its positive effect on food purchasing behaviour and resultant increase in quality of diet (Woo, Leung, Ho, Sham, Lam & Janus, 1999). Income has also been seen to impact on diet quality, due to the higher relative cost of nutritious compared to less nutritious food. In a series of analyses, Drewnowski documented that the cost of healthy nutrient-dense food such as fruits and vegetables were reliably more expensive than more energy-dense, less nutritious foods (Drewnowski, 2004, 2004; Drewnowski & Darmon, 2005). Thus, families from lower socioeconomic strata have fewer monetary resources to purchase healthy nutrient dense foods (Darmon, Briend & Drewnowski, 2004). Indeed, it has been found that the relative availability of fruits and vegetables in the home is greater among families from high compared to low socioeconomic strata (Neumark-Sztainer et al. 2003). Fruit and vegetable consumption has been shown to have an inverse association with body mass index after controlling for demographic, lifestyle and socioeconomic factors (Heo, Kim, Wylie-Rosett, Allison, Heymsfield & Faith, 2011). Furthermore, longitudinal studies among overweight adults found greater fruit and/or vegetable consumption was associated with a slower rate of body fat accumulation and weight gain (Ledoux, Hingle & Baranowski, 2011).

It should be noted though that the magnitude of the income effect on obesity has the potential to be overestimated due to the reverse negative causality shown to exist from obesity to income (Averett & Korenman, 1996; Cawley, 2004).

In regards to socioeconomic status and predisposition to obesity, it is not just 'who you are', but 'where you are'. It has been documented that individuals residing in low socioeconomic regions exhibit higher rates of obesity than those in higher status areas (Ellaway, Anderson & Macintyre, 1997). This may be due to the reduced prevalence of recreational facilities such as parks and sports fields, and/or a lesser feeling of safety outdoors, which both may contribute to diminished energy expenditure and subsequent weight gain (Burdette & Whitaker, 2005). Low socioeconomic neighbourhoods have also been shown to exhibit greater prevalence of fast-food outlets than higher status areas, most likely in respond to the demands of the market. For instance, in an ecological study of 267 postal districts in Melbourne, Australia, families living in the poorest socioeconomic strata experienced 2.5 times the exposure to fast-food outlets and, thus, increased access to relatively inexpensive, calorically dense foods, compared to families from the wealthiest socioeconomic strata (Reidpath et al. 2002). In Australia, it has been highlighted that level of remoteness is positively associated with body mass index (ARHA, 2013). The geographical social clustering of obesity has also been documented, whereby the social norms of an area relating to body composition can make being obese more or less aberrant, which influences the proliferation of obesity by increasing or decreasing the incentive to maintain a healthy body image (Hruschka et al. 2014).

Several studies in the literature document individual level social and economic variables that influence body fat accumulation, such as those relating to occupation. Not being in continuous paid employment has been shown to associate an increased likelihood of gaining weight (Morris, Cook & Sharper, 1992). Looking deeper into occupational variables, Lakdawalla and Philipson (2002) looked at the long-run Body Mass Index of individuals in the United States between 1976 and 1994 as it related to level of on-the-job physical activity, which due to technological advancement had declined, and as would be theoretically expected, found a strong negative relationship between the two variables. Other occupation related variables such as number of hours worked per week

(Courtemanche, 2009), blue collar employment (Park, 2009), and shift work (Park, 2009), have each been shown to positively correlate with body mass index.

The literature highlighted thus far makes the case for the impact of numerous socioeconomic variables on the proliferation of obesity. In addition to socioeconomic factors, numerous demographical and lifestyle variables have been shown in separate studies to associate with body weight and obesity. These include age (Lahti-Koski, Vartianinen, Mannisto & Pietinen, 2000), gender (female) (WHO, 2014), marital status (Lipowicz, Gronkiewicz & Malina, 2002), and smoking status (Pinkowish, 1999), which have each been documented to positively associate to body fat accumulation and obesity. Physical activity level is of course shown to have a negative influence on obesity (Kimm et al. 2005). Alcohol consumption has been shown to exhibit an inverted-U Kuznets curve type relationship with body mass index (Suter & Tremblay, 2005). Such variables would need to be controlled for in an analysis of environmental factors pertaining to obesity prevalence.

A study analysing the impact of these demographical and lifestyle variables on obesity, as well as the socioeconomic variables previously highlighted, all in one collective analysis, is yet to be done for an Australian national cohort.

Another individual demographic factor that has been shown to partly account for the disproportionate prevalence of obesity is ethnicity. Indeed, there are many cases of different ethnic groups residing in the same society but exhibiting differing rates of obesity. The most heavily noted example of this is that in the United States between Anglo-Saxon residents, African-Americans, and Hispanics, with the latter two ethnic groups exhibiting a 51% and 21% higher obesity rate compared to Anglo-Saxons respectively (Centres for Disease Control and Prevention, 2010). Another ethnic group in the United States with a higher rate of obesity than the general population is that of the indigenous population (Broussard et al. 1991). This positive indigenous to non-indigenous obesity rate differential is also present in other developed nations, including Canada (Tjepkema, 2006) and Australia (Australian Bureau of Statistics, 2005).

In the case of Australia, the indigenous obesity rate is 34% versus 18% for non-indigenous (Australian Bureau of Statistics, 2005). This disparity in obesity rates between the two populations partly explains and contributes to the health gap that exists between indigenous and non-indigenous Australians, including a 12 year lower life expectancy. Compared to non-indigenous Australians, the indigenous population experiences lower levels of advantage across every major socioeconomic indicator including education, employment, and income (Australian Bureau of Statistics, 2010). Given this, and the evidence presented thus far in this paper of an inverse relationship existing between obesity prevalence and each of these socioeconomic variables, there is perhaps an explanatory link present between the obesity and corresponding health status of indigenous Australians and the population's socioeconomic circumstances. Australian Bureau of Statistics data shows that indigenous people who did not complete high school were more likely to engage in low levels of physical activity, and were less likely to eat fruit and vegetables on a daily basis, than those who did complete high school (ABS, 2004). Further research into which socioeconomic variables contribute to the greater predisposition of obesity for the indigenous population of Australia is required.

A study done by Corey, Ng, and Young (2011) compared the socioeconomic patterning of obesity between indigenous and non-indigenous Canadians. The key finding from this study was that the incidence of obesity was 80% higher among indigenous males and 64% for indigenous females who were unemployed compared to those employed, while employment was not significantly associated with obesity among the non-indigenous. This finding holds potential public health policy formation implications in Canada. A study of similar nature and scope is yet to be done for the case of Australia. Furthermore, research highlighting the potential difference in impact on obesity likelihood that different factors could have on indigenous people compared to non-indigenous people is yet to be done.

While the literature highlighted in this review showcases some interesting and potentially policy inducing relationships, it is important to note that it is difficult to measure and quantify associations between obesity and environmental variables with unwavering accuracy and validity. This is due to a number of reasons, including the close association that exists between particular socioeconomic variables (e.g. education and employment), that the casual relationships between obesity and socioeconomic variables can sometimes work both ways (e.g. unemployment may lead to obesity but obesity may also lead to unemployment), and also because other factors may also be influencing both (e.g. access to employment opportunities and health services). Therefore the level of risk attached to a particular factor may depend on whether other factors are also present in the analysis, and certain combinations of risk factors may impact on obesity in different ways. Nevertheless, the more research that is done in this area, the better the understanding that can be reached of the complex socioeconomic-obesity relationship.

3 RESEARCH QUESTIONS

This study venture aims to contribute to the extant literature and enhance the existing scholarly knowledge of the environmental influence on obesity by answering the following research questions:

1. *Which individual-level socioeconomic, demographic and lifestyle variables are associated with an increased odds of being obese for an Australian population sample?*

2. *Which individual-level socioeconomic, demographic and lifestyle variables are associated with a decreased odds of being obese for an Australian population sample?*

3. *Which individual-level socioeconomic, demographic and lifestyle variables are not associated with the odds of being obese for an Australian population sample?*

4. *Are any individual-level socioeconomic, demographic and lifestyle variables associated with a greater impact on the odds of being obese for indigenous Australians compared to non-indigenous Australians sample?*

4 METHODOLOGY

The methodology employed in this research venture is based loosely upon that carried out by Corey, Ng and Young (2011) who had a similar scope of study when determining the socioeconomic patterning of obesity among indigenous versus non-indigenous Canadians. Corey, Ng and Young (2011) employed logistic regression to analyse the effects of a range of selected demographical, behavioural and socioeconomic variables on the dichotomous dependent variable of obesity, and compared the results of indigenous and non-indigenous samples. This study differs in that it draws on a sample from the Australian population, and analyses the potentially different impact in magnitude of variables on obesity between the indigenous and non-indigenous groups through the use of interaction terms in a single logistic regression, as oppose to running and comparing two separate regressions.

Upon being granted access to the data set, the dependent variable of obesity was calculated from the height and weight variables in the dataset, and corrected for self-reporting self-serving bias errors in accordance with Brandrup, Hayes, Clarke, and Kortt (2008). The independent variables of interest were selected in accordance with the literature. Some new variables had to be derived from the combining or condensing of pre-existing ones in the data set, while other variables simply had to be quality assured via the omitting of non-respondents. Descriptive statistics of the finalised sample were then generated. These included the means and standard deviations for each of the two populations (indigenous and non-indigenous), as well as the statistical significance of the difference between the two means calculated with two-sample Welch t-tests. An ordered logistic regression using a categorical dependent variable of underweight or healthy, overweight, and obese was then employed using all the independent variables of interest. This was solely performed so that a Brant detail test as per Long and Freese (2006) could be employed to test and show the violation of the parallel regression assumption, meaning that Indigeneity has a different (greater) effect on the odds of being obese than for overweight in this study sample.

Subsequently, the major analyses were undertaken. Logistic regression of the dichotomous dependent variable obesity was run against the numerous independent variables. This was labelled 'Regression A'. The coefficients of this regression were then exponentiated to gain the respective odds ratios to aid in the interpretation of the results.

Then, this same logistic regression was run again, but with Indigeneity as a dichotomous dummy interaction term for each variable.   Subsequently, in a process of sequential elimination, the least significant interaction term was removed from regression one-by-one until only significant interactions were present in the final model. This was labelled 'Regression B'. This use of interaction analysis is a point of difference for this study among the existing literature. Studies in the area of socioeconomic patterning of obesity have thus far generally looked at single populations or samples, and thus run multiple/logistic regression or fixed/random effects models depending on the nature of the data and type of dependent variable, and leave it at that. In the case of Corey, Ng, and Young (2011), separate regressions were run for the indigenous and non-indigenous samples with the results of the two regressions being compared against each other.

Adding interaction terms to a regression model can greatly expand the understanding of the interrelationships among variables in the model. A standard logistic model is as follows:

$$\text{logit}(Y) = \alpha + bX + cZ$$

An interaction hypothesis is that the impact of X on Y depends on the value of Z. That is, the effect of the predictor variable X on the response variable Y is different for different values of the other predictor variable Z. This can be tested by adding a term to the model where the two predictor models are multiplied. The interaction logistic regression model has the form:

$$\text{logit}(Y) = \alpha + bX + cZ + dXZ$$

The interaction literature refers to X as the focal independent variable, Z as the moderator variable, and d as the interaction term. If the interaction term is significant it indicates that the slope for Y on X is significantly different for each value of Z. For a simple example in the context of this study, let obesity be a dichotomous dependent variable, X be income, and Z be Indigeneity status (yes or no). If the interaction coefficient tests as significant the inference is that the magnitude of the impact of income on the likelihood of being obesity (positive or negative) depends on whether a person is indigenous or non-indigenous, that is, the impact is different for indigenous and non-indigenous people. The coefficients of the interaction terms were then exponentiated for interpretation.

Overall, the method of analysis employed in this study was developed and conducted to not only reveal the socioeconomic patterning of obesity among the sample, but to identify whether any included variables had a greater explanatory impact on the obesity likelihood of indigenous persons.

Analytical Software

Version 12.0 of STATA/SE Data Analysis and Statistical Software (StataCorp. 2011. *Stata Statistical Software: Release 12*. College Station, TX: StataCorp LP) was the sole analytical software employed in this study. It was elected due to its pre-existing familiarity, as well as it fulfilling the required criteria of being able process the large HILDA dataset, and the ability to conduct the intended analytical method of logistic regression with interaction terms.

5 DATA

The data was sourced entirely from the Household, Income Labour Dynamics in Australia (HILDA) panel. The HILDA is the most comprehensive household level societal dataset gathered on the Australian population. It is a household-level questionnaire conducted both over the phone and via posted hard-copies. As the name of the survey suggests, the information collected centre around economic and subjective well-being, as well as labour and family dynamics. It is designed to be nationally representative in its sampling, and since 2001 over 19, 000 recurring individuals have been interviewed annually to form a comprehensive panel dataset.

For this study, only a single wave of the HILDA data set was called upon, that of the 12th and most recent wave. Thus the panel nature of the HILDA dataset was not used. Instead, a cross-sectional static approach was taken. This was due largely to the time constraints associated with completing this research venture. A longitudinal dynamic assessment would potentially result in more powerful findings, and rests as an endeavour for future research.

The HILDA dataset was particularly attractive for use in this study as it fulfilled the criteria of having body weight and height, Indigeneity status, as well as numerous other demographical, behavioural, and socioeconomic variables of interest, all in the one dataset. As well, it was familiar to both the chief researcher, and the supervisor who has worked extensively with it.

The following is a listing and explanation of the variables included in the analysis.

Dependent Variable

Obesity (corrected): Dichotomous variable that equals 1 if corrected Body Mass Index (BMI) is equal to or greater than 30 kg/m^2.

BMI is calculated by dividing weight in kilograms by the square of height in metres.

The measurements of weight and height taken in the HILDA survey are self reported. A potential limitation using this form of data is that survey respondents have been shown to under-report their weight and over-report their height (Flood, Webb, Lazarus & Pang, 2000). This can adversely affect the validity of corresponding BMI, overweight and obesity statistics. For example, in the 1995 National Health Survey of Australia, self-reporting errors resulted in a calculation of mean BMI being

1.3 and 1.1 units lower than reality for women and men, respectively. This would affect the validity of the findings of studies which employ the under-calculated BMI data. While direct measurement of height and weight by trained professionals is more accurate, it is often not practical due to logistical and/or cost constraints. One approach for accounting for self-serving bias errors in self-reported data is the use of correction equations.

Brandrup, Hayes, Clarke and Kortt (2008) developed a correction equation for self-reported height and weight based on nationally representative Australian data. The equations for 'corrected' BMI from self reported height (cm) and weight (kg), are as follows:

Men BMI corrected = $$\frac{(1.002 \times ??? \; ??? \; h? + 0.07)}{(0.00911 \times ??h???\; h? + 0.1375)^2}$$

Women BMI corrected = $$\frac{(1.04 \times ??? \; ??? \; h? - 0.067)}{(0.00863 \times ??h???\; h? + 0.2095)^2}$$

The use of these two equations on self-reported data resulted in BMI statistics and the estimation of overweight and obesity prevalence being more aligned with directly measured values (Flood, Webb, Lazarus & Pang, 2000).

These equations were applied to the HILDA dataset and used to derive the variable of corrected obesity, which is the dependent variable in this study.

It should be noted that obesity, as oppose to overweight, was used as the dependent variable for two reasons. The first being that the major differential between the indigenous and non-indigenous Australian populations is in obesity, not overweight. Australian Bureau of Statistics data shows that 36% of indigenous persons are obese, compared to 18% of non-indigenous persons. Due partly to this greater proportion of the indigenous population being in the obese category compared to non-indigenous, overweight prevalence is inverse in that 31% of indigenous persons are overweight versus 36% of non-indigenous persons (Australian Bureau of Statistics, 2005). The dataset employed in this study mirrors that of a greater difference existing between the indigenous and non-indigenous population in obesity rather than in overweight. This was tested via an ordered logistic regression with a categorical dependent body weight classification variable of corrected underweight or healthy, overweight and obese. A Brant detail test as per Long and Freese (2006) was employed to outline that Indigeneity (p=0.015) violates the parallel regression assumption, so has a different, in this case greater, effect on obesity prevalence. The results of this Brant detail test are listed in Table Two.

Secondly, given that obesity is higher in the spectrum of body weight classification, it carries a greater risk of morbidity and mortality from health ailments than overweight does (Larsson, Karlsson & Sullivan, 2002). Overall, obesity imposes a greater health and subsequent social and economic burden than overweight, is much more prevalent among the indigenous population, and was thus the investigative variable of interest.

Independent Variables

Three classes of independent variables relating to individual-level circumstances were included in the analysis. In addition to the socioeconomic variables which were of primary interest in this study, demographical and behavioural lifestyle factors that the literature shows to pertain to obesity were controlled for. The selection of variables included for analysis was limited to a degree by the HILDA dataset. It is important to note that other behavioural and socioeconomic variables, such as diet and level of on-the-job physical activity, have been linked to obesity prevalence and would have been included in the analysis but are not included as part of the HILDA questionnaires and corresponding dataset.

Demographical variables:

Age	Continuous variable of age in years.
Sex	Dichotomous variable equal to 1 if male, 0 if female.
Indigeneity	Dichotomous variable equal to 1 if indigenous (aboriginal and/or Torres Strait Islander), 0 if non-indigenous.
Marital Status	Dichotomous variable equal to 1 if married, 0 if non-married. De-facto relationships were classified as non-married.
Children	Dichotomous variable equal to 1 if have any children under the age of 14, 0 if no children under 14.

	The child age of 14 was employed because it is a variable already derived in the HILDA data set without significant data loss, and served as an age whereby children generally become self-sufficient to a point of not requiring supervision, which allows more time for parents to carry out personal undertakings, such as an exercise regime.

Lifestyle behavioural variables:

Physical activity level	Dichotomous variable equal to 1 if a dedicated exercise session is undertaken three or more times per week on average, 0 if not. Three times per week was elected as the determining cut-off for being physically active in accordance with the American College of Sports Medicine guidelines (ACSM, 2010).
Smoking status	Categorical variable equal to 0 if a non-smoker, equal to 1 if an ex-smoker, and equal to 2 if a current smoker.
Alcohol consumption	Categorical variable equal to 0 if “never drinks”, equal to 1 if “drinks occasionally”, equal to 2 if drinks 1 or 2 times a week, and equal to 3 if drinks more than 2 days a week. A more objective measure of alcohol consumption such as number of standard drinks consumed per week would be more applicable, but suffered significant data loss compared to this variable of alcohol consumption regularity.

Socioeconomic Variables:

Employment	Dichotomous variable equal to 1 if currently in paid employment, 0 if not in paid employment.
Household income	Continuous measure of gross household income for most previous financial year.

	Household income was elected over personal income as it was intuitively figured to have a greater effect on purchasing and consumption behaviour.
Education level	Categorical variable equal to 1 if less than year 12 level, equal to 2 if year 12 level, equal to 3 for certificate or diploma, and equal to 4 for university plus.
Mother's education	Dichotomous variable equal to 1 if mother completed year 12, 0 if mother did not complete year 12. A more encompassing measure of mother's education that takes into account post-high school qualifications would be more applicable, but such variables suffered significant data loss compared to schooling level.
Father's education	Dichotomous variable equal to 1 if father completed year 12, 0 if father didn't complete year 12. A more encompassing measure of father's education that takes into account post-high school qualifications would be more applicable, but such variables suffered significant data loss compared to schooling level.
Place of residence	Categorical variable equal to 0 if residence is in a major city, equal to 1 if not (inner or outer regional, or remote). Regional and remote were grouped together due to a very limited portion of the dataset identifying as remote. Major city is defined as any of Sydney, Melbourne, Brisbane, Perth or Adelaide.

As well as two Socio-Economic Indexes for Areas (SEIFA) measures. SEIFA indexes are developed by the Australian Bureau of Statistics, and rank geographical areas in Australia according to relative socioeconomic advantage and disadvantage based on information from the five-yearly Census. The SEIFA indexes classify regions from relative worst to best in deciles. The two SEIFA indexes included for analysis in this study as independent variables are the index for economic resources, and the index of education and occupation. For the purpose of parsimony, these two indexes were each condensed from a rating of 10 deciles to a three way rating of lower (bottom three deciles), middle

(middle four deciles) or upper (top three deciles) class. The variables included in each of the indexes are listed below.

SEIFA Index of Economic Resources included variables:

- % People with stated annual household equivalised income between $13,000 and $20,799 (approx. 2nd and 3rd deciles)
- % One parent families with dependent offspring only
- % Occupied private dwellings with no car
- % Households renting from Government or Community organisation
- % Households paying rent less than $120 per week (excluding $0 per week)
- % People aged 15 years and over who are unemployed
- % Households who are lone person households
- % Occupied private dwellings requiring one or more extra bedrooms (based on Canadian National Occupancy Standard)
- % Households owning dwelling they occupy (without a mortgage)
- % Dwellings with at least one person who is an owner of an unincorporated enterprise
- % Households paying mortgage greater than $2,120 per month
- % Households owning dwelling (with a mortgage)
- % Households paying rent greater than $290 per week
- % People with stated annual household equivalised income greater than $52,000 (approx 9th and 10th deciles)
- % Occupied private dwellings with four or more bedrooms

SEIFA Index of Education and Occupation included variables:

- % People aged 15 years and over who left school at Year 11 or lower
- % People aged 15 years and over with no post-school qualifications
- % Employed people who work in a Skill Level 5 occupation
- % Employed people who work in a Skill Level 4 occupation
- % People (in the labour force) unemployed
- % People aged 15 years and over with a certificate qualification
- % People aged 15 years and over at university or other tertiary institution

- % People aged 15 years and over with an advanced diploma or diploma qualification
- % Employed people who work in a Skill Level 1 occupation

Due to the rate of non-response for some variables, the final sample was a condensed 10, 085 Australian residents between 15 and 98 years of age, 266 of which identified as indigenous. This equates to 2.64% of the study sample population being indigenous, which may seem low, but is aligned closely with the estimated total relative Australian indigenous population of 3.0% (Australian Bureau of Statistics, 2011).

6 DESCRIPTIVE STATISTICS

The descriptive characteristics of the study sample are presented concisely in Table Three and Table Four. Table Three details the means and 95% confidence intervals for each variable analysed by indigenous identity, and the statistical significance of difference between the means of the indigenous versus the non-indigenous populations in the sample. Table Four showcases the relative proportions (distribution) of the indigenous and non-indigenous populations that correspond to each value of the categorical type variables.

The mean of almost every variable included in the analysis is statistically different between the indigenous and non-indigenous populations. Only gender and physical activity level are not statistically different between the two at 0.05 level of significance. Both measures of obesity, the self-reported and the corrected, are significantly higher for the indigenous versus non-indigenous sample, being 41%/48% and 26%/33% respectively. These statistics align with those reported by the Australian Bureau of Statistics that gave rise to this study, which were obesity rates of 34% for the indigenous population and 18% for the non-indigenous. The obesity rates calculated from the sample in this study are markedly higher than those reported by the Australian Bureau of Statistics, which was based on census data, but a differential between the indigenous and non-indigenous populations is very much present in both cases. Given that the HILDA aims to be nationally representative, this differential was expected. It was important to establish though, as if the statistics of the sample did not align with that of the Australian nation, then results of this study would be low in validity and carrying it out would be somewhat in vain. The reason for the markedly higher rates of obesity in the study sample compared to the aggregate Australian population is unknown.

In regards to the statistical difference in the mean of the independent variables, compared to the non-indigenous population the indigenous group in the sample are at 0.05 level significantly younger, less are married, more have children under 14 years of age, more are current smokers and less have never smoked, drink alcohol less regularly, less are in paid employment, earned a lower household income in the preceding financial year, had a lower personal education level, lower parental high school completion rates, greater remoteness of residence, and lower rating on the SEIFA index for economic resources as well as that for education and occupation. This highlights an overall difference in demographic, lifestyle, and socioeconomic variables between the indigenous and non-indigenous populations in the sample. Whether these differences interact with the difference in obesity prevalence was one of the aims of this study.

7 RESULTS

This study employed two separate regression analyses. The results of the two regression analyses are presented and summarised separately in Table Five and Table Six respectively. Table Five details the coefficient estimates, odds-ratios, standard errors and level of significance for Regression A, which is the multivariate logistic regression predicting obesity (corrected) from demographic, lifestyle and socioeconomic factors for the study sample as a whole, incorporating both indigenous and non-indigenous populations. Table Six showcases the same information for Regression B, which is the multivariate logistic regression that is the same as Regression A but incorporates an interaction term for Indigeneity for each variable. Only the interactions that are statistically significant in Regression B are shown in Table Six.

For Regression A, all but a few variables had a statistically significant association with obesity for the sample as a whole at 5% level of statistical significance. The variables of household income and a certificate or diploma education were significant at the 10% level. The only variables included in the analysis that did not have a statistical association with obesity were gender, year 12 education level, geographical place of residence outside a major city, and the SEIFA economic resources rating of the area of residence.

For the study sample, the odds of being obese were 80.29% (1.8029 [odds-ratio], 1.39-2.33 [95% confidence interval], 0.000 [p-value]) greater for indigenous people than for non-indigenous people. Collectively, for every year older, the odds of being obese increased by 1.35% (1.0135, 1.01-1.02, 0.000). Being married increased the odds of being obese by 13.65% compared to not being married (1.1365, 1.03-1.25, 0.009). Having one or more children that are under 14 years of age increased the odds of being obese by 11.76% (1.1176, 1.01-1.24, 0.009). Being physically active on average 3 or more times a week reduced the odds of being obese by 43.2% compared to being physically active less than this on average (0.5680, 0.52-0.62, 0.000). Smoking status was significantly associated with obesity, with ex-smokers (those who used to smoke but have since quit) having a 30.15% (1.3015, 1.17-1.45, 0.000) greater odds of being obese compared to those who never smoked, and current smokers having a 13.53% (1.1353, 1.01-1.28, 0.039) greater odds of being obese than non-smokers. Being in paid employment had increased odds of being obese of 15.95% (1.1595, 1.04-1.29, 0.007). Having greater or less annual household income had no effect (1.0000, 1.00-1.00, 0.055) on the odds of being obese. Completing year 12 of school compared to not completing year 12 did not have a statistically significant effect on obesity. Having a certificate or diploma meant a 10.52% (1.1052, 0.99-1.24, 0.084) greater odds of being obese compared to not having completed year 12. Having a university level education had a 20.4% (0.7960, 0.70-0.91, 0.001) lower odds of being obese. If the mother completed year 12 of school, the odds of being obese were 18.03% (0.8197, 0.73-0.92, 0.001) lower. If the father completed year 12 of school, the odds of being obese were 13.35 (0.8665, 0.77-0.97, 0.017) lower. Residing in an area classed as being in the middle tier (4th to 7th deciles) of the SEIFA education and occupation index reduced the odds of being obese by 24.34% (0.7566, 0.67-0.85, 0.000) compared to being in the lowest tier (1st to 3rd deciles). Residing in an area classed as being in the top tier (8th to 10th deciles) of the SEIFA education and occupation index reduced the odds of being obese by 41% (0.5900, 0.50-0.70, 0.000) compared to being in the lowest tier (1st to 3rd deciles).

Regression B, which incorporated interaction terms for Indigeneity with each independent variable, revealed a number of variables that had a greater impact on the odds of being obese for the indigenous population in the sample than for the non-indigenous population. Having a university education meant decreased odds of being obese of 22.94% (0.7706, 0.67-0.88, 0.000) compared to not finishing year 12. Having a university education and being indigenous though, meant increased odds of being obese of 426% (5.2600, 2.00-13.86, 0.001) compared to not having finished high school. If the mother completed year 12, the odds of being obese were 16.25% (0.8375, 0.74-0.94, 0.003) lower. The mother completing year 12 for indigenous people though meant the odds of being obese were 52.22% (0.4778, 0.25-0.93, 0.029) lower. Residing in an area classed as being in the middle tier (4th to 7th deciles) or the upper tier (8th to 10th deciles) of the SEIFA economic resources index compared to being in the lowest tier (1st to 3rd deciles) did not significantly associate with the odds of being obese. Residing in an area classed as being in the middle tier of this index and being indigenous didn't associate with the odds of being obese. Residing in an area classed as being in the upper tier of the SEIFA economic resources index and being indigenous did significantly associate with the odds of being obese though, with this meaning a 62.07% reduced odds of being obese than if indigenous and living in an area in the lower tier.

Of course, as Indigeneity is employed as an interaction in this second regression, the estimated coefficients and odds-ratios presented in Table Six now represent the impact on obesity that the corresponding variables have for the non-indigenous population in the sample. The significant interactions that occur for university education, mother completing year 12, and the upper tier of the SEIFA economic resources index indicate that the magnitude of the impact of these variables on the odds of being obese is dependent upon Indigeneity.

Indigeneity is still a significant predictor variable in its own right in the second regression model, as presented in Table Six, which implies that the obesity prevalence differential between the two populations in the sample is not fully explained by the variables included for analysis. That is, other variables that are not looked at in this study also account for the increased obesity rate of the indigenous population.

A concise summary of the study results is presented below in answering the study research questions. The first three research questions are answered by Regression A, as presented in Table Five. The fourth and final research question is answered by Regression B, as presented in Table Six. Statistical level of significant was taken to be 5% (p=0.050). Note that the result for each variable is in relation to the respective reference value or category.

1. Which individual-level demographic, lifestyle, and socioeconomic variables are associated with an increased odds of being obese for an Australian population sample?

- Age +1.35% (0.000)
- Indigeneity +80.29% (0.000)
- Marriage +13.65% (0.009)
- Children under 14 +11.76% (0.031)
- Ex-smoker +30.15% (0.000)
- Current smoker +13.53% (0.039)
- Occasional alcohol consumption +25.14% (0.001)
- Paid employment +15.95% (0.007)

2. Which individual-level demographic, lifestyle, and socioeconomic variables are associated with a decreased odds of being obese for an Australian population sample?

- Physical activity three or more times/week -43.2% (0.000)
- Alcohol consumption 1-2x/week -19.3% (0.006)
- Alcohol consumption >2x/week -18.6% (0.002)
- University education -20.4% (0.001)
- Mother completing year 12 -18.0% (0.001)
- Father completing year 12 -13.3% (0.017)
- SEIFA education/occupation index
  - Middle tier -24.3% (0.000)
  - Upper tier -41.0% (0.000)

3. Which individual-level demographic, lifestyle, and socioeconomic variables are not associated with the odds of being obese for an Australian population sample?

▪ Gender (male)	-3.12% (0.487)
▪ Year 12 education	-7.24% (0.303)
▪ Certificate/Diploma education	+10.52% (0.084)
▪ Household income	+/- 0.00% (0.055)
▪ Residence outside a major city	+7.39% (0.165)
▪ SEIFA economic resources index	
- Middle tier	+1.40% (0.826)
- Upper tier	-2.49% (0.778)

4. Are any individual-level demographic, lifestyle, and socioeconomic variables associated with a greater impact on the odds of being obese for indigenous Australians compared to non-indigenous Australians?

Three statistically significant interactions for Indigeneity were found in Regression B. That is, three variables had a greater impact on obesity for those in the sample identifying as indigenous. These were:

- University education
    - -22.9% (0.000) for non-indigenous
    - +426% (0.001) for indigenous

- Mother completing year 12
    - -18.3% (0.003) for non-indigenous
    - -52.2% (0.029) for indigenous

- SEIFA economic resources index upper tier
    - Not statistically significant for non-indigenous
    - -62.0% (0.046) for indigenous

8 DISCUSSION

The results of this study are reported in terms of odds ratios. It needs to be noted that odds ratios are different to probabilities and relative risks, and interpreting them as such is false and potentially misleading. A probability is the likelihood that a particular outcome will occur, or the proportion of times that an outcome is calculated to occur relative to the number of total observations. A relative risk is the ratio of 2 probabilities. The odds are the probability of an outcome occurring, divided by the probability of that outcome not occurring. An odds ratio is the ratio of 2 odds. The reason for reporting the results of this study in odds ratios is that the variable of interest of obesity is binary in nature, so logistic regression was the method of analysis. The coefficients from logistic regression represent the change in the logit of the dependent variable for each unit change in the respective predictor variable. Logit is not intuitive though, so poses an issue for interpretation. When exponentiated, however, the coefficients give the respective odds ratio. As has been done in this study, for even easier interpretation, odds ratios can subsequently be converted to the percentage markers of the odds by subtracting one. This is a common method of reporting results within the epidemiological literature, particularly for analyses of dichotomous outcomes such as in this study.

It also needs to be noted that the associations found in this study are just that – associations. Just because there is correlation does not mean that there is causation. This study did not aim to uncover direct causes of obesity, but instead, which individual level variables were more commonly associated with it. If obesity is more prevalent under certain circumstances, public health policy and promotion can be targeted specifically at populations living in those circumstances. Causations cannot be feasibly concluded in a static cross-sectional study such as this. Instead, a longitudinal analysis of the effect that the change in associated variables over time has on obesity is required, and would have much more powerful findings. This more advanced method of analysis was not undertaken due to time constraints, but is an avenue for further research.

Furthermore, a value of 0 for the dependent variable of obesity, which designates non-obesity, should not be interpreted as a healthy weight classification, but one of either underweight, healthy, or overweight. Different patterning would no doubt be found in a three-way ordered logistic regression which included overweight in addition to underweight/healthy and obesity as dependent variable categories. Indeed, the Brant detail test conducted as per Long and Freese (2006) on this very regression, which was done to show the differing effect of Indigeneity on obesity compared to overweight, reveals that a number of variables violate the parallel regression assumption in addition to Indigeneity (0.000), including age (0.000), gender (0.000), marital status (0.012), paid employment

(0.008), each level of education including completing year 12 (0.012), certificate/diploma (0.033), and university (0.000), as well as physical activity level (0.000), and alcohol consumption of more than two times per week (0.001). These statistical violations, with the body mass index classification of underweight/healthy as the reference, infer that the said variables have a differing (non-parallel) impact on obesity compared to overweight. Including the three or even four body weight classes into one study is another avenue for further research. This study, however, was only concerned with the patterning of obesity, due to obesity bearing greater social and health costs compared to overweight in Australia (Colagiuri et al. 2010), as well as being the major differential in body weight class between the Australian indigenous and non-indigenous populations (Australian Bureau of Statistics, 2005).

The results of this study are discussed in relation to the study research questions. The first three research questions are answered by Regression A, as presented in Table Five. The fourth and final research question is answered by Regression B, as presented in Table Six.

1. Which individual-level demographic, lifestyle, and socioeconomic variables are associated with an increased odds of being obese for an Australian population sample?

Those variables which had a statistically significant positive association with the odds of being obese compared to the respective reference points were age, Indigeneity, being married, having children under 14, and being a former or current smoker. Most of these associations are documented and supported by the pre-existing literature.

Age has been shown to have a positive linear relationship to body mass index (Lahti-Koski, Vartianinen, Mannisto & Pietinen, 2000). The major mechanism behind age exhibiting a positive association with the odds of being obese is that resting metabolic rate, which is the magnitude of calories naturally expended when the body is in a resting state, declines as people get older, due to a number of factors including a natural reduction in metabolism-boosting muscle mass and aerobic capacity (Poehlman et al. 1992). Thus, keeping physical activity levels constant, people of a greater age will generally expend less energy per day, so are naturally at increased odds of gaining weight and becoming obese.

Within numerous developed nations the indigenous population exhibits a higher rate of obesity than the non-indigenous population. Cases of this phenomenon include the United States (Broussard et al. 1991), Canada (Tjepkema, 2006), and Australia (Australian Bureau of Statistics, 2005). One reason for this is that these indigenous populations, including Australian aboriginals and Torres Strait

Islanders, have been shown to have a greater genetic predisposition to fat mass accumulation. One example of such a genetic phenomenon is that of insulin resistance, which has been found to occur in populations such as indigenous Australians and the American Pima Indians. Insulin is a hormone secreted by the pancreas, and among other bodily functions, stimulates the storage of fatty acids from the blood, which are derived from digested food, as fat deposits. In this way, insulin has a major role in contributing to body fat levels. Insulin resistance refers to a lower sensitivity of body cells to insulin, meaning that more insulin is secreted to achieve the required bodily functions. The greater the amount of insulin circulating in the blood the greater the rate of fat storage, and in turn, the greater the potential for more accumulation of body fat over time (Mehran et al. 2012). This increased propensity to store fat would in food-sparse environments, such as that encountered by hunter-gatherer populations, aid in human survival (Voight, Kudaravalli, Wen & Pritchard, 2006). With the development of agricultural practices like farming though, food has become readily available, so genes such as those relating to insulin resistance are no longer an advantage for survival, and have ceased being involved in the natural selection process. Thus, it has been theorised that the prevalence of obsogenic genes in a population varies depending on the recency of a population's exposure to an agricultural economy (Hum, Mol & Genet, 2006). Indigenous Australians became subject to agricultural practices roughly only two centuries ago when Australia was settled by the English, compared to Caucasians of European ancestry who as a population have been farming for multiple millennia (Mazoyer & Roudart, 2006). This translates to a modern-day greater genetic predisposition to fat mass accumulation and obesity, as well as the many health implications this entails, for the indigenous population. Genes are not the sole determinant of whether a person will become obese or not though. Indeed, although obesity prevalence is high amongst populations such as indigenous Australians, it is far from 100%. The moderating factor of the environment on genetics is in this way pivotal. Indigenous Australians more commonly fall within lower socioeconomic strata than the non-indigenous population (Altman, Biddle & Hunter, 2005). Although living in the same country, state and even city or town as non-indigenous populations, indigenous people more commonly make up the lower echelons for variables such as education, income, and employment. As a population, the indigenous people are thus living in different day-to-day personal-level environments than the non-indigenous population. Environmental socioeconomic factors such as education, income and employment have been shown to affect obesity rates (McLaren, 2007), so this different socioeconomic environment could together with genetics lead to and partly explain the differential in obesity rates between the indigenous and non-indigenous populations. Additionally, due to the differing genetics, or other factors such as culture, some environmental variables might have a greater or different moderating impact on obesity development for the indigenous than the non-indigenous population. Uncovering these potential relationships was a primary focus of this study, and will be discussed in detail in the coming pages. A statistically significant effect of Indigeneity on the odds of being obese was found in spite of controlling for an array of socioeconomic, demographical and lifestyle factors though.

Being married compared to not being married has been documented to have an association with greater mean body mass index (Lipowicz, Gronkiewicz & Malina, 2002). There are two primary hypotheses for this relationship. The social obligation hypothesis states that those in relationships may eat more regular meals and/or richer and denser foods due to social obligations which may arise because of marriage. Secondly, and perhaps more importantly, the marriage market hypothesis states that when adults are no longer in the marriage market, that is, they are in a stable life union, they lose one of the primary incentives for maintaining a healthy body weight – attracting a partner (Averett, Sikora & Argys, 2008).

The relationship between smoking and obesity, which individually are the first and third greatest contributors to disease burden in Australia respectively (Australian Institute of Health and Welfare, 2003), is well documented in the literature. This study found a positive association for the odds of being obese for both ex-smokers and current smokers compared to non-smokers, with the association for the ex-smoker category being greater. Many previous studies have documented this positive impact of smoking cessation on body mass index and obesity (Pinkowish, 1999; Snerve & Jorde, 2008). This is due to smoking cessation leading to both a reduced resting metabolic rate and an increased appetite and subsequent caloric intake (Moffatt & Owens, 1991). Smoking itself, on the other hand, has generally been found to have a negative relationship with body mass index and obesity, due its negative effect on appetite and positive effect on resting metabolic rate (Chhabra & Chhabra, 2011; Snerve & Jorde, 2008). The findings of this study are in contrast to this general census within the literature, with it being found that being a current smoker has an increased odds of obesity compared to being a non-smoker. A potential mechanism behind this finding is that, as government educational campaigns have made it largely well-known that smoking poses an increased risk of developing chronic health ailments in the future, individuals who smoke despite this knowledge are intuitively more likely to partake in other damaging lifestyle practices that are enjoyable and utility maximising in the short-term but knowingly bear an increased risk of future health issues in the long-term. Indeed, in this study sample, a greater proportion of those who identified as current smokers (43.74%) or ex-smokers (48.48%) drank alcohol most regularly (more than 2 times per week) compared to the non-smokers in the sample (32.47%). A calorie-dense diet and a sedentary lifestyle are both other examples of such future health damaging phenomena, and both contribute to the development of obesity. Thus, it is not that smoking directly causes obesity, but maybe, those individuals who smoke are more likely than those who do not smoke to lead an obsogenic lifestyle. Overall, the relationship between smoking and obesity is multifaceted and complex. The finding that smoking cessation has a greater impact on the odds of being obese than continued smoking supports the notion that the health benefits of effective anti-smoking campaigns and the consequent decline in smoking rates must be traded-off with the health costs of a potential increased obesity prevalence.

The dichotomous variable of having one or more children under 14 year of age was found in this study to have a statistically significant positive association with the odds of being obese. Having children as an explanatory variable for body mass index or obesity was not found to have been studied within the pre-existing literature. It was included in this analysis as it was thought to be a potential key demographical variable relating to obesity due to its likely impact on time availability. The age of 14 was elected as the cut-off as it was already a derived variable within the dataset, as well as it being taken as the age from which children become self-sufficient to a level that allows the parents more time for personal undertakings. Theoretically, having younger children decreases the time available for individuals to undertake a regular physical activity regime. Indeed, the data in this study shows that 35% of the sample which have no children under 14 undertake physical activity three or more times per week on average, while comparatively 29% (difference p=0.000) of those who have children under 14 do so. Thus, for this study sample those who had younger children (under 14) were more likely to lead a more sedentary lifestyle than non-parents or parents of children over 14. This works to explain the positive association with having children under 14 and the odds of being obese.

Not all the findings of this study are backed by or align with those in the literature. One case example is that of the relationship between employment and obesity. Some studies show the association between employment status and body fat accumulation to be a negative one (Morris, Cook & Sharper, 1992). This study, however, finds the opposite relationship at a statistically significant level, in that being in paid employment is associated with increased odds of being obese. There are numerous mechanisms that may explain this finding. One is that being employed leaves less time to cook meals at home, making time scarcer and thus more valuable, so eating time-cheap take-away calorie-dense food becomes more likely. Furthermore, this study controls for household income, not personal income. This was a deliberate choice as it was intuitively figured that household income would have a greater effect on purchasing and consumption behaviour. Perhaps there is a personal income effect within this employment finding. Being unemployed would generally result in a relatively low personal income, a personal income that is perhaps so low that the income-induced lower level of potential food consumption outside of the household is so low that being obese is less likely. While being in paid work and the consequent higher income results in a greater ability to purchase and consume outside the household, enabling the required amount of calories over time to become obese to be consumed. The case for overweight, which other studies include in the analysis in relation to employment, but this study does not, may be different. Indeed, the Brant detail test conducted on the ordered logistic regression which included overweight separate to obesity showed that the variable of being in paid work had a statistically significant different affect on the odds of being overweight compared to the odds of being obese.

2. Which individual-level demographic, lifestyle, and socioeconomic variables are associated with a decreased odds of being obese for an Australian population sample?

The results of Regression A showcased not only variables which had a statistically significant positive association with the odds of being obese, but many that had a statistically significant negative association. These were being physically active three or more times a week, having a university level of education (compared to not finishing school), having a mother who completed year 12, having a father who completed year 12, and residing in an area rated more highly on the SEIFA education and occupation index. The findings in the literature mirror many of these negative associations as well.

Physical activity is exceedingly documented to have a negative relationship with body mass index and obesity (Kimm et al. 2005; Paeratakul, Popkin, Keyou, Adair & Stevens, 1998). Exercise directly affects body fat accumulation and storage, as it involves the expenditure (use) of calories, so simply put, less calories are available to be stored as fat. Physical activity also diminishes the odds of being obese through other mechanisms, such as temporarily increasing insulin sensitivity, meaning that less insulin is secreted and so the rate of body tissue fat accumulation and storage diminishes (Borghouts & Keizer, 2000). Additionally, a regular physical activity regime can build and maintain lean muscle mass, which increases the resting metabolic rate (resting calorie expenditure) (Pratley et al. 1994). Being physically active three times per week or more on average was the largest negative explanatory variable for obesity in this study, which only further highlights the importance of exercise prescription and promotion in public health policy.

The relationship between obesity and education has been a major focus within the literature, with many studies using education as a proxy for socioeconomic status. Many studies and reviews have documented a negative influence of education level of body mass index and obesity. The concept is that as individuals become more educated, the importance of lifestyle and nutrition in regards to health is more readily understood. So, the more educated an individual is, the more likely they are to lead a more healthy life. Indeed, education is documented to have a positive effect on food purchasing behaviour and resultant increase in quality of diet (Woo, Leung, Ho, Sham, Lam & Janus, 1999). In this study, education was only a statistically significant explanatory variable for the odds of being obese at university level (when compared to the reference point of not completing year 12 of high school). The lower levels of education of diploma and certificate course and completing year 12, when compared to not completing year 12, were not significant predictors. Indicating that the affect of education on obesity propensity may in some cases only kick into effect at higher levels. In contrast though, some studies note the importance of education not at this final stage, but during early childhood. Level of cognitive stimulation between the ages of 0 and 8 has been shown to have a negative relationship on the development of obesity later in life (Strauss & Knight, 1999). Which form or level of education is most influential remains unknown, however, what is known is that the relationship between obesity and personal education level is although multifaceted, negative in nature.

This study found that in addition to personal education, parental education is statistically linked with a decreased odds of being obese. Specifically, both the mother and father completing year 12 of high school was found to each independently decrease the odds of being obese compared to if the respective parent did not complete year 12. This finding is mirrored within the literature (Lamerz et al. 2005). The reasoning behind the influence of parental education on the obesity is multifaceted. To surmise, it may be due to the heritability of educational attainment (Heath et al. 1985), and/or the premise that more highly educated parents are intuitively more likely to have knowledge of, understand and pass on lessons in the importance of leading a healthy lifestyle.

In continuing with the education theme, the Socio-Economic Indexes for Areas (SEIFA) rating of education and occupation was found to relate to the odds of being obese. Specifically, residing in an area that was rated in the top tier (8^{th} to 10^{th} deciles) or the middle tier (4^{th} to 7^{th} deciles) compared to the bottom tier (1^{st} to 3^{rd} deciles) were both associated with a decreased odds of being obese. One mechanism for this finding may be that, due to more highly educated people having an enhanced knowledge of nutrition and health and the demand for a better quality diet (Woo, Leung, Ho, Sham, Lam & Janus, 1999), areas with a higher index of education will theoretically have a lower demand for less nutritious calorie dense fast-food. So, market forces will thus theoretically result in a relatively lower prevalence of fast-food outlets in areas rated more highly on the SEIFA education and occupation index. Thus, even if an individual is not very educated, residing in a highly educated area will reduce the odds of being obese due to a lower prevalence of and temptation by fast-food outlets. Indeed, the effect of fast-food restaurant frequency on obesity propensity is well documented in the literature to be positive (Courtemanche et al. 2013; Chou et al. 2004). This explanation fits with the findings of this study, in that the odds of being obese are reduced when residing in an area ranked in the middle tier compared to the bottom tier on the SEIFA education and occupation index, with these odds being reduced further still when residing in an even higher rated area in the top tier. A further potential mechanism for this finding is that, even if only lowly educated, residing in a highly educated area would mean a greater degree of association and contact with more highly educated people than in a lower rated area, which might result in a greater level of informal non-recognized education from the everyday conversation with and observation of others in the community. This is known as social contagion, whereby people learn from and react to those around them (Smith & Christakis, 2008). Studies show that such social ties and norms of acceptable body size can indeed serve as conduits for the proliferation of obesity (Hruschka et al. 2011; Christakis & Fowler, 2007). Gaining large amounts of body weight and becoming obese is in some social communities viewed as being more aberrant than in others, which will reduce the incentive and tendency to do so.

The relationship between alcohol consumption and obesity was miscellaneous for this study, with occasional alcohol consumption having a statistically significant positive relationship with the odds of being obese, while higher rates of alcohol consumption had a negative relationship. The science supports this finding, in that despite the comparatively high energy content of alcohol and its many forms, the relationship between its consumption and weight gain does not seem to be linear. Alcohol enhances energy intake due to the caloric content of the alcohol as well as its appetite-enhancing effects. The experimental metabolic evidence suggests that the irregular to moderate consumption of alcohol may represent a risk factor for the development of a positive energy balance and thus weight gain (Suter & Tremblay, 2005). In the heavy alcohol consumer, however, a larger fraction of the energy in alcohol does not need to be accounted for in the energy balance equation. This is due to the activity of the microsomal ethanol-oxidizing system (MEOS) increasing after chronic alcohol consumption, which along with increasing alcohol tolerance, reduces the availability of alcohol to be used as energy (Lieber, 1999). Experimental data in combination with epidemiologic findings suggest that alcohol energy counts more in moderate nondaily alcohol consumers than in some moderate daily and all heavy consumers. This explains the finding of this study in relation to alcohol, where lower regularity of alcohol consumption was found to statistically correlate with greater odds of obesity, while higher consumption rates were found to associate with a lower odds of being obese.

3. Which individual-level demographic, lifestyle, and socioeconomic variables are not associated with the odds of being obese for an Australian population sample?

While many of the variables included for analysis in this study were found to have statistically significant positive or negative associations with the odds of being obese, some were not. These were gender, household income, not residing in a major city, and the geographical area of residence rating on the SEIFA economic resources index.

Statistics in the pre-existing literature indicate that more women are obese than males (WHO, 2014). This is perhaps due to women naturally accumulating a greater proportion of body fat mass than males (Lafortuna, Maffiuletti, Agosti & Santorio, 2005), and/or being likely to lead a more sedentary lifestyle than men. For the sample analysed in this study though, gender was not a statistically significant predictor of the odds of being obese.

Household income is another variable that was found to not relate to the odds of being obese. The association between household income and obesity was found to be minorly statistically significant; however with an odds-ratio of 1.000, its impact on obesity for this study sample is indifferent. Some studies in the literature reveal a positive association between income and obesity (Chang & Lauderdale, 2005; Monteiro, Conde & Popkin, 2001), most likely due to the mechanism of a greater income allowing the greater consumption of food. Not all studies document this positive relationship between income and body weight though. Some find an inverted U-shape Kuznets-type curve relationship between income and Body Mass Index, whereby the odds of being obese become greater as income rises up to a point, which from there after the odds of being obese become less as income continues to rise (Lakdawalla & Philipson, 2009). This is perhaps due to the upward effect of income on body weight being offset at a point by two phenomena; the demand for greater food consumption only increases up to a point, from which it remains constant, by which time the education effect kicks in, increasing the demand for an ideal body weight. The education effect is thought to occur with income due to the multicollinearity that commonly exists between the two variables. Due to this documented non-linear relationship, when a neutral odds for being obese was found for household income in this study, the variable was squared and re-analysed. Household income when squared was less significantly significant than the original variable though ($p=0.276$ compared to $p=0.055$). It's important to note that it was household income that was employed in this study, not personal income, which was the variable employed in some of the studies noted from the literature which find a meaningful relationship. This highlights the potentially different impact on obesity between personal and household income, possibly due to the notion that personal income is more disposable.

Another variable that studies show to be related to obesity but was not found to be in this study is that of residing outside a major city. It is well documented that residing in a rural area increases the odds of being obese compared to living in a metropolitan centre (Zhao and Kaestner, 2010; ARHA, 2013). This is largely put down to suburban sprawl. Areas of increased suburban sprawl are such that work, school, and social activities are less accessible by foot, leading to a decreased propensity to be physically active, increasing the odds of weight gain and obesity (Vandegrift & Yoked, 2004). Residing outside a metropolitan centre was not found to statistically associate with obesity in this study though.

Unlike the SEIFA education and occupation index, the SEIFA index for economic resources did not statistically correlate with obesity odds. The literature highlights that those residing in highly rated socioeconomic areas are at a reduced odds of being obese compared to those in lower class areas (Ellaway, Anderson & Macintyre, 1997). This may stem from the reduced prevalence of recreational facilities such as parks and sports fields, and/or a lesser feeling of outdoor safety, which both may contribute to diminished energy expenditure and subsequent weight gain (Burdette & Whitaker, 2005). Low socioeconomic neighbourhoods have also been shown to exhibit greater prevalence of fast-food outlets than higher status areas, most likely in respond to the demands of the market. For instance, in an ecological study of 267 postal districts in Melbourne, Australia, families living in the poorest socioeconomic strata experienced 2.5 times the exposure to fast-food outlets and, thus, increased access to relatively inexpensive, calorically dense foods, compared to families from the wealthiest socioeconomic strata (Reidpath et al. 2002). A statistical relationship between the economic rating of the area of residence and obesity odds was not found for this study sample though, possibly due to a correlation with the other SEIFA index included in the analysis.

4. Are any individual-level demographic, lifestyle, and socioeconomic variables associated with a greater impact on the odds of being obese for indigenous Australians compared to non-indigenous Australians?

Regression model B employed the use of interaction terms to test possible interaction of Indigeneity with those variables analysed in Regression A, to reveal whether any of these variables had a greater impact on the odds of being obese for the indigenous population in the sample than for the non-indigenous population. A review of the literature reveals that this particular scope of research has not been documented. Thus, there was no particular expectation or hypotheses concerning the possible interactions of Indigeneity. Due to the lack of literature on the topic, explanations for the results are hard to justify with credible peer-reviewed evidence, and the discussion that follows is largely only conjectural intuitive offerings.

In total three statistically significant interactions for Indigeneity were found. These were university education (compared to not completing year 12), mother completing year 12, and residing in an area rated in the top tier (8^{th} to 10^{th} deciles) on the SEIFA index for economic resources (compared to residing in an area in the lower tier of the 1^{st} to 3^{rd} deciles).

One variable that interacted with Indigeneity in relation to obesity is mother's education. Having a mother that completed year 12 of high school compared to a mother who didn't reduced the odds of obesity by 18.3% for the non-indigenous study sample, but for the indigenous sample, this reduced the odds of obesity by 52.2%. This is quite a significant finding. As discussed previously, the literature details pre-existing evidence and explanations for the negative effect of parental education on body fat accumulation and obesity, particularly for the mother who is typically the arbiter in relation to child diet and lifestyle. The information within the literature does not explain however why this variable seemingly matters more for indigenous Australians than for non-indigenous Australians. Looking closely at the numbers in this study, one reason may be that less of the indigenous sample have mothers who completed year 12 than those making up the non-indigenous sample (mean difference p=0.000). So, as an indigenous person having a mother who completed year 12 is a relatively larger variable increase than for a non-indigenous person, it will intuitively have a greater effect on any dependent variables, which is in this case obesity. Additional conjectural explanations for this result were gained through alternative sources. Qualitative type research whereby a number of selected people who were identified as being involved with and having potentially greater knowledge of indigenous health as well as social and cultural constructs were asked to comment on the finding. These people included professional indigenous health experts, social workers, and community support workers. These sources brought to light the multitude of public programs and projects in place that are centred on addressing the many deficits and disadvantages incurred by indigenous Australians. Many of these endeavours are implemented within schools that have a high prevalence of indigenous students, with many having a focus on maternal skills and nutrition. Thus, indigenous people who do not complete year 12 are subject to less maternal, child rearing and nutrition specific education than those who do complete year 12. The mother is the traditional primary care giver of the family, and when indigenous women go on to have children, whether or not they completed school and were subject to more or less educational programs on maternity and nutrition will intuitively affect the diet and lifestyle lessons they instil in their children. This may, in turn, affect the odds of their children becoming obese. Since these programs have the primary aim of reducing the multifaceted inequality that exists between the two populations, many are exclusively carried out in schools and communities with high indigenous rates. Thus, non-indigenous women are generally not subject to these educational programs in school, so not completing year 12 may not pose the same effect. Thus, the results of this study somewhat demonstrate the effectiveness of these programs. This is all intuitive speculation though. A listing of the maternal and child nutrition programs and projects previously or currently in place in Australia can be viewed in Table Seven.

Another variable analysed in Regression B that statistically interacted with Indigeneity is the SEIFA index for economic resources, which rates geographical areas in Australia in regards to 15 variables to do with general wealth. Interestingly though, in this study the variable of the SEIFA economic resources index rating was not statistically significant for the study sample as a whole, nor for the non-indigenous study sample alone. It does however statistically interact with the indigenous study sample, with those residing in an area rated in the top tier (8th to 10th deciles) having a reduced odds of being obese of 62.0% compared to those residing in the bottom tier (1st to 3rd deciles). Maybe, due to the documented genetically induced greater level of insulin resistance, the effect of the greater prevalence and exposure of fast-food outlets in lower socioeconomic areas has a greater effect on the body fat accumulation and obesity for indigenous people than non-indigenous people. This is only speculation though.

Having a university education compared to not finishing high school and being indigenous had a statistically greater impact on the odds of being obese than having a university education compared to not finishing high school and being non-indigenous. For the non-indigenous population in this study sample, the odds of being obese were 22.9% (p=0.000) less for those university educated. For the indigenous population, however, having a university education correlated with an increased odds of being obese of 426% (p=0.001). This seems unrealistic, particularly given the well documented negative education effect on body weight and obesity. A mechanism behind this finding may be that since a university education will generally translate to a more sedentary based career, this would theoretically have a greater effect on weight gain and obesity propensity for indigenous persons due to the genetically greater level of insulin resistance, the effects of which are exacerbated by low levels of physical activity. However, only a small proportion of indigenous people attain a university education. Indeed, in the indigenous sample in this study, which is in total quite small at 266, 11.28% of individuals identified as having a university level education. So, this interaction finding is based somewhat on only 30 individuals, 20 of which happen to be obese. This could well be due to other variables not included in this regression analysis. Indeed, and crucially, the variable of Indigeneity is still a statistically significant predictor in its own right (p=0.007), indicating that the greater obesity prevalence of the indigenous sample is not fully explained by the variables in this analysis. Furthermore, if this were the case, it would theoretically be supported by a statistically significant interaction for physical activity as well, which it is not. It is particularly seen as a peculiar result as it is incongruent to the two previously discussed interactions of mother's education and economic rating of area of residence, as more educated mothers tend to produce more educated offspring, and more educated people tend to reside in more highly rated economic areas, both of which reduce the odds of being obese. Overall, this interaction result relating to university education is put down to a sampling error, and although statistically significant, is not seen to be realistic.

It needs to be reiterated that due to being a novel academic area, many of the mechanisms and explanations discussed for the interactions with Indigeneity are not backed by peer-reviewed research and are simply conjectural offerings. Additionally, the study results cannot truly be taken to be representative of the indigenous population in Australia. The sample of indigenous people in this study of 266 is small. This transfers to even smaller portions for each categorical variable. For example, 30 out of the 266 indigenous people have a university education, and 20 of these are classed as obese. This small sample size has low validity and explanatory power. Furthermore, the indigenous sample in this study is not necessarily representative of the indigenous population as a whole. The HILDA surveys are conducted over the phone and via mail for households, so only indigenous persons who are integrated within society are included. Those residing on indigenous reserves are not. Most of the indigenous population within this study sample reside in metropolitan areas. Only 1% of the study sample reside in the Northern Territory. Where as in reality, 13% of indigenous people reside in the Northern Territory (Australian Bureau of Statistics, 2005). This is a sampling error, and affects the validity of the findings. In this light, insight can be taken from this study, particular for further more robust research venture, but definite conclusions cannot be drawn.

A majority of the variables included in the analysis are statistically significant predictors for the odds of an individual being obese. Overall, the demographical, behavioural, and socioeconomic patterning of obesity in this study sample from Australia was found to align mostly with that in other studies, though some expected associations were not found to mirror those from other studies on other sample populations, highlighting the potential effect of nationality and country-specific explanatory variables.

9 CONCLUSION

This thesis sought to contribute to the extant literature and existing scholarly knowledge by uncovering socioeconomic, demographical and behavioural patterning of obesity in an Australian national cohort, and assess the interaction of Indigeneity with such variables. Specifically, the aims of this study were to identify which of an array of individual level intermediary environmental variables associate with an increased odds of being obese, which are associated with a decreased odds of being obese, and which seemingly have no statistical relation to obesity prevalence in an Australian population sample. Additionally, it was endeavoured to identify whether any of the analysed variables had a greater impact on the odds of being obese for the indigenous Australians within the sample compared to the non-indigenous Australians.

This research venture was motivated by the fact that, due to its increasing prevalence and predisposing effect on deleterious health outcomes, obesity is one of the most pressing contemporary national health concerns in Australia. Furthermore, obesity rates are significantly higher among indigenous Australians, which corresponds to the staggering and socially unjust health differential that exists between the indigenous and non-indigenous populations. Thus, research into the underlying patterning and potential aetiology of obesity, with a focus on identifying any factors that may contribute to the ethnic differential, is very much warranted.

This study employed multivariate logistic regression techniques to collectively analyse a multitude of variables which were highlighted by the pre-existing literature to pertain to obesity. Interaction terms were then included for the variable of Indigeneity to highlight any factors for which the effect on the odds of being obese is dependent upon indigenous status. It was found that numerous variables associate with obesity, revealing the potential contribution of individual level intermediary environmental variables to the obesity epidemic currently plaguing Australia. Furthermore, the magnitude of the impact on the odds of being obese for several variables was found to be exacerbated by Indigeneity.

Those variables which had a statistically significant positive association with obesity were age, being indigenous, being married, having children under 14, being a current or ex-smoker, occasional alcohol consumption, and being in paid employment. Conversely, a negative relationship with the odds of being obese was found for the variables of being physically active three or more times per week, consuming alcohol 1-2 and more than 2 times per week, having a university education, having a mother and/or father who completed year 12, and residing in an area rated in the middle and upper tiers of the SEIFA education and occupation index. While the variables of gender, year 12 and certificate/diploma education, household income, residence outside a major city, and SEIFA economic resources index rating of the area of residence were each not found to associate with the odds of being obese. The variables of mother completing year 12 and SEIFA economic resources index rating of the area of residence were found to statistically interact with Indigeneity, indicating that these factors have a greater impact on obesity for indigenous people compared to non-indigenous people.

The result of this study showcases the moderating effect of environmental factors on the prevalence of obesity, demonstrating that several socioeconomic, demographical and lifestyle variables may act as conduits for its proliferation. These findings underscore the notion that resource-efficient public health policy to curb the upsurging obesity epidemic should potentially involve health programs and promotion which are developed specifically for and targeted directly at predisposed population groups. Furthermore, 'close the gap' type programs aimed at reducing the health differential between indigenous and non-indigenous Australians should take note of the potential differing intermediary effects of environmental variables on obesity between the populations. Those variables which may more greatly predispose indigenous people to obesity than non-indigenous people would ideally be a focal point of such targeted public health policy.

As is usual in original research ventures, this study is subject to a range of limitations, which draws from the validity and generalisability of the findings. The major drawback in this study was the small size of the indigenous sample. As indigenous people make up a relatively small 3% of the total Australian population, it is difficult to acquire a study sample with a proportion of indigenous people sufficiently large to hold high explanatory power. In another potential sampling error, some of the analysed variables appeared on an optional supplementary self-complete questionnaire, so the original sample size of 19000 was significantly reduced to 10,085 individuals. The HILDA dataset is designed to be representative of the Australian population at large. Given that the sample for this study was condensed in an uncontrolled for and unaccounted for manner (subject merely to the will of individuals in the sample to complete and return the self-complete questionnaires), the results could potentially be not as representative as if the full HILDA sample was used. This should be taken into account when interpreting the study findings. An additional possible sampling error is that of the dependent variable of obesity. Best efforts were made to correct for self-serving bias in the self-reported data, but this remains imperfect. Furthermore, this study is a single cross-section, which is useful for identifying trends and correlations, but correlation does not necessarily denote causation. It cannot be feasibly concluded in a static cross-sectional study such as this that causation between the independent and dependent variables exists. Instead, a longitudinal analysis of the effect that the change in associated variables over time has on obesity is required, and would have much more powerful findings. This more advanced method of analysis was not undertaken due to time constraints, but is an avenue for further research.

There are numerous other courses for further research for which this study has set the basis for. The most obvious of which is the inclusion of other variables, particularly in the interaction analysis of Indigeneity, as the set of variables analysed in this study do not fully explain the higher incidence of obesity among the indigenous sample. Examples of supplementary variables include those relating to diet such as vegetable and fruit intake, and as well as leisure-time usage variables such as hours of television watched per week. Furthermore, the use of third-party measured as oppose to self-reported height and weight in the classification of obesity would heighten the validity of findings. Other methods such as waist-to-hip or waist-to-height ratios as well as bioelectrical impedance body fat percentage could also be employed, data depending. Conducting separate analyses for men and women is another means of expanding the frontier of knowledge in this field, as just as different variables may have differing moderating effects on obesity between indigenous and non-indigenous people, it might between males and females too.

In conclusion, this study has showcased the patterning of obesity among a nationally representative sample of the Australian population for a range of individual level socioeconomic, behavioural and demographic variables. Furthermore, it has demonstrated that some variables may have a greater or differing impact on obesity for the indigenous population than for the non-indigenous population, which works to explain the differential in obesity prevalence and overall health present between the two population groups. Overall, this study is one of the first to offer insight into such matters, and has enhanced the academic understanding of the role of individual level intermediary environmental factors on what is a contemporary health crisis in Australia.

TABLE ONE: Summary of Literature Review

Variable	Documented Relationship with BMI/Obesity	Study
GDP per capita	Positive up to $US3000	Egger, Swinburn & Islam, 2012
Real price fast-food	Negative	Chou, Grossman & Saffer, 2004
Real price restaurant food	Negative	Chou, Grossman & Saffer, 2004
Real price groceries	Negative	Chou, Grossman & Saffer, 2004; Cawley, 1999; Lakdawalla & Philipson, 2002
Real price cigarettes	Positive	Chou, Grossman & Saffer, 2004
Cessation of smoking	Positive	Pinkowish, 1999; Courtemanche, 2009
Female labour market participation	Positive	Philipson, 2001; Anderson , Butcher & Levine, 2003
Fast-food stores per capita	Positive	Chou, Grossman & Saffer, 2004; Currie et al. 2009
Restaurants per capita	Positive	Courtemanche, Pinkston, Ruhm, & Wehby, 2013
Walmart centres per capita	Positive	Courtemanche & Carden, 2009
Convenience stores per capita	Positve	Courtemanche, Pinkston, Ruhm, & Wehby, 2013
Real price of petrol	Negative	Courtemanche, 2011
Urban sprawl	Positive	Zhao and Kaestner, 2010; Vandegrift & Yoked, 2004
State unemployment rate	Positive / Negative	Zhang, Lamichhane & Wang, 2014 / Ruhm, 2000
50/10 income inequality	Negative	Courtemanche, Pinkston, Ruhm, & Wehby, 2013
Proportion population in an active job	Negative	Courtemanche, Pinkston, Ruhm, & Wehby, 2013
Socioeconomic status (Individual education or income as proxy)	Negative for women (developed nations) Positive for women and men (developing nations)	Sobal & Stunkard, 1989; McLaren 2007; Ball & Crawford, 2005
Parental education	Negative	Lamerz et al. 2005
Employment status	Negative	Ball & Crawford, 2005; Morris, Cook & Sharper, 1992
Economic wealth of area of residence	Negative	Ellaway, Anderson & Macintyre, 1997
Remoteness of residence	Positive	ARHA, 2013
On-the-job physical activity	Negative	Lakdawalla & Philipson, 2002
Hours worked per week	Positive	Courtemanche, 2009
Blue collar employment	Positive	Park, 2009
Shift work	Positive	Park, 2009
Age	Positive	Lahti-Koski, Vartianinen, Mannisto & Pietinen, 2000
Gender (female)	Positive	WHO, 2014
Marital status	Positive	Lipowicz, Gronkiewicz & Malina, 2002
Physical activity level	Negative	Kimm et al. 2005; Paeratakul, Popkin, Keyou, Adair & Stevens, 1998
Alcohol consumption	Inverted-U relationship	Suter & Tremblay, 2005
Fruit and vegetable intake	Negative	Heo, Kim, Wylie-Rosett, Allison, Heymsfield & Faith, 2011
Ethnicity	Various	Centres for Disease Control and Prevention, 2010
Indigeneity	Positive	Broussard et al. 1991; Penm, 2008

TABLE TWO: Results of Brant Detail Test of Parallel Regression Assumption Conducted on the Ordered Logistic Regression of corrected Underweight/Healthy, Overweight and Obesity on the Demographical, Lifestyle and Socioeconomic Variables

Variable	P-Value
All	0.000
Age	0.000
Gender (male)	0.000
Indigenous	0.015
Married	0.012
Children	0.301
Physically Active >3x/week	0.000
Smoking Status: Non-smoker (reference)	-
Ex-smoker	0.933
Current Smoker	0.456
Alcohol Consumption: Non-drinker (reference)	-
Occasionally	0.124
1-2x/week	0.127
>2x/week	0.001
Employment	0.008
Household Income	0.803
Education Level: <Year 12 (reference)	-
Year 12	0.012
Certificate/Diploma	0.033
University Plus	0.000
Mother completed year 12	0.319
Father completed year 12	0.259
Residing outside a major city	0.452
SEIFA economic resources: Lower (reference)	-
Middle	0.480
Higher	0.463
SEIFA education/occupation: Lower (reference)	-
Middle	0.090
Higher	0.184

A significant test statistic provides evidence that the parallel regression assumption has been violated.

TABLE THREE: Descriptive Characteristics of Sample by Indigenous Identity

Variable	Non-Indigenous (n=9829)		Indigenous (n=266)		Difference (Ha P-value)
	Mean	95% CI	Mean	95% CI	
Obese (self reported)	0.26	0.25-0.27	0.41	0.35-0.47	0.000
Obese (corrected)	0.33	0.32-0.34	0.48	0.42-0.54	0.000
Age	43.00	42.64-43.37	33.48	31.71-35.25	0.000
Gender (male)	0.46	0.45-0.47	0.2	0.36-0.48	0.172
Married	0.58	0.57-0.59	0.44	0.38-0.50	0.000
Children (has children under 14)	0.31	0.30-0.32	0.39	0.33-0.45	0.016
Physically active >3x/week	0.35	0.34-0.36	0.32	0.26-0.8	0.386
Smoking Status	0.60	0.59-0.62	1.03	0.92-1.14	0.000
Alcohol Consumption	1.86	1.83-1.88	1.52	1.38-1.65	0.000
Employment (is in paid work)	0.67	0.66-0.68	0.56	0.50-0.62	0.000
Household income	87888.48	86279-89497	70920.23	61054-80786	0.000
Education level	2.51	2.48-2.53	2.09	1.97-2.22	0.000
Mother’s education (completed year 12)	0.29	0.28-0.30	0.23	0.18-0.28	0.025
Father’s education (completed year 12)	0.28	0.27-0.29	0.17	0.12-0.21	0.000
Residing outside a major city	0.39	0.38-0.40	0.52	0.46-0.58	0.000
SEIFA economic resources index	2.01	1.99-2.02	1.58	1.50-1.66	0.000
SEIFA education and occupation index	2.05	2.03-2.07	1.62	1.53-1.70	0.000

TABLE FOUR: Distribution of Sample Among Categorical Variables by Indigenous Identity

Variable	(Binary) Value	Non-Indigenous (n=9829)	Indigenous (n=266)
		% of Sample	% of Sample
Obese (self reported)	(0) Non-obese	74.24	59.40
	(1) Obese	25.76	40.60
Obese (corrected)	(0) Non-obese	67.19	51,88
	(1) Obese	32.81	48.12
Gender	(0) Female	54.07	58.27
	(1) Male	45.93	41.73
Marital Status	(0) Non-married	41.66	56.02
	(1) Married	58.34	43.98
Children	(0) No children under 14	68.61	61.28
	(1) Children	31.39	38.72
Physically active >3x/week	(0) No	65.53	68.05
	(1) Yes	34.47	31.95
Smoking status	(0) Non-smoker	57.27	37.22
	(1) Ex-smoker	25.12	22.56
	(2) Current smoker	17.60	40.23
Alcohol consumption	(0) Non-drinker	16.33	22.56
	(1) Occasionally	22.62	32.33
	(2) 1-2x/week	20.11	16.17
	(3) >2x/week	40.94	28.95
Employment	(0) Not in paid work	32.89	43.61
	(1) In paid work	67.11	56.39
Education level	(1) < Year 12	28.26	40.60
	(2) Year 12	17.02	20.68
	(3) Certificate/Diploma	30.56	27.44
	(4) University plus	24.16	11.28
Mother's education	(0) < Year 12	70.75	76.69
	(1) Year 12	29.25	23.31
Father's education	(0) < Year 12	71.71	83.46
	(1) Year 12	28.29	16.54
Place of Residence	(0) Major city	61.01	48.12
	(1) Regional or Remote	38.99	51.88
SEIFA economic resources	(1) Lower	29.06	53.76
	(2) Middle	41.00	34.59
	(3) Upper	29.94	11.65
SEIFA education/occupation	(1) Lower	27.50	51.50
	(2) Middle	40.02	35.34
	(3) Upper	32.48	13.16

TABLE FIVE: Multivariate Logistic Regression Predicting Obesity (corrected) from Demographic, Lifestyle, and Socioeconomic Factors

Variable	Coefficient	Odds-ratio	Std. Err.	95% CI	P-value
Constant	-1.0288	0.3574	0.1194	0.28-0.45	0.000
Age	0.0134	1.0135	0.0016	1.01-1.02	0.000
Gender (male)	-0.0317	0.9688	0.0456	0.89-1.06	0.487
Indigenous	0.5894	1.8029	0.1310	1.39-2.33	0.000
Married	0.1279	1.1365	0.0491	1.03-1.25	0.009
Children	0.1112	1.1176	0.0517	1.01-1.24	0.031
Physically Active >3x/week	-0.5657	0.5680	0.0487	0.52-0.62	0.000
Smoking Status: Non-smoker (reference)	-	-	-	-	-
Ex-smoker	0.2635	1.3015	0.0536	1.17-1.45	0.000
Current Smoker	0.1269	1.1353	0.0613	1.01-1.28	0.039
Alcohol Consumption: Non-drinker (reference)	-	-	-	-	-
Occasionally	0.2242	1.2514	0.0704	1.09-1.44	0.001
1-2x/week	-0.2136	0.8077	0.0774	0.69-0.94	0.006
>2x/week	-0.2058	0.8140	0.0679	0.71-0.93	0.002
Employment	0.1480	1.1595	0.0548	1.04-1.29	0.007
Household Income	6.29e-07	1.0000	3.28e-07	1.00-1.00	0.055
Education Level: <Year 12 (reference)	-	-	-	-	-
Year 12	-0.0748	0.9279	0.0727	0.80-1.07	0.303
Certificate/Diploma	0.1000	1.1052	0.0579	0.99-1.24	0.084
University Plus	-0.2281	0.7960	0.0689	0.70-0.91	0.001
Mother completed year 12	-0.1988	0.8197	0.0599	0.73-0.92	0.001
Father completed year 12	-0.1433	0.8665	0.0600	0.77-0.97	0.017
Residing outside a major city	0.0713	1.0739	0.0513	0.97-1.19	0.165
SEIFA economic resources: Lower (reference)	-	-	-	-	-
Middle	0.0139	1.0140	0.0633	0.90-1.15	0.826
Higher	-0.0252	0.9751	0.0893	0.82-1.16	0.778
SEIFA education/occupation: Lower (reference)	-	-	-	-	-
Middle	-0.2786	0.7566	0.0607	0.67-0.85	0.000
Higher	-0.5276	0.5900	0.0845	0.50-0.70	0.000

TABLE SIX: Multivariate Logistic Regression Predicting Obesity (corrected) from Demographic, Lifestyle, and Socioeconomic Variables with the Interaction (#) of Indigeneity

Variable	Coefficient	Odds-ratio	Std. Err.	95% CI	P-value
Constant	-1.0401	0.3531	0.1199	0.28-0.45	0.000
Age	0.0134	1.0135	0.0016	1.01-1.02	0.000
Gender (male)	-0.0297	0.9708	0.0456	0.89-1.06	0.516
Indigenous	0.6510	1.9173	0.2401	1.20-3.07	0.007
Married	0.1288	1.1374	0.0492	1.03-1.25	0.009
Children	0.1150	1.1219	0.0518	1.01-1.24	0.026
Physically Active >3x/week	-0.5684	0.5664	0.0488	0.51-0.62	0.000
Smoking Status: Non-smoker (reference)	-	-	-	-	-
Ex-smoker	0.2629	1.3006	0.0537	1.17-1.44	0.000
Current Smoker	0.1318	1.1408	0.0614	1.01-1.29	0.032
Alcohol Consumption: Non-drinker (reference)	-	-	-	-	-
Occasionally	0.2258	1.2533	0.0705	1.09-1.44	0.001
1-2x/week	-0.2079	0.8122	0.0775	0.70-0.95	0.007
>2x/week	-0.2006	0.8183	0.0680	0.72-0.93	0.003
Employment	0.1430	1.1537	0.0548	1.04-1.28	0.009
Household Income	6.47e-07	1.0000	3.29e-07	1.00-1.00	0.049
Father completed year 12	-0.1458	0.8643	0.0601	0.77-0.97	0.015
Residing outside a major city	0.0785	1.0817	0.0515	0.98-1.20	0.127
SEIFA education/occupation: Lower (reference)	-	-	-	-	-
Middle	-0.2766	0.7584	0.0608	0.67-0.85	0.000
Higher	-0.5253	0.5914	0.0847	0.50-0.70	0.000
Education Level: <Year 12 (reference)	-	-	-	-	-
Year 12	-0.0840	0.9195	0.0742	0.80-1.06	0.258
Certificate/Diploma	0.0918	1.0961	0.0588	0.98-1.23	0.118
University Plus	-0.2605	0.7706	0.0697	0.67-0.88	0.000
Education Level # Indigenous <Year 12 (reference)	-	-	-	-	-
Year 12	0.1987	1.2200	0.3692	0.59-2.52	0.590
Certificate/Diploma	0.1987	1.2199	0.3317	0.64-2.34	0.549
University Plus	1.6601	5.2600	0.4945	2.00-13.86	0.001
Mother completed year 12	-0.1773	0.8375	0.0606	0.74-0.94	0.003
Mother completed year 12 # Indigenous	-0.7386	0.4778	0.3392	0.25-0.93	0.029
SEIFA economic resources: Lower (reference)	-	-	-	-	-
Middle	0.0216	1.0218	0.0642	0.90-1.16	0.737
Higher	-0.0069	0.9932	0.0899	0.83-1.18	0.939
SEIFA economic resources # indigenous: Lower (reference)	-	-	-	-	-
Middle	-0.2284	0.7958	0.2972	0.44-1.42	0.442
Higher	-0.9694	0.3793	0.4854	0.15-0.98	0.046

TABLE SEVEN: Public Indigenous Programs and Projects Centred on Maternity and Child Nutrition

Title of Program	Reach
A-B See with Wor-Ra-Kee (Karuah Family Nutrition and School Access Project)	NSW
Active-ate	QLD
Be active eat well	VIC
Binya Gurang - Promotion of breastfeeding to Aboriginal and Torres Strait Islander women	NSW
Bulgarr Ngaru fruit and vegetable program and market garden	NSW
Cherbourg healthy pregnancies project	QLD
Child health nutrition education and support program	SA
Childhood healthy weight project	NT
Cool CAP school canteen accreditation program	TAS
CREATE healthy eating in schools	SA
Early childhood nutrition and anaemia prevention program	NT
Family food patch project	TAS
Family nutrition project	NT
Filling the gaps; nutrition and physical activity needs assessment for children	VIC
Folate intake and blood folate levels in the Western Australian Aboriginal population	WA
Footprints in time: the longitudinal survey of Indigenous children	National
Fresh for kids	NSW
Fresh tastes NSW healthy school canteen strategy	NSW
Fun not fuss with food program	QLD
Genetic and environmental determinants related to recurrent, low grade disease in Aboriginal children	QLD
Gomeroi gaaynggal – Gomeroi babies program	NSW
Good food great kids - Yarra Valley community health service 2002-2004	VIC
Good start breakfast club	National
Growing strong: feeding you and your baby	QLD

Growth assessment and action (GAA) data collection program	NT
Growth assessment and action (GAA) program	QLD
Healthier babies and preschoolers through child care services	SA
Healthy active Australia community and schools grants program	National
Healthy eating advisory service	VIC
Healthy eating schools program	VIC
Healthy for life	National
Healthy jarjums make healthy food choices	QLD
Healthy Kids	ACT
Healthy Kids - Food is Fun project	NSW
Healthy Kids - Healthy Food for Kids in Care project	NSW
Healthy Kids - Healthy Kids, Eat Right, Play Right	NSW
Healthy Kids Queensland Physical Activity and Nutrition Survey	QLD
Healthy Options Tasmania (HOT)	TAS
Healthy ways project	SA
Hero rewards	National
Infant feeding guidelines	NT
Inside outside	ACT
Karralika 'Plot to plate' garden program	ACT
Kids - 'Go for your life'	VIC
Kitchen garden at Red Hill School	ACT
Kool purple kookas	NSW
Koori kook up	NSW
Live outside the box primary school project	NSW
Move well eat well for schools project	TAS
National Aboriginal and Torres Strait Islander child and maternal health exemplar site initiative	National
National Aboriginal and Torres Strait Islander Nutrition Strategy and Action Plan 2000-2010 (NATSINSAP)	National

National child nutrition projects	National
New directions bubba's business program	QLD
Nganampa Health Council Child and maternal health program	SA
NPY child nutrition and wellbeing program	NT
Nutrition and physical activity program	NT
Nutrition ready-to-go at out of school hours care (OOSHC)	NSW
Physical activity and nutrition out of school hours care program	QLD
School Nutrition Program	NT
Sea of bellies	NSW
Start right eat right	TAS
Start Right Eat Right Award	VIC
Stay strong and healthy – it's worth it	NSW
Strong family, strong culture program	WA
Strong women, strong babies, strong culture	NT
Study of environment on Aboriginal resilience and child health (SEARCH)	NSW
Taste bubs strong babies solid start	WA
Tennant Creek Primary School – Healthy food happy kids	NT
The Aboriginal birth cohort study	National
Toddler tucker program	WA
Waltja early childhood and nutrition projects	NT
Waltja's APY Mother's and Children's program	NT
Well Baby Clinic	NT
Western Australian healthy schools project (WAHSP)	WA
Working together for healthier Mullewa kids	WA

SOURCE: http://www.healthinfonet.ecu.edu.au/health-risks/nutrition/programs-projects/maternal-child-nutrition

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THESIS TOPIC SELECTION

My interest in economics and the desire to undertake postgraduate research in the area was sparked on a flight from Melbourne to Townsville in late 2010 when I read the book 'Freakonomics', written by University of Chicago economist Dr. Steven Levitt and New York Times journalist Stephen J. Dubner. A peculiar title that has since become an international best-seller, it covers some of the research undertaken by Dr. Levitt, where he applies standard economic theory to a diverse range of subject matter that is generally considered outside the realms of study of traditional economics. Topics of research indulged in by Dr. Levitt and presented in 'Freakonomics' include the socioeconomic patterning of baby names, information control as it pertains to Ku Klux Klan members and real estate agents, the economics of crack cocaine drug dealing, the impact of legalized abortion on crime rates, and many more new-fangled topics. Aside from offering novel and somewhat wry insight into many social phenomena, 'Freakonomics' opened my eyes to the expansive horizon of study that economics can encompass. It revealed to me the notion that economics is not just the study of money markets and the trade of commodities, as purported by many, but at its core, is a social science and the study of human beings. The way in which Dr. Levitt applied the analytical thinking of economics to social systems inspired me, and got me thinking of what other social issues the tools of economics could be applied to.

As an undergraduate student I studied a double degree of business (majoring in economics) and sport and exercise science. Within the latter degree, subject content included the physiology and treatment as well as health implications of obesity, which has become both a national and global health crisis of epidemic proportions. My studies in exercise science looked at the physiological causes and consequences of obesity, but given that it is not an infectious condition, but is lifestyle driven due to the day-to-day choices that people make, the economist in me figured that there might be factors at play on a larger scale that could at least partly explain the huge upsurge in obesity rates that has occurred within Australia and across the western world over the last few decades. I sought to investigate this further, and upon being invited to undertake honours in economics at the completion of my undergraduate studies, this formed the general area of interest for my research and subsequent thesis.

I thought about the possibility of socioeconomic drivers of obesity. Research into the area revealed some work had been done on the patterning and affect of aggregate level variables on obesity, but little had been done on individual level variables, particularly for an Australian population. In my preliminary stage of research I delved into the statistics concerning obesity within Australia, which brought to light the startling differential in obesity rates that exists between the non-indigenous and indigenous populations, being 18% versus 34% respectively. Given my knowledge of the health implications of being obese, I intuitively figured that this differential was at least partly to blame for the much publicised health ‘gap’ present between the two populations, the most shocking statistic being that indigenous persons have a 12 year lower life expectancy. In addition to the ‘gap’ in health that is present between the two populations, a gap of similar nature in socioeconomic status also exists. Together this equates to an indigenous population that is extremely under-privileged relative to the non-indigenous population, both in health and in socioeconomic status. Social disadvantage such as this concerns me, as it does most human beings, and in turn, I’m very interested in both its causes and potential cures. I thus decided to focus my research particularly on the relationship that exists between socioeconomic factors and the incidence of obesity for the general Australian population, but with a particular emphasis on the indigenous.

This subject of study interests me immensely, and so was a natural choice for my thesis, as I felt this would mean the work entailed would be a joyful endeavour, as oppose to a chore. Furthermore, it is a topic that in my mind was calling out to be studied, and one that could potentially hold important policy, and in turn, social as well as economic implications. This gave me great motivation moving forward.