UNTANGLING THE HEALTH CONSEQUENCES AND ADVERSE LABOUR MARKET OUTCOMES OF OBESITY IN THE AUSTRALIAN ADULT POPULATION: NEW INSIGHTS FROM LONGITUDINAL DATA

A Thesis submitted by

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ABSTRACT

The rising prevalence of obesity is a pressing public health issue worldwide. The prevalence of obesity has almost tripled since 1975, and in 2016 it was estimated that over 650 million adults aged 18 years and above were obese, worldwide. Rising obesity is also a serious public health concern in Australia. The prevalence of obesity has sharply increased since 1995, and nearly one in three adults in Australia are obese. It is estimated that more than three-quarters of Australia's adult population will be either overweight or obese by 2025. The high prevalence and severity of obesity impose a substantial burden on Australian individuals, families, the health system and the economy. Understanding obesity-induced health and economic costs and ascertaining the source of these costs are imperative for formulating appropriate public policies. Therefore, this thesis aims to investigate the prevalence, identify the associated risk factors, and disentangle the various burdens of obesity. This thesis put a particular emphasis on the economics of obesity. It applies a wide range of health econometric techniques to provide new evidence on the relationships between obesity, health and labour market outcomes. This 'PhD by publication' thesis is an accumulation of twelve individual studies using data from a nationally representative longitudinal survey, Household, Income and Labour Dynamics in Australia Survey (HILDA). The research articles included are divided into three main parts: prevalence and risk factors of obesity; health and well-being costs of obesity; and adverse labour market outcomes of obesity.

- **The rising prevalence and risk factors of adult obesity in Australia:** The first part of the thesis outlines the prevalence and associated risk factors of adult obesity in Australia. It includes three individual studies. The first study demonstrates the trend in the prevalence of adult obesity and its association with geographic remoteness. The second reveals the impact of disadvantaged neighbourhood and lifestyle characteristics on obesity. The third explores the association between job-related factors and obesity in the Australian adult population following a retrospective research design.
- **Untangling the health consequences of adult obesity in Australia:** The second part of the thesis includes five individual studies that articulate the health and well-being costs of obesity in Australia. The first study captures the chronic disease burden of obesity in Australia. The second explores the longitudinal association between obesity and disability. The third shows the link between obesity and higher healthcare services utilization. The fourth reveals the relationships between obesity and self-assessed

general and mental health. The fifth demonstrates the diminishing health-related quality of life due to different comorbid chronic diseases in the obese population.

- **Obesity and adverse labour market outcomes:** The third part of the thesis consists of four separate studies on adverse labour market outcomes. These four articles demonstrate that obese people have higher absenteeism, higher presenteeism, lower levels of job satisfaction, and increased employment discrimination.

The evidence from this thesis should be helpful for health policy-makers to find ways to reduce the rising prevalence of obesity, health and well-being costs, and the associated adverse labour market outcomes.

Keywords: Absenteeism, Australia, Chronic disease burden, Disability, Disadvantaged neighbourhoods, employment discrimination, Geographic remoteness, Health consequences, Health-related quality of life, HILDA, Job-related characteristics, Job satisfaction, Labour market outcomes, Obesity, Presenteeism

CERTIFICATION OF THESIS

This thesis is the work of Syed Afroz Keramat except where due reference is made, with the majority of the authorship of the papers presented as a thesis by publication undertaken by the student.

The work contained in this thesis is original and has not previously been submitted for a degree at any other higher education institutions, except where acknowledged.

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Student and supervisors' signatures of endorsement are held at the University of Southern Queensland (USQ).

STATEMENT OF PUBLICATIONS AND OTHER RESEARCH CONTRIBUTIONS

This PhD thesis is drawn from the following published and submitted papers in peer review journals. I am the lead author for all of the publications and manuscripts. I led the writing of the manuscript, from initial drafting to final revisions, and had final ownership of the submission. I contributed to 95% of the quantitative analyses and over 75% of the conception, design, interpretation of results, and preparation of manuscripts for each study. I gratefully acknowledge the guidance and work of many others in the published and submitted studies contained in this thesis.

Article I: Keramat, S. A., Alam, K., Al-Hanawi, M. K., Gow, J., Biddle, S. J. H, & Hashmi, R. (2021). Trends in the prevalence of adult overweight and obesity in Australia, and its association with geographic remoteness. Scientific Reports, 11(1), 1-9.

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Article IV: Keramat, S. A., Alam, K., Rana, R. H., Chowdhury. R., Farjana, F., Hashmi, R., Gow, J., & Biddle, S. J. H. (2021). Obesity and the risk of developing chronic diseases in middle-aged and older adults: Findings from an Australian longitudinal population survey, 2009-2017. PloS one (Accepted).

Article V: Keramat, S. A., Alam, K., Sathi, N. J., Gow, J., Biddle, S. J. H., & Al-Hanawi, M. K. (2021). Self-reported disability and its association with obesity and physical activity in Australian adults: Results from a longitudinal study. SSM-Population Health, 14, 100765.

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Article VII: Keramat, S. A., Alam, K., Ahinkorah, B. O., Islam, M. S., Islam, M. I., Hossain, M. Z., Ahmed, S., Gow, J., & Biddle, S. J. (2021). Obesity, Disability and Self-Perceived Health Outcomes in Australian Adults: A Longitudinal Analysis Using 14 Annual Waves of the HILDA Cohort. ClinicoEconomics and Outcomes Research, 13, 777-788.

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Article VIII: Keramat, S. A., Alam, K., Ahinkorah, B.O., Aboagye, R.G., Saha, M., Samad, N., Gow, J., Biddle, S. J. H. and Seidu, A. A. (2021). Comorbid Chronic Diseases and Health-related Quality of Life in the Obese Population: a Longitudinal Analysis of a Nationally Representative Household Survey in Australia. SSM-Population Health (under review).

Article IX: Keramat, S. A., Alam, K., Gow, J., & Biddle, S. J. H. (2020). Gender differences in the longitudinal association between obesity, and disability with workplace absenteeism in the Australian working population. PloS one, 15(5), e0233512.

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Article X: Keramat, S. A., Alam, K., Gow, J., & Biddle, S. J. H. (2020). A longitudinal exploration of the relationship between obesity, and long term health condition with presenteeism in Australian workplaces, 2006-2018. PloS one, 15(8), e0238260.

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Article XI: Keramat, S. A., Alam, K., Gow, J., & Biddle, S. J. H. (2020). Obesity, long-term health problems, and workplace satisfaction: a longitudinal study of Australian workers. Journal of Community Health, 45(2), 288-300.

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DEDICATION

I want to dedicate my PhD thesis to my beloved parents (Syed Ali Asfer and Afroja Asfer) for their endless love, support, encouragement, and dua; and my son (Syed Md Jabir Abdullah) for bringing good fortune and more luck into my academic and personal life.

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ACRONYMS AND ABBREVIATIONS

ABS	Australian Bureau of Statistics
ADA	Australian Data Archive
AHPF	Australian Health Performance Framework
AIHW	Australian Institute of Health and Welfare
ANOVA	Analysis of Variance
AOR	Adjusted Odds Ratio
ASGC	Australian Standard Geographical Classification
ATSI	Aboriginal or Torres Strait Islander
AUD	Australian Dollar
BHPS	British Household Panel Survey
BMI	Body Mass Index
BP	Bodily Pain
CD	Census Collection District
CI	Confidence Interval
CS	Composite Score
CVD	Cardiovascular Disease
DALYs	Disability-adjusted Life Years
DSS	Department of Social Services
GBD	Global Burden of Disease
GEE	Generalized Estimating Equation
GH	General Health
GLM	Generalized Linear Model
GLS	Generalized Least Squares Estimates
HILDA	Household, Income and Labour Dynamics in Australia Survey
HRQoL	Health-related Quality of Life
ICF	International Classification of Functioning, Disability, and Health
IER	Index of Economic Resources
IRR	Incidence Rate Ratio
IRSAD	Index of Relative Socioeconomic Advantage and Disadvantage
K10	Kessler Psychological Distress Scale
LOCF	Last Observation Carried Forward
LTHC	Long-term health condition

MCS	Mental Component Summary
MET	Metabolic Equivalent of Task
MH	Mental Health
MHI-5	Mental Health Inventory-5
MRP	Marginal Revenue Product
NCDs	Non-communicable Diseases
NCLD	National Centre for Longitudinal Data
NHS	National Health Survey
OECD	Organisation for Economic Co-operation and Development
OR	Odds Ratio
PCS	Physical Component Summary
PF	Physical Functioning
PSID	Panel Study of Income Dynamics
QoL	Quality of Life
RE	Role Emotional
RP	Role Physical
SCQ	Self-completion Questionnaire
SD	Standard Deviation
SEIFA	Socio-Economic Indexes for Areas
SEM	Social-Ecological Model
SOEP	German Socio-Economic Panel
SF	Social Functioning
SF-6D	Short-Form Six-Dimension
SF-36	36-Item Short-Form Health Survey
US	United States
VT	Vitality
WC	Waist Circumference
WHO	World Health Organization
ZINB	Zero-Inflated Negative Binomial

LIST OF PUBLICATIONS AND UNDER-REVIEW ARTICLES ARISING FROM THE THESIS

Article I: Keramat, S. A., Alam, K., Al-Hanawi, M. K., Gow, J., Biddle, S. J. H, & Hashmi, R. (2021). Trends in the prevalence of adult overweight and obesity in Australia, and its association with geographic remoteness. Scientific Reports, 11(1), 1-9.
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LIST OF PUBLICATIONS THAT I CONTRIBUTED TO THROUGHOUT THE PHD PROGRAM (BUT NOT CONSIDERED PART OF THE THESIS)

Article I: Alam, K., Mahumud, R. A., Alam, F., **Keramat, SA.**, Erdiaw-Kwasie, M. O., & Sarker, A. R. Determinants of access to eHealth services in regional Australia. International journal of medical informatics, 2019; 131, 103960.
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Article II: Ahmad, K., Khanam, T., **Keramat, S. A.,** Islam, M. I., Kabir, E., & Khanam, R. (2020). Interaction between the place of residence and wealth on the risk of overweight and obesity in Bangladeshi women. PloS one, 15(12), e0243349.
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Article V: Mahumud, RA, Gow, J, Alam, K, **Keramat, S. A.**, Hossain, MG, Sultana, M, Sarker, AR, Islam, SMS. Cost-effectiveness of the introduction of two-dose bi-valent (Cervarix) and quadrivalent (Gardasil) HPV vaccination for adolescent girls in Bangladesh. Vaccine, 2020; 38(2):165-172.
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Article VI: Mahumud, RA, Alam, K, **Keramat, S. A.**, Ormsby, G. M., Dunn, J., & Gow, J. (2020). Cost-effectiveness evaluations of the 9-Valent human papillomavirus (HPV) vaccine: Evidence from a systematic review. PloS one, 15(6), e0233499.

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Article VII: Mahumud, RA, **Keramat, S. A.**, Ormsby, GM, Sultana, M, Rawal, LB, Alam, K, Gow, J, Renzaho, AM. Wealth-related inequalities of women's knowledge of cervical cancer screening and service utilisation in 18 resource-constrained countries: Evidence from a pooled decomposition analysis. International Journal for Equity in Health, 2020; 19(1): 1- 15.
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Article VIII: Mahumud, RA, Alam, K., **Keramat, S. A.,** Renzaho, A. M., Hossain, M. G., Haque, R., & Gow, J. (2020). Wealth stratified inequalities in service utilisation of breast cancer screening across the geographical regions: a pooled decomposition analysis. Archives of Public Health, 78(1), 1-12.
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Article X: Haque, R., Alam, K., Rahman, S. M., Keramat, S. A., & Al-Hanawi, M. K. (2021). Women's empowerment and fertility decision-making in 53 low and middle resource countries: a pooled analysis of demographic and health surveys. BMJ open, 11(6), e045952.
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Article XI: Mahumud, R. A., Dawson, A. J., Chen, W., Biswas, T., **Keramat, S. A.,** Morton, R. L., & Renzaho, A. M. (2021). The risk and protective factors for suicidal burden among 251 763 school-based adolescents in 77 low-and middle-income to high-income countries: assessing global, regional and national variations. Psychological medicine, 1-19.
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CHAPTER 1: INTRODUCTION

1.1 Context

Overweight and obesity are global public health problems. The rates of overweight and obesity in Australia have risen to an epidemic level over the past two decades. In 2017-18, nearly two-thirds of Australian adults were either overweight or obese, and one in three adults were obese (Australian Bureau of Statistics, 2018a). Obesity has become a burden to the Australian economy due to the higher direct health costs and indirect non-healthcare costs associated with its increased incidence. In 2011-12, the total annual cost of obesity to the Australian economy was AUD 8.6 billion, of which 3.8 billion were direct, and 4.8 billion were indirect costs (PwC Australia, 2015). However, these costs did not account for lost well-being and foregone earnings. The annual costs would reach AUD 120 billion if reduced well-being were included (The Herald/Age, 2011). It is estimated that the costs of obesity will rise significantly by 2024-25 due to the higher prevalence of severely obese people (Body Mass Index [BMI] $\geq$ 40) (PwC Australia, 2015).

Obesity has a significant impact on people's health and leads to adverse labour market outcomes. In 2015, it was a leading contributor to non-fatal burden (living with the disease), and 8.4% of the total disease burden was attributable to overweight and obesity in Australia (Australian Institute of Health and Welfare, 2020a). Obesity is the leading risk factor for non-communicable diseases (NCDs) (Atlantis et al., 2009), and there is robust evidence that severe obesity is associated with higher all-cause mortality (Flegal et al., 2013). However, there is little empirical evidence regarding the hidden health burden of obesity in Australia. In particular, less is known about the effects of obesity on adverse health outcomes, such as disability, comorbid chronic conditions, health-related quality of life, and self-assessed physiological and psychological health.

There is growing evidence in the literature that obesity is associated with adverse labour market outcomes (Averett and Keorenman, 1996). The most commonly observed effect is that obese people, especially obese women, face discrimination in getting jobs and earn lower wages (Averett, 2014). Obese people also have lower productivity and have higher absenteeism rates than the non-obese (Averett, 2014). However, there is no current evidence of whether obesity affects other labour market outcomes, such as presenteeism, job satisfaction, and job discrimination in a longitudinal research setting. For public policymakers, it is essential to identify the degree and direction of the relationship between obesity and adverse labour market outcomes to enable the design of effective public policy (Averett, 2014).

Therefore, it is crucial to identify the adverse effects of obesity beyond the traditional health burden and labour market outcomes. This study attempts to discover the impact of obesity on individual's health and working lives so that policymakers could design policies that are more effective. In exploring these themes, this thesis will contribute to the field of economics of obesity.

1.2 Definition of obesity

Monitoring the incidence and prevalence of overweight and obesity is invaluable to policymakers in identifying population groups at risk, checking the burden of obesity, and developing prevention strategies. Overweight and obesity refer to the accumulation of abnormal or excessive fat in the body that poses a risk to health (World Health Organization, 2020a). Various methods are frequently used to measure weight status, such as waist circumference, waist to hip ratio, and skinfold thickness. The most common measure used for monitoring overweight and obesity, particularly in large population samples, is Body Mass Index (BMI). BMI is measured using the formula of weight (in kilograms) divided by height (in metres) squared. BMI is considered an appropriate and internationally recognised measure of defining obesity at the population level for both adults and children, notwithstanding some limitations, including the use of self-reported data (Gorber et al., 2007a). The World Health Organization (WHO) has set standard cut-off points for BMI to describe an individual's weight status. An adult will be defined as obese if their BMI is ≥ 30. Table 1 displays details about the body size classification and the concerned BMI scores.

Table 1: BMI classifications for adults

Body size classification	**BMI (kg/m^2)**
Underweight	< 18.50
Normal/healthy weight	18.50-24.99
Overweight/pre-obese	25.00-29.99
Obese	≥ 30.0
Obese class I	30.00-34.99
Obese class II	35.00-39.99
Obese class III	≥ 40.0

Source: (World Health Organization, 2021)

1.3 The obesity epidemic in Australia

The prevalence of obesity has been rising alarmingly in developed nations in recent decades. Australia ranked sixth in adult obesity among OECD member countries in 2019 (Australian Institute of Health and Welfare, 2019a). In 2017-18, nearly two in three (67%) adults were overweight or obese, and one in three adults were obese (31%) (Australian Bureau of Statistics, 2018a). The combined rates were 63% and 57% in 2014-15 and 1995, respectively (Australian Institute of Health and Welfare, 2017a). The prevalence of severe obesity (BMI ≥ 35) has nearly doubled over the past two decades, to 9% in 2014-15 from 5% in 1995 (Australian Institute of Health and Welfare, 2017a). Figure 1 displays comparative statistics in the prevalence of overweight and obesity in two different periods, 1995 and 2017-18.

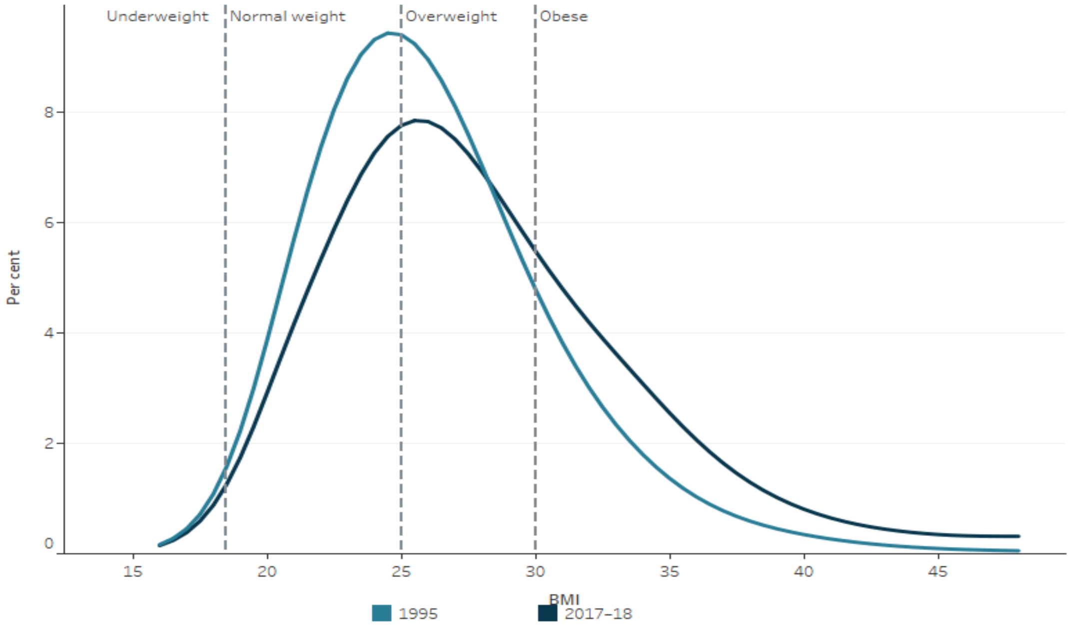

Figure 1: Proportion of obesity among Australian adults, 1995 and 2017-18

Source: (Australian Institute of Health and Welfare, 2020b)

It is estimated that the majority (over three-quarters) of Australian adults will be either overweight or obese by 2025, with a tripling in the prevalence of severe obesity compared to the level in 1995 (Hayes et al., 2017). It is also projected that 83% of men and 75% of women aged over 20 years will be overweight or obese by 2025 if the current epidemic level is unchecked (Obesity Policy Coalition, 2018).

1.4 Age and sex-specific obesity rates in Australia

The prevalence of adult overweight and obesity in men and women has increased over the past decades in Australia. Figure 2 presents the trend in the prevalence of overweight and obesity by gender. The figure shows that the proportion of overweight and obesity combined was higher in males (75%) than females (60%) in 2017-18. However, the rates were 71% and 64% in men, and 56% and 49% in women in 2014-15 and 1995, respectively (Figure 2). The gap is much narrower in the case of obesity prevalence only. In 2017-18, the proportion of obesity in men and women were 33% and 30%, respectively (Australian Bureau of Statistics, 2018a).

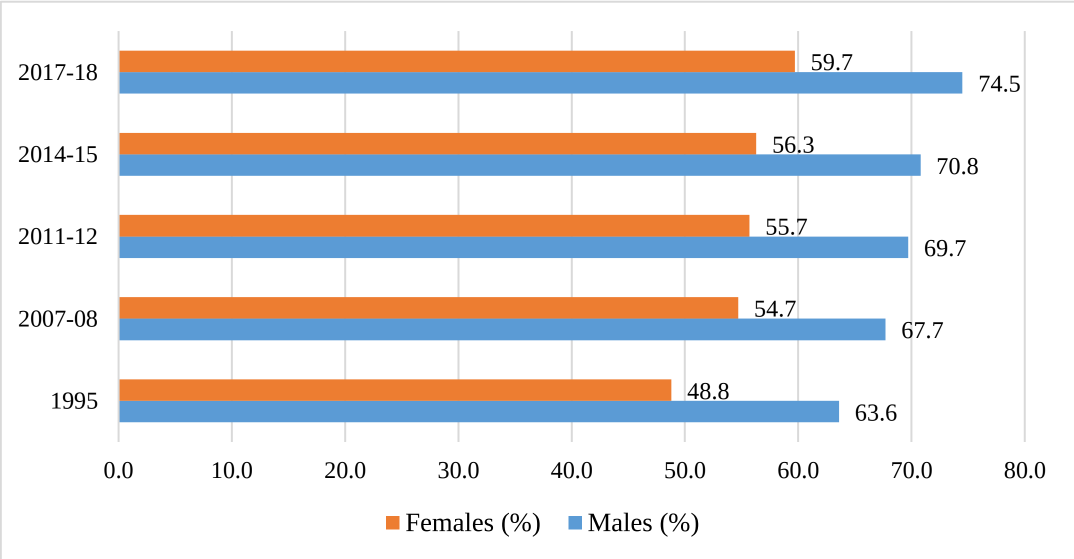

Figure 2: Trends in the prevalence of overweight and obesity by gender, 1995 to 2017-18

Source: (Australian Bureau of Statistics, 2018a)

Figure 3 demonstrates the prevalence of overweight and obesity by age groups and gender in 2017-18. The figure shows that 83% and 73% of Australian men and women aged 65 to 74 were obese. It also highlights that proportion of overweight and obesity was above 60% among the adults aged 35 years and over irrespective of gender.

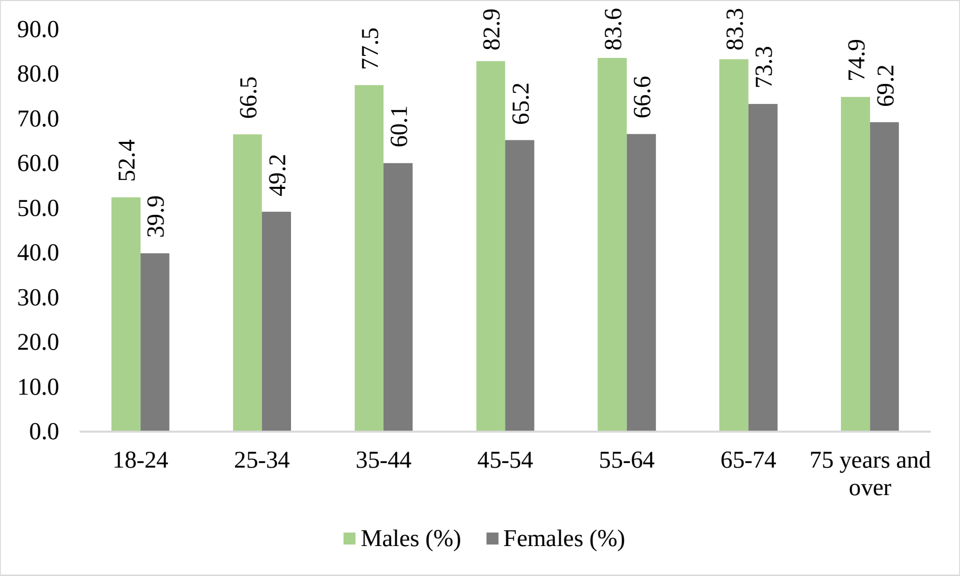

Figure 3: Proportion of overweight and obesity by age groups and gender, in 2017-18
Source: (Australian Bureau of Statistics, 2018a)

1.5 Factors influencing overweight and obesity

There is a perception that overweight and obesity arise from a sustained energy or caloric imbalance, meaning that energy intake through eating and drinking is higher than the energy released through movement. According to the CDC, consuming low-nutrient and energy-dense food and beverages, performing no or low physical activity, having a sedentary lifestyle, and insufficient sleep may lead to weight gain (Centers for Disease Control and Prevention, 2016). Besides, factors such as an individual's appetite, satiety, metabolism, and body fat distribution contribute to weight gain (National Health and Medical Research Council, 2013). However, an earlier study developed a model that shows that obesity is a multifactorial condition (Butland et al., 2007). A complex interaction between factors, such as genetics, environment, behaviours and societal factors, contributes to a positive energy balance (Australian Institute of Health and Welfare, 2017a). Key factors that contributed to developing overweight and obesity are displayed in Figure 4. The figure shows that broad factors, such as societal, environmental, socioeconomic, knowledge, attitudes, beliefs, health behaviours, psychological, safety, and biological directly or indirectly influence overweight and obesity. More specifically, many factors perform together or alone in developing overweight and obesity, wherein some elements have a higher direct impact on adiposity than others. These broad factors have a complex interplay and may influence the individual risk factors of obesity. For example, socioeconomic characteristics affect the common risk factors, such as dietary pattern, exercise, and obesogenic environment.

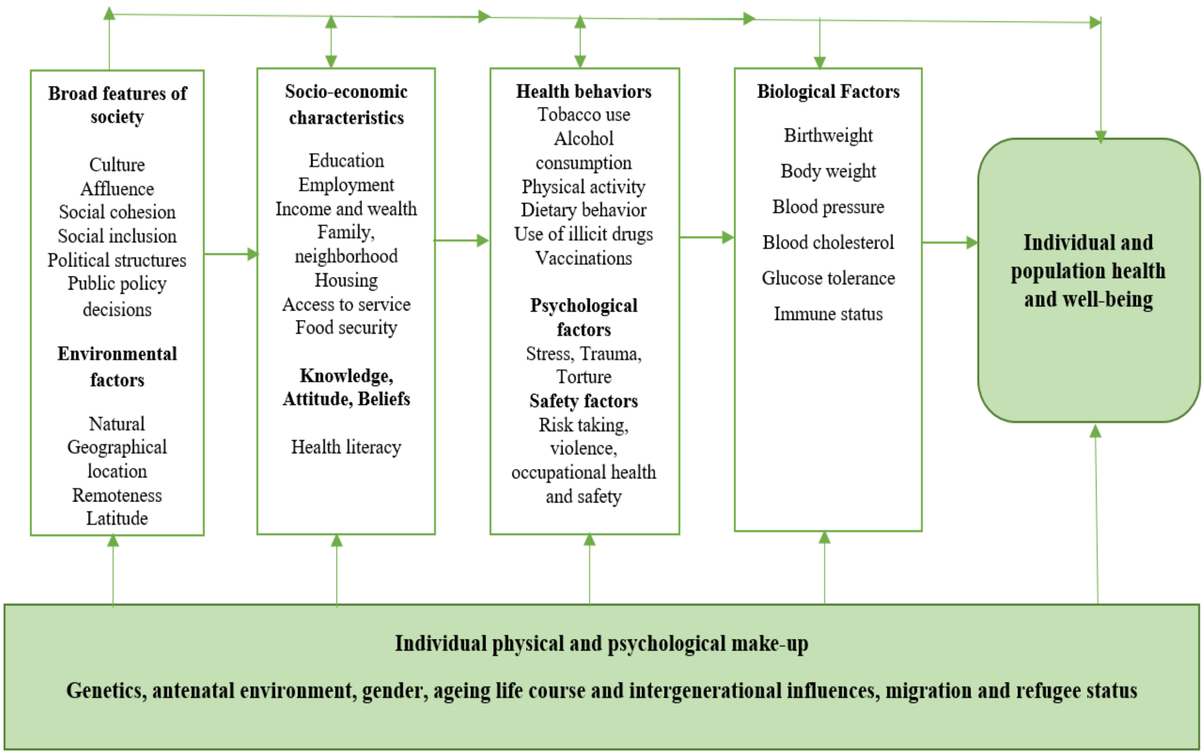

Figure 4: Framework for determinants of health

Note: Green shading indicates common social determinants of health

Source: (Australian Institute of Health and Welfare, 2020c)

1.6 Costs of obesity

Overweight and obesity have become major public health concerns in Australia since they negatively impact individuals' health and quality of life. Obesity also affects society through generating direct and indirect costs. It increases the risk of developing non-communicable diseases, such as type 2 diabetes, chronic kidney disease, cardiovascular disease, and cancer (Australian Institute of Health and Welfare, 2017b). Thereby, obesity leads to higher healthcare services utilization that can be translated into higher healthcare spending. Obesity negatively affects an individual's ability to work and productivity in the workplace.

Further, obesity generates costs to the government, the obese population, broader society, private health insurers, carers and family members, and employers through affecting individual's health and well-being. Figure 5 displays a summary of the costs of obesity that multiple stakeholders bear. For example, obesity negatively influences worker's productivity (absenteeism and presenteeism), and employers bear these costs.

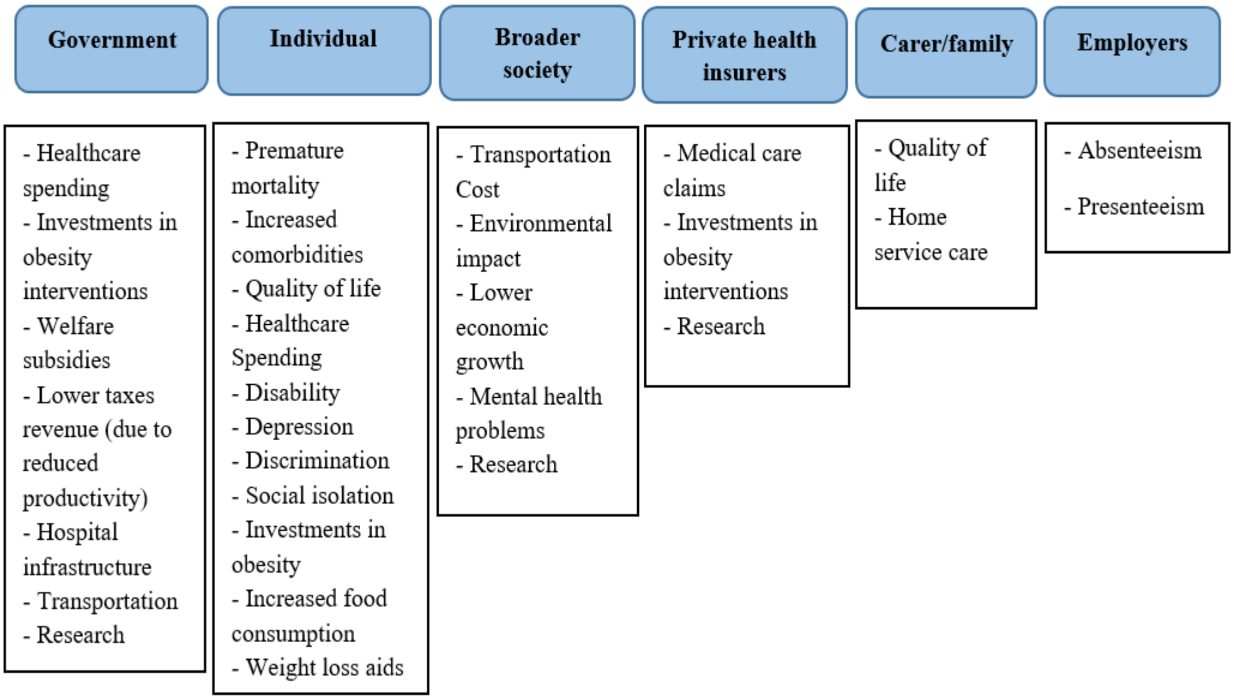

Figure 5: Cost of obesity borne by relevant stakeholders

Source: (PwC Australia, 2015)

1.7 Literature review

The literature on the health costs and effects of obesity on labour market outcomes has been growing since the 1990s. These studies primarily focus on medical expenses, earnings impact and probability of employment due to obesity, although mainly from the perspective of the USA and European countries. This section provides available evidence on the risk factors of obesity, health and well-being costs, and adverse labour market outcomes of adult obesity. A brief overview of the literature on twelve distinct topics highlights existing knowledge and helps readers understand why the current set of studies has been undertaken.

1.7.1 Geographic remoteness and obesity

Analyses of geographic disparity in the prevalence of NCDs are essential for public health intervention as they identify the conditions' above-average prevalence or 'hot spots'. The geographical disparity also exists in the prevalence of adult obesity. Discordant results have been found in the literature regarding the association between geographic remoteness and obesity in developed countries (Befort et al., 2012; Gong et al., 2018; He et al., 2017;

Neovius and Rasmussen, 2008; Padez, 2006; Peytremann-Bridevaux et al., 2007; Svensson et al., 2007). A recent United States (US) study confirmed that substantial geographic differences exist in obesity prevalence among Asian Americans (Gong et al., 2018). Four empirical studies conducted in the US and European countries indicate that living in rural settings is positively associated with overweight and obesity (Befort et al., 2012; Neovius and Rasmussen, 2008; Padez, 2006; Svensson et al., 2007). However, a study of 10 European countries provides evidence that the prevalence of obesity does not vary between rural and urban settings (Peytremann-Bridevaux et al., 2007). Moreover, some studies have documented within-country (e.g., state-level or region-level) variation in overweight and obesity prevalence in developed countries, such as the US, Canada and Finland (Gurka et al., 2018; Lahti-Koski et al., 2008; Pouliou and Elliott, 2009).

1.7.2 Disadvantaged neighbourhoods, lifestyle factors and obesity

A recent well-designed longitudinal study concluded that neighbourhood socioeconomic disadvantage is associated with higher BMI among middle and older aged (40-65 years) Australians (Rachele et al., 2017). Further, a recent study provided evidence that neighbourhood disadvantage is positively associated with the BMI of immigrants to Australia (Menigoz et al., 2018). Moreover, a longitudinal study conducted in China revealed that age, education, residence, and ethnicity are significantly associated with overweight and obesity (He et al., 2017). However, the main limitation of the existing studies is that longitudinal association was ascribed by pooling cross-sectional surveys instead of capturing the within-person change in obesity by utilizing a cohort study design. Further, past studies conducted in Australia did not cover the general population or adults of all age groups. Additionally, these longitudinal studies ignored some critical lifestyle factors when risk factors of obesity were modelled.

At the individual level, lifestyle factors (e.g., diet and physical activity) play an essential role in maintaining the human body’s energy balance (National Health and Medical Research Council, 2013). Negative health behaviours, such as low vegetable and fruit consumption, contribute to weight gain (Allender et al., 2012). Further, the disadvantaged neighbourhood is a significant factor associated with a higher BMI (Australian Institute of Health and Welfare, 2018a). In 2014-2015, it was observed that adults living in the most socioeconomically disadvantaged areas (34%) were more obese compared to adults living in the least disadvantaged areas (22%) (Australian Institute of Health and Welfare, 2018a). These data indicate that disadvantaged neighbourhoods might influence the weight status of Australian adults. One of the main methods through which living in a disadvantaged neighbourhood affects overweight and obesity is easy access to unhealthy foods, less availability of nutritious foods, lack of recreational spaces or parks, limited opportunities for physical activities, and higher exposure to chemicals that increase fatty tissue in the human body (Black and Macinko, 2008; The National Institutes of Health (NIH), 2020). However, no study has yet exclusively studied the role of disadvantaged neighbourhoods and lifestyle factors on adult weight status in a longitudinal setting.

1.7.3 Job-related characteristics and obesity

Existing evidence on the association between job-related characteristics and obesity have focused on particular job-related characteristics. For example, numerous studies have attempted to explain the association between long work hours and obesity. These studies have reported mixed results. Studies conducted in the USA and Australia have confirmed that long work hours significantly increased the odds of obesity in workers irrespective of gender (Di Milia et al., 2013; Di Milia and Mummery, 2009; Park et al., 2014). Other studies also demonstrated that prolonged work hours are significantly associated with obesity in male, but not female, manual workers (Escoto et al., 2010; Jang et al., 2013). However, a Korean study revealed that long work hours heightens the risk of obesity among female workers (Yoon et al., 2016).

The demand for shift workers is growing in Australia as it gives employers greater flexibility to maximize production and provide services around the clock (Australian Bureau of Statistics, 2010). The number of shift workers in Australia grew from 1.5 million in 2012 to 1.7 million in 2015 (Connery, 2017). Some studies have attempted to estimate if shift work contributes to obesity (Di Milia et al., 2013; Jang et al., 2013; Lee et al., 2016; Miaomiao Sun et al., 2018; Yoon et al., 2016), but the results have not been consistent. Some of these studies found that the odds of being obese are significantly higher among shift workers (Lee et al., 2016; Miaomiao Sun et al., 2018; Yoon et al., 2016). Other studies concluded that shift work is not associated with workers' obesity status (Di Milia et al., 2013; Jang et al., 2013).

Apart from the most common job-related characteristics, some cross-sectional studies have examined the influence of employment contracts (permanent, fixed-term and casual contracts) (Artazcoz et al., 2016), firm size (large, medium or small) (Park et al., 2014), supervisory responsibility (or not) (Artazcoz et al., 2016), and whether or not paid sick leave is available (Park et al., 2014), on workers' obesity status. A recent study conducted among American workers reported a confusing association between firm size and obesity and reported no significant association between paid sick leave and obesity (Park et al., 2014). Similarly, a European study pointed out that employment contract types and supervisory roles were not associated with health status in European workers (Artazcoz et al., 2016).

1.7.4 Obesity and chronic disease burden

Overweight and obesity contributed 8.4% of the risk factor of the burden of diseases in Australia in 2015 (Australian Institute of Health and Welfare, 2019b). There is increasing empirical evidence that obesity triggers the likelihood of different NCDs, such as type 2 diabetes, high blood pressure, CVD, cancer, asthma, sleep apnea, and poor mental health (Atlantis et al., 2009). Excessive weight gain from early childhood to adulthood is consistently associated with the risk of heart disease (Bjerregaard et al., 2020). Obesity also significantly increases the risk of heart disease-related morbidity and mortality at an older age. Further, it is strongly associated with the incidence of type 2 diabetes (Guh et al., 2009) and depression (Preiss et al., 2013). Furthermore, the likelihood of different patterns of arthritis, such as osteoarthritis, rheumatoid arthritis, psoriatic arthritis, is often associated with increased body weight (Blagojevic et al., 2010). The burden of these chronic diseases includes low quality of life, productivity loss, and increased healthcare costs (Chooi et al., 2019; Jia and Lubetkin, 2005). Managing obesity can reduce the prevalence of and mortality from these chronic diseases (Lemay et al., 2019) and improve health-related quality of life (Lemstra and Rogers, 2016). A previous study has claimed that the prevalence of diabetes, high cholesterol, high blood pressure, and CVD among Australian adults could be reduced significantly by reducing body weight (Atlantis et al., 2009).

1.7.5 Obesity and disability

The rising prevalence of disability is, in part, due to the ageing trajectory of the population and the higher incidence of chronic diseases (World Health Organization, 2018). Previous research has found that the obese, tobacco users, alcohol drinkers, and physically inactive people were more likely to be disabled (Mathers and Loncar, 2006; World Health Organization, 2015). A longitudinal study revealed that being obese in mid-life is associated with a higher risk of being physically disabled at an older age (Wong et al., 2015a). A Dutch study identified age, excessive body fat, depression, and joint complaints as the significant risk factors for disability (Taş et al., 2007). Further, a systematic review provides evidence that older age and poor health condition increased the risk of being disabled (Tas et al., 2007).

Furthermore, a prospective cohort study shows that obesity, physical inactivity, and hypertension caused disability in Italian adults (Balzi et al., 2009). Moreover, Korean research identified that people with poor physical health, depression, and obesity had a higher tendency of having a disability (Kim et al., 2005). Additionally, other evidence reported that limited daily activities, low physical functioning, multiple physical and psychological conditions were positively associated with disability (Mehta et al., 2002; Sinclair et al., 2001).

1.7.6 Obesity, multimorbidity, and healthcare services utilisation

Both obesity and multimorbidity have emerged as critical public health problems in Australia. In 2017-2018, approximately 31% of Australian adults were obese, and 20% had multimorbidity (Australian Bureau of Statistics, 2018a; Australian Institute of Health and Welfare, 2020d). Obesity prevalence has tripled among Australian adults over the past three decades (Hayes et al., 2017). The high prevalence of obesity and multimorbidity imposes a substantial health burden and increases healthcare resource utilization. In 2015, overweight and obesity were responsible for 8.4% of the total burden of disease in Australia (Australian Institute of Health and Welfare, 2020e). Besides, one in every eight hospital admissions, one in every six days spent in hospital, and one in every six dollars spent on hospitalization could be attributed to individuals who were overweight or obese (Korda et al., 2015). Like obesity, chronic conditions have a significant impact on people’s health and healthcare utilisation. In 2015, chronic diseases were responsible for approximately 66% of the disease burden (both fatal and non-fatal) in Australia (Australian Institute of Health and Welfare, 2020d). In 2017-18, five in ten hospitalizations and nine in ten deaths were attributed to ten selected chronic conditions in Australia (Australian Institute of Health and Welfare, 2020d).

Research to date shows that obese and adults with multimorbidity were more likely to consume a wide range of healthcare services (Marsha A. Raebel et al., 2004; Reidpath et al., 2002): including diagnostic services (Elrashidi et al., 2016; Peterson and Mahmoudi, 2015); prescribed drugs (Bell et al., 2011; Trasande and Chatterjee, 2009); emergency room visits (Elrashidi et al., 2016; Goetzel et al., 2010); and inpatient services (Payne et al., 2013;

Peterson and Mahmoudi, 2015). Existing evidence also demonstrates that obese and adults with multimorbidity are more likely to utilize healthcare services, such as doctor consultations, hospital admissions, medical equipment applications, and medicines, than others (Korda et al., 2015; R. Palladino et al., 2016).

1.7.7 Obesity, disability, and health outcomes

Obesity has several adverse health outcomes, including reduced life expectancy (Finkelstein et al., 2010; Vidra et al., 2019). A recent US study found that higher BMI is associated with lower expected survival and is responsible for approximately 95 million years of life lost in that nation (Finkelstein et al., 2010). Other studies have shown that obesity is a significant risk factor for increased morbidity and mortality linked to chronic diseases, including CVD, diabetes, cancer, osteoarthritis, liver and kidney disease, sleep apnea, and depression (Hruby and Hu, 2015; Pi-Sunyer, 2009). Like obesity, people with disability experience health-related problems such as compromised functional ability, pain or fatigue, and inactivity. Moreover, persons with a disability often face restrictions in participating in work and intimate relationships and may perceive a poor health-related quality of life (Roebroeck et al., 2009). Due to the extent of obesity and disability among Australians, it is warranted to understand the role of obesity and disability in determining Australian adults' self-perceived health and mental health status.

1.7.8 Comorbid chronic diseases and health-related quality of life in obese population

Quality of life broadly refers to the extent to which an individual can function successfully in daily life and their perceived well-being across physical, emotional, and social structures (Klassen et al., 2017; Perales et al., 2014). Obesity is associated with increased comorbidity, mortality and reduced health-related quality of life (HRQoL) (Busutil et al., 2017; Kortt and Dollery, 2011; Schelbert, 2009; Ul-Haq et al., 2012; Zhu et al., 2015). The health burden among individuals with raised BMI is becoming concerning, especially in those with co-occurring chronic conditions (Guh et al., 2009; Schienkiewitz et al., 2012). The relationship between BMI and HRQoL has been investigated in several population-based studies, and each has confirmed a negative association between BMI and self-perceived quality of life, with a higher risk of poorer HRQoL in overweight and obese persons (Audureau et al., 2016; Busutil et al., 2017; Jia and Lubetkin, 2005; Kolotkin et al., 2001; Renzaho et al., 2010; Song et al., 2015). Further, obese persons report increased levels of pain which has been considered the most significant impairment to HRQoL (Audureau et al., 2016; Kolotkin et al., 2001; Kortt and Clarke, 2005). Moreover, overweight and obese people experience higher psychological distress, which is another considerable impairment to their HRQoL (Kolotkin et al., 2001; Kolotkin and Andersen, 2017). Several studies across diverse geographical locations have reported that comorbid chronic diseases are associated with poor quality of life. For instance, earlier studies found that overweight or obese individuals often report physical, mental, and social relationship problems (Banegas et al., 2007; Choo et al., 2014; Pimenta et al., 2015; Rozjabek et al., 2020; Slagter et al., 2015). Of those reporting poor HRQoL, the highest burden was found among those with multiple comorbid chronic conditions (Lima et al., 2009). Other empirical studies have reported poor HRQoL among persons with comorbid or multimorbid diseases (Busetto et al., 2012; Tyack et al., 2018; Zhang et al., 2018).

HRQoL among obese individuals is understudied, with only a few empirical studies focused on establishing the association between comorbidities and quality of life. Two studies have reported that overweight and obesity were associated with low or poor HRQoL (Hoare et al., 2019; Renzaho et al., 2010). However, a recent study did not find a statistically significant association between HRQoL (measured by SF-6D) and comorbid chronic diseases in the Australian general population (Kortt and Dollery, 2011). The discrepancy in the relationship between comorbid conditions and HRQoL in the existing literature warrants further investigation to draw robust conclusions on the longitudinal relationship between comorbidity and HRQoL in the obese population.

1.7.9 Obesity and absenteeism in the workplace

Globally, the prevalence of obesity has almost tripled since 1975 (World Health Organization, 2020a). Worldwide more than 650 million adults aged 18 years or over were obese in 2016 (World Health Organization, 2020a). Studies conducted on US workers demonstrated that obese employees were more likely to be absent from the workplace than their healthy weight counterparts (Frone, 2007; Poston et al., 2011; Tucker and Friedman, 1998). Moreover, a study in Ireland concluded that obese employees were 72% more prone to be absent (Fitzgerald et al., 2016). Further, a recent study in the Netherlands revealed that obese workers took 14 days of extra leave per annum compared to their lower weight counterparts (Jans et al., 2007). Similar results have been found in a British study where the authors claimed that obese workers were absent for four extra days per year (Harvey et al., 2010). However, a study in Germany did not find evidence that overweight men took more sick leave days (Lehnert et al., 2014). A few studies have also examined the longitudinal association between obesity and workplace absenteeism (Howard and Potter, 2014; Reber et al., 2018; Roos et al., 2015; Vanwormer et al., 2012). A prospective study among middle-aged employees in Finland revealed that stable obesity and weight gain in the follow-up period increased the risk of prolonged sickness absence (Roos et al., 2015). Two US-based longitudinal studies also provided evidence that obesity is positively associated with absenteeism (Howard and Potter, 2014; Vanwormer et al., 2012).

1.7.10 Obesity and presenteeism in the workplace

It may be assumed that obesity negatively impacts workers' performance as obese people often suffer from comorbidities, including diabetes, cardiovascular diseases, and musculoskeletal disorders. The existing empirical evidence shows that obesity is positively associated with presenteeism (Gates et al., 2008; Goetzel et al., 2010; Janssens et al., 2012; Kudel et al., 2018; Sanchez Bustillos et al., 2015). Findings from two recent studies conducted in Canada and Belgium suggests that obesity is positively and significantly associated with impaired productivity (Janssens et al., 2012; Sanchez Bustillos et al., 2015). Moreover, three studies conducted in the US reported similar findings (Gates et al., 2008; Goetzel et al., 2010; Kudel et al., 2018). One study utilized data of 59,772 adult workers in different US occupations and found that work productivity impairment is significantly higher among obese workers than their normal-weight peers (Kudel et al., 2018). Another study in the US concluded that the rate of presenteeism is 12% higher among obese workers compared with their healthy weight counterparts (Goetzel et al., 2010).

Similarly, another study of 341 manufacturing employees in the US found that obese workers are less productive than their healthy weight counterparts (Gates et al., 2008). The study design of all of these research studies was cross-sectional and based in the US, Canada, or European countries. As a result, a systematic review study suggested conducting a longitudinal study to reconfirm the association between obesity and productivity loss in the workplace (Trogdon et al., 2008).

1.7.11 Obesity and job satisfaction

Job satisfaction is a subjective measure of a worker's perception of their job (Bruno et al., 2015) and depends on their expectations (Clark, 1997). Due to low expectations about their job, it is hypothesized that obese workers have low satisfaction with different aspects of their job. Some empirical studies explore the association between obesity and various aspects of job satisfaction (Bruno et al., 2015; Pagan et al., 2016). Mixed results have been observed in the literature while confirming the association between obesity and job security satisfaction (Bruno et al., 2015; Muenster et al., 2011). A recent longitudinal study revealed that obesity had no significant influence on pay and job security satisfaction among Italian workers (Bruno et al., 2015). However, another quantitative analysis confirmed that obesity significantly reduced German worker's job security satisfaction (Muenster et al., 2011). In addition, a longitudinal study on Korean workers confirmed that obesity is negatively associated with job quality (an index where job security was a component) (Kim and Han, 2015).

1.7.12 Obesity, disability, and employment discrimination

People suffering from both obesity and disability are often subject to workplace discrimination. A recent study concluded that obese and disabled people faced higher levels of harassment and discrimination in the workplace and other areas of their lives (Jones et al., 2018). Recent empirical evidence also reveals that workplace harassment and discrimination continues to grow among workers with disabilities in the USA and UK despite protective legislation (Fevre et al., 2013; Snyder et al., 2010). Further, there is evidence that obese people experience higher unemployment levels than healthy-weight peers in the USA (Tunceli et al., 2006). Studies of USA adults showed that obesity is associated with several forms of discrimination, including in the workplace (Hunte and Williams, 2009; Lewis et al., 2011). A few studies conducted in European countries: UK (Morris, 2006), Finland (Böckerman et al., 2019; Sarlio-Lahteenkorva and Lahelma, 1999) and Denmark (Greve, 2008) found that obese people tend to earn less than their non-obese counterparts and that overweight people were also more likely to report employment discrimination and discriminatory experiences than healthy weight counterparts (Roehling et al., 2007).

Physical disabilities also prevent people from securing continuous employment (Waterhouse et al., 2010). According to the Australian Institute of Health and Welfare (AIHW), people with disabilities are under-represented in the Australian workforce (53% compared to 84% of those without disabilities) (Australian Institute of Health and Welfare, 2020f), and the rate of employment is declining (Australian Institute of Health and Welfare, 2017c). The empirical evidence demonstrates that people with psychiatric disabilities have longer unemployment durations, lower probability of securing highly-paid jobs, have lower earnings, and are denied training opportunities and promotions (Baldwin and Marcus, 2006; Stuart, 2006). There is also evidence that people with physical and sensory impairments face large-scale hiring discrimination in the USA (McMahon, 2012).

1.8 Research gaps

The prevalence of obesity continues to rise in Australia, and it has become a serious public health concern. Identification of the risk factors of adult obesity is vital to halt the obesity epidemic. However, there is little evidence in the literature regarding the factors related to obesity in the Australian adult population using a longitudinal research design. For example, little is known about how geographic remoteness, disadvantaged neighbourhoods, lifestyle, and job-related characteristics influence an individual's obesity status.

The existing literature offers some evidence on the association between obesity, health and labour market outcomes. However, these have received very little attention in Australia. Further, the impact of obesity on health and labour market outcomes using a longitudinal research design is hardly referenced in the literature. This study seeks to fill that gap in the literature in the Australian context using data from the nationally representative survey, the Household, Income and Labour Dynamics in Australia (HILDA). This study will be the first systemic investigation of the influence of obesity on new dimensions of health status and labour market outcomes using a longitudinal research design.

1.9 Objective of the study

This research endeavours to fill gaps in the existing literature by providing new evidence on the trends in the prevalence of adult obesity in Australia, associated risk factors, and its effect on health and labour market outcomes using longitudinal data. The thesis includes twelve distinct studies, which can be divided into three main parts: (i) prevalence and risk factors of obesity, (ii) the health and well-being costs of obesity, and (iii) the impact of obesity on adverse labour market outcomes.

Prevalence and risk factors of obesity (Chapter 2): The first part of the thesis focuses on the risk factors of adult obesity in Australia. This chapter includes three individual studies. The objective of the first study is to examine geographic remoteness as a potential risk factor for an individual being overweight or obese in adulthood. The second study investigates the impact of disadvantaged neighbourhoods and lifestyle factors on obesity amongst Australian adults. The third study aimed to examine the longitudinal association between nine job-related characteristics and obesity among Australian employees using a nationally representative sample.

The health and well-being costs of obesity (Chapter 3): The second part of the thesis attempts to capture the health consequences of obesity. This chapter includes five distinct studies. The objective of the first study is to investigate whether obesity is a significant risk factor for type 2 diabetes, heart diseases, asthma, arthritis and depression in Australian adults, using nationally representative panel data. The purpose of the second study is to analyse the relationship between obesity and physical activity with disability. The third study investigates the association between obesity and multimorbidity with health service utilization using a longitudinal research design. The objective of the fourth study is to examine the relationship between obesity and disability with self-reported health and mental health among Australian adults aged 15 years and above. The fifth study examines the relationship between nine comorbid chronic conditions and health-related quality of life (HRQoL) separately, along with the number of chronic diseases among the Australian obese population.

The impact of obesity on adverse labour market outcomes (Chapter 4): The third part of the thesis focuses on adverse labour market outcomes. The last part of the thesis consists of four separate studies. The first study examines gender differences in the longitudinal association between obesity and disability with absenteeism in the workplace. The purpose of the second study is to explore the longitudinal association between obesity and long-term health condition (LTHC) with presenteeism or working while sick. The objective of the third study is to investigate the impact of obesity, long-term health problems on three specific aspects of job satisfaction (overall job satisfaction, pay satisfaction and job security satisfaction) in a cohort of Australian adults. The fourth study aims to investigate the association between obesity and disability with employment discrimination within Australia.

1.10 Overview of methods

This thesis includes twelve studies based on secondary analyses of unit record data from the HILDA survey. A brief discussion of the data source used for this thesis now ensues. This section also outlines the study design and methods that were followed to address the research questions.

1.10.1 Data sources

This study exploited the most recent longitudinal data from the HILDA survey to analyse the factors associated with obesity and the effects of obesity on health and labour market outcomes. The primary reason for choosing the HILDA survey as the data source for all twelve studies is that it contains information on self-reported BMI, health status and labour market activities. Other advantages of using the data set include detailed information on socio-demographic and lifestyle characteristics, including age, gender, education, civil status, labour force status, ethnicity, and smoking and alcohol consumption at several time points. Another critical reason is that HILDA is a nationally representative household-based longitudinal survey. No other Australian population surveys have provided such rigorous information about an individual over time. Therefore, the HILDA dataset contains the appropriate information to answer the research questions.

This household panel survey is similar to the Panel Study of Income Dynamics (PSID) in the US, the British Household Panel Survey (BHPS), and the German Socio-Economic Panel (SOEP). The survey collects information annually from the adult members of the same household. The survey collects data on three main areas: economic and subjective well-being, labour market dynamics, and family life. More specifically, it gathers information on a wide range of topics, including wealth, retirement, fertility, health, education, skills, abilities, job-related discrimination, intentions and plans, non-co-residential family relationships, health insurance, youth, literacy and numeracy, diet, and material deprivation from household members aged 15 years or over through both self-completion questionnaires and face-to-face interviews by trained interviewers. The HILDA survey commenced in 2001 and collected information on 19,914 individuals from 7682 households following the University of Melbourne's ethical guidelines. Since then, the survey has gathered information annually from over 17,000 Australians. HILDA survey selects sample households through multi-stage sampling techniques that are representative of the Australian population. A detailed description of the HILDA sampling technique and survey methodology has been outlined elsewhere (Freidin et al., 2002).

1.10.2 Study design

All studies included in this thesis were longitudinal in design. All twelve studies applied a wide range of health economics and epidemiological methods to answer different research questions. Table 2 demonstrates the research focus, research question, study design, data source, analytic sample, and methods at a glance.

Table 2: Research question, study design, data source, analytic sample, and methods of the twelve studies at a glance

Research Focus	Study	Research Question (RQ)	Study design	Data source	Analytic sample	Methods
Prevalence and risk factors of adult obesity	Study 1	How does geographic remoteness associated with the incidence of obesity?	Longitudinal, retrospective study	HILDA; 14 successive waves (wave 6 through 19, 2006 to 2019)	199,675 person-year observations from 26,713 individuals.	Longitudinal random-effects logistic regression
	Study 2	Do neighbourhood disadvantage and lifestyle factors have any causal effect on BMI status?	Longitudinal, retrospective study	HILDA; two annual waves of data: Wave 13 (2013), Wave 17 (2017).	21,468 yearly observations from 10,734 adults.	Generalized Estimating Equation (GEE) with logistic link function
	Study 3	Do job-related characteristics (e.g. working hours and type of work) have any effect on obesity?	Longitudinal, retrospective study	HILDA; two annual waves of data: Wave 13 (2013), Wave 17 (2017).	16,980 person-year observations from 11,521 employees.	GEE with logistic link function
Health consequences of adult obesity	Study 4	Does a definite directional relationship exist between obesity and chronic diseases?	Longitudinal, retrospective study	HILDA; three annual waves of data: Wave 9 (2009), Wave 13 (2013), Wave 17 (2017).	20,538 person-year observations from 9,822 unique participants	Longitudinal random-effects logistic regression
	Study 5	What is the direction of the relationship between obesity, disability, and physical activity?	Longitudinal, retrospective study	HILDA; 14 successive waves (wave 6 through 19, 2006 to 2019)	189,519 person-year observations from 26,208 participants.	GEE with logistic link function

	Study 6	Does a longitudinal association exist between obesity, multimorbidity, and healthcare services utilisation?	Longitudinal, retrospective study	HILDA; three annual waves of data: Wave 9 (2009), Wave 13 (2013), Wave 17 (2017).	41,073 person-year observations of 20,120 individuals.	GEE with logistic link function, negative binomial and Zero-Inflated Negative Binomial [ZINB]
	Study 7	To what extent do obesity influence health outcomes (self-assessed health and mental health)?	Longitudinal, retrospective study	HILDA; 13 successive waves (wave 6 through 18, 2006 to 2018)	180,044 yearly observations from 25,804 unique participants.	Longitudinal random-effects logistic regression
	Study 8	Do comorbid chronic diseases diminish utility score in the obese population?	Longitudinal, retrospective study	HILDA; three annual waves of data: Wave 9 (2009), Wave 13 (2013), Wave 17 (2017).	9,444 person-year observations from 5,524 unique respondents.	GEE
The impact of obesity on labour market outcomes	Study 9	Does obesity influence absenteeism in the workplace?	Longitudinal, retrospective study	HILDA; 13 successive waves (wave 6 through 18, 2006 to 2018)	117,769 yearly observations from 19,851 adult employees.	ZINB
	Study 10	Does obesity influence productivity (presenteeism) in the workplace?	Longitudinal, retrospective study	HILDA; 13 successive waves (wave 6 through 18, 2006 to 2018)	111,086 person-year observations from 19,087 participants.	GEE with logistic link function

	Study 11	What is the mechanism through which obesity and disability affect diverse job satisfaction?	Longitudinal, retrospective study	HILDA; 12 successive waves (wave 6 through 17, 2006 to 2017)	82,064 person-year observations.	Generalized least squares estimation and random-effects ordered probit model
	Study 12	How does obesity and disability were associated with perceived employment discrimination?	Longitudinal, retrospective study	HILDA; four annual waves of data: Wave 8 (2008), Wave 10 (2010), Wave 14 (2014), and Wave 18 (2018).	17,174 person-year observations from 11,079 participants.	Longitudinal random-effects logistic regression

1.11 Theoretical framework

1.11.1 The social-ecological model: A framework for prevention

To reduce the health burden due to injuries and diseases, health professionals have long been searching for a solution to offer sustainable policy interventions among populations. A 4-level social-ecological model (SEM) is helpful to understand the complex aetiology of adult obesity. The SEM shows the complex interplay among individual, relationship, community, and societal factors and helps to understand the risk factors and strategies for preventing obesity (Centers for Disease Control and Prevention, 2021). Different levels of the SEM help to clarify how multiple factors and their interaction influence adult weight outcome. SEM facilitates the information to conceptualize the range of risk factors that people face. How one level factor affects another level can be traced by this model of overlapping rings and ultimately allows health professionals to understand the locus of the prevention strategy (Figure 6). This model enables implementing a flexible program that can prevent risk factors and promote protective determinants from each of the different levels of the model.

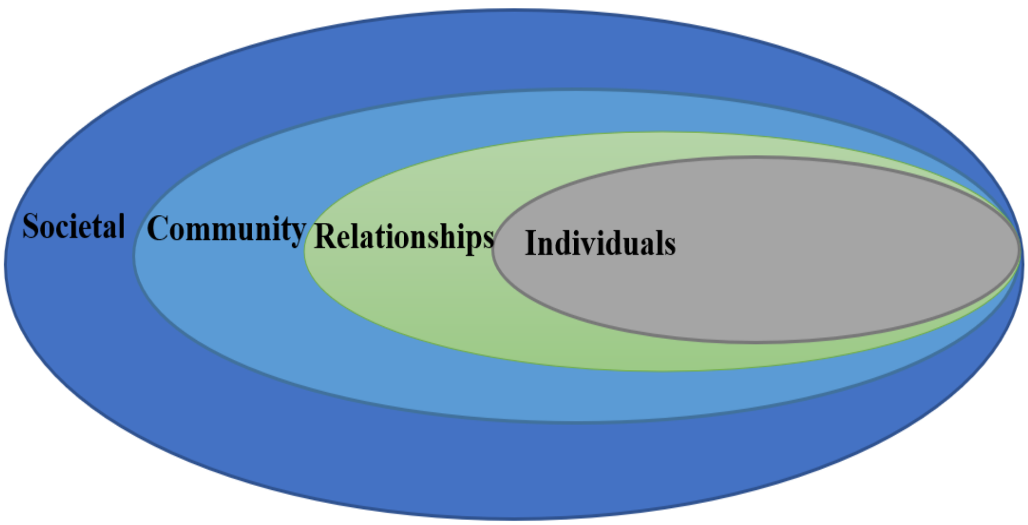

Figure 6: The social-ecological model
Source: (Centers for Disease Control and Prevention, 2021)

In Figure 6, the overlapping rings briefly show the interplay among four levels from lowest individual to highest societal factor. This ring function implies that interplay across multiple levels of this framework is crucial in preventing risk uncertainty. The core objective is to create a population-level impact.

Individuals: The first layer of the SEM identifies personal characteristics, biological factors, and individual behaviours that increase the likelihood of obesity. Example of individual elements that increase the likelihood of obesity includes age, gender, education, income, and employment status.

Relationships: The second layer reveals the interaction between two or more people that may increase the risk of being obese. Their closest people influence an individual's behaviour. These risk factors include tensions or struggles among family members, marital instability, and emotionally unsupportive family members.

Community: The third level explores the settings or institutions, such as schools, workplaces, and neighbourhoods, in which social relations occur. Examples include the income level of neighbourhoods, the extent of economic and recreational opportunities, and the physical layout of a neighbourhood. The third layer of the SEM identifies the characteristics of these settings that might influence adult weight status.

Societal: The fourth level focuses on the broad societal factors that influence an individual's health status. The factors include social and cultural norms, health, economic, and educational policies. These important societal factors can be used to promote healthy living and remove health-related inequalities.

1.11.2 Grossman's (1972) model of demand for health and health care

There are reasons to believe that obesity influences productivity in the workplace (Vingård et al., 2005). Grossman's (1972) model of demand for health and health care is consistent with the interpretation that obese workers are less productive than non-obese workers. The main idea of the Grossman's (1972) model of demand for health and health care is individuals invest in their health to increase earnings. Grossman's (1972) mentions four important aspects of health demand. The most critical aspect of health is that it is both a consumption and an investment good. As consumption goods, health yields direct utility (i.e. health makes individuals feel better). As an investment good, health increases the number of days to participate in the labour market and earn money. Thus, health can be seen as a capital good (Grossman, 2017).

Figure 7 provides a clear explanation of the health capital concept. The health capital stock of an individual provides health output in the form of healthy days. Individuals use a set of health inputs to invest in health and thus increase their health capital stock. An increment in the health stock provides more healthy days for the individual to work.

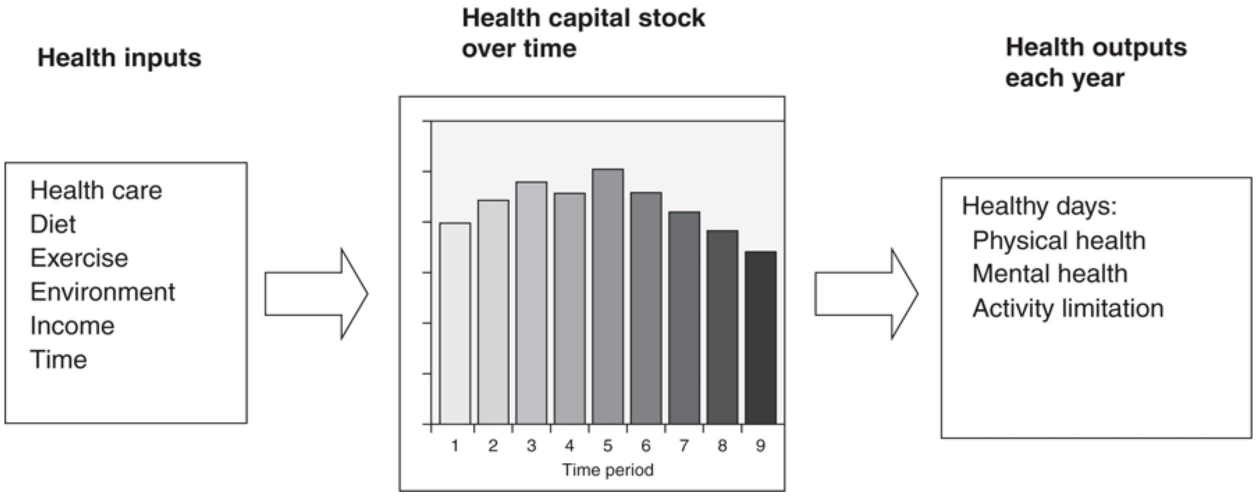

Figure 7: Investments in health capital

Source: (Folland et al., 2016)

Figure 8 illustrates the production of healthy days using a single input, health stock. Higher health stock leads to more healthy days. The shape of the function indicates diminishing marginal returns. H_{min} refers to the point where health stock is minimum. Production of healthy days at this point is zero. Health stock at the point H_{min} indicates death.

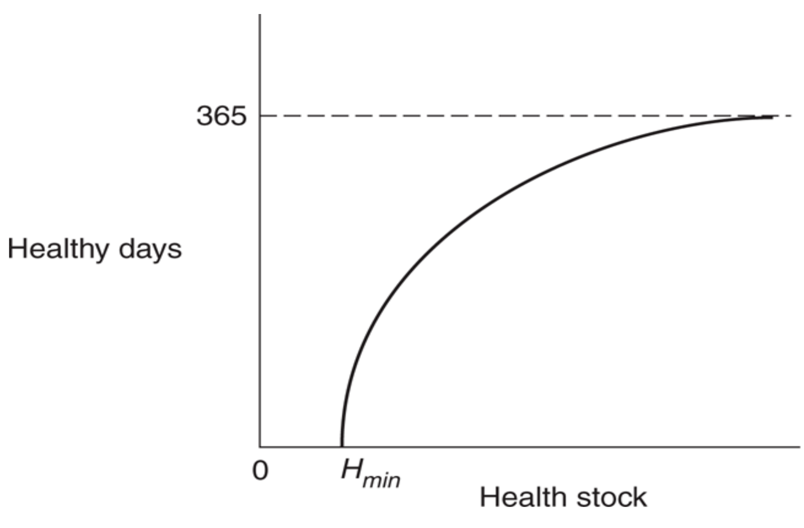

Figure 8: Relationship of healthy days to healthy stock

Source: (Folland et al., 2016)

The health capital model can be used to describe many other aspects of obesity. For example, obesity influences health capital by making the body less productive. It also depreciates the individual health stock quicker. As a result, individuals may opt for early retirement from the labour market. Kpelitse et al. (2014) outlined the influence of an individual's health stock in making retirement decisions from the labour market based on Grossman's (1972) model. The authors also point out that deterioration of health stock may reduce wage rates, influencing the individual to take an early retirement decision (Kpelitse et al., 2014). According to Godard (2016), retirement might be an influential factor for weight changes. Besides, Grossman's (1972) models of demand for health and health care is consistent with the interpretation that retired individuals may invest in health-producing activities, such as healthier diets or physical exercise that may change their weight (Godard, 2016).

1.11.3 Becker's model of economic discrimination

There are strong reasons to believe that obesity may influence labour market outcomes. Becker's (1957) model of economic discrimination is consistent with the interpretation that obese workers may face discrimination leading to lower wages and unemployment. Wage and employment differences in the labour market may arise among equally skilled workers in the same job due to workers' physical structure, race, gender, ethnicity or other seemingly irrelevant characteristics (Cain, 1986). These differences are commonly known as labour market discrimination. Perhaps the most striking discrimination in the labour market exists in the form of wage gaps. Men earn more than women, and whites earn more than non-whites, non-obese earn more than obese (Cawley, 2004). The economic analysis of discrimination is based on Gary Becker's 'theory of labour market discrimination'. Competitive economic models of discrimination are of two types: taste-based and statistical models of discrimination. Becker's (1957) models of economic discrimination are based on personal prejudice or taste against associating with a particular group. The sources of taste-based discrimination are employer, co-worker and customer (Becker, 2010).

Let us assume that there are two types of workers in the labour market: obese and non-obese workers, and an employer has a prejudice against obese workers. In the competitive labour market, employers have to pay constant wages for hiring labour. If the firm has to pay the same compensation to all equally skilled (obese and non-obese) workers, the firm will not employ obese workers even though they are as skilled and productive. In this situation, a firm may trade-off by hiring obese workers at a low wage rate and increase their profit margin. This is how employer prejudice and taste lead to variations in wages and employment in the labour market. This is explained further in Figure 9.

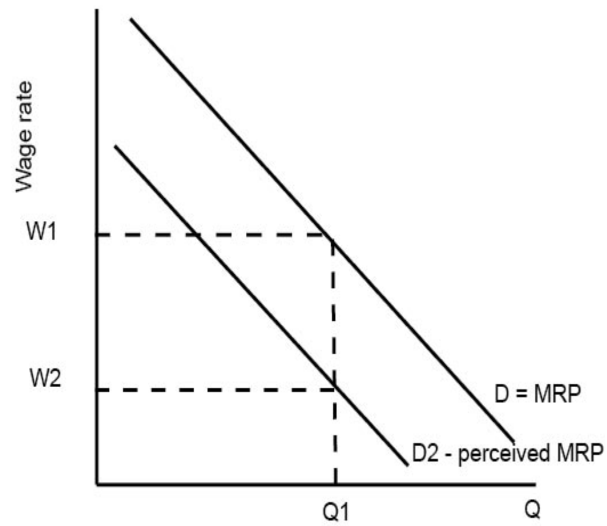

Figure 9: Employer discrimination in demand for labour

Source: (Pettinger, 2017)

It is assumed that obese and non-obese workers have the same level of productivity. Due to the same productivity of the workers, the employer will face the same marginal revenue product (MRP) curve irrespective of the type of worker employed. In Figure 9, *MRP* demonstrates the demand for labour curve. A competitive firm will hire labour until the wage and marginal revenue product of labour are equal. As a result, if the wage rate is $W1$, the firm will employ $Q1$ workers. If the firm discriminates against obese workers, then no workers from the obese group will be employed at the wage level $W1$. Because of employers' taste and prejudice, the firm discriminates against obese workers by paying lower wages. In this case, the 'perceived' MRP of the obese workers will be lower. The probable explanation of this wage discrimination is that employers believe that overweight workers are less productive (Godard, 2016). If all employers have the same prejudice and taste while hiring obese workers, the obese workers will face unemployment and wage reductions.

1.12 Conceptual framework

A range of factors influence overweight and obesity, and it poses enormous health and economic burdens to an individual and society as a whole. The conceptual framework of this thesis builds upon the Australian Health Performance Framework (AHPF) to identify the risk factors of obesity and its health and workplace costs. The framework aims to improve health outcomes and ensure the sustainability of the Australian healthcare system. Figure 10 highlights a range of factors that can influence the health and labour market status and interrelationships among these factors within the health system. Although, the conceptual framework utilized in the thesis does not intend to encompass all the risk factors and burdens of obesity. Instead, this framework aims to visualize the factors contributing to weight gain and its adverse effects on health and labour market outcomes. The domain, determinants of health, in the conceptual framework includes socioeconomic, health behaviours, personal biomedical and environmental factors that influence people’s health status, labour force status, and healthcare requirements. In line with the context, three studies were conducted. This thesis checks how different risk factors, such as (i) geographic remoteness, (ii) disadvantaged neighbourhoods and lifestyle factors, and (iii) job-related characteristics influence the obesity status of Australians. The health system domains include effectiveness, safety, appropriateness, continuity of care, accessibility, efficiency, and sustainability to capture the healthcare system's activity, quality, and performance. The health status domain reflects health conditions, function, wellbeing, and deaths of the population. In line with the health status context, this study conducts five individual studies. More specifically, this study examines the relationships between obesity and (i) chronic disease burden, (ii) disability, (iii) healthcare services utilisation, (iv) self-assessed health and mental health, and (v) health-related quality of life. Costs on the workforce domain reflect adverse labour market outcomes that may arise from components of health determinants. The section conducted four separate studies, namely, the effects of obesity on (i) absenteeism, (ii) presenteeism, (iii) job satisfaction, and (iv) employment discrimination in the workplace following this context. The health system context domain includes contextual issues, such as demographics, community and social capital, governance and structure, financing, workforce, infrastructure, and information, research, and evidence required to plan a sustainable healthcare system.

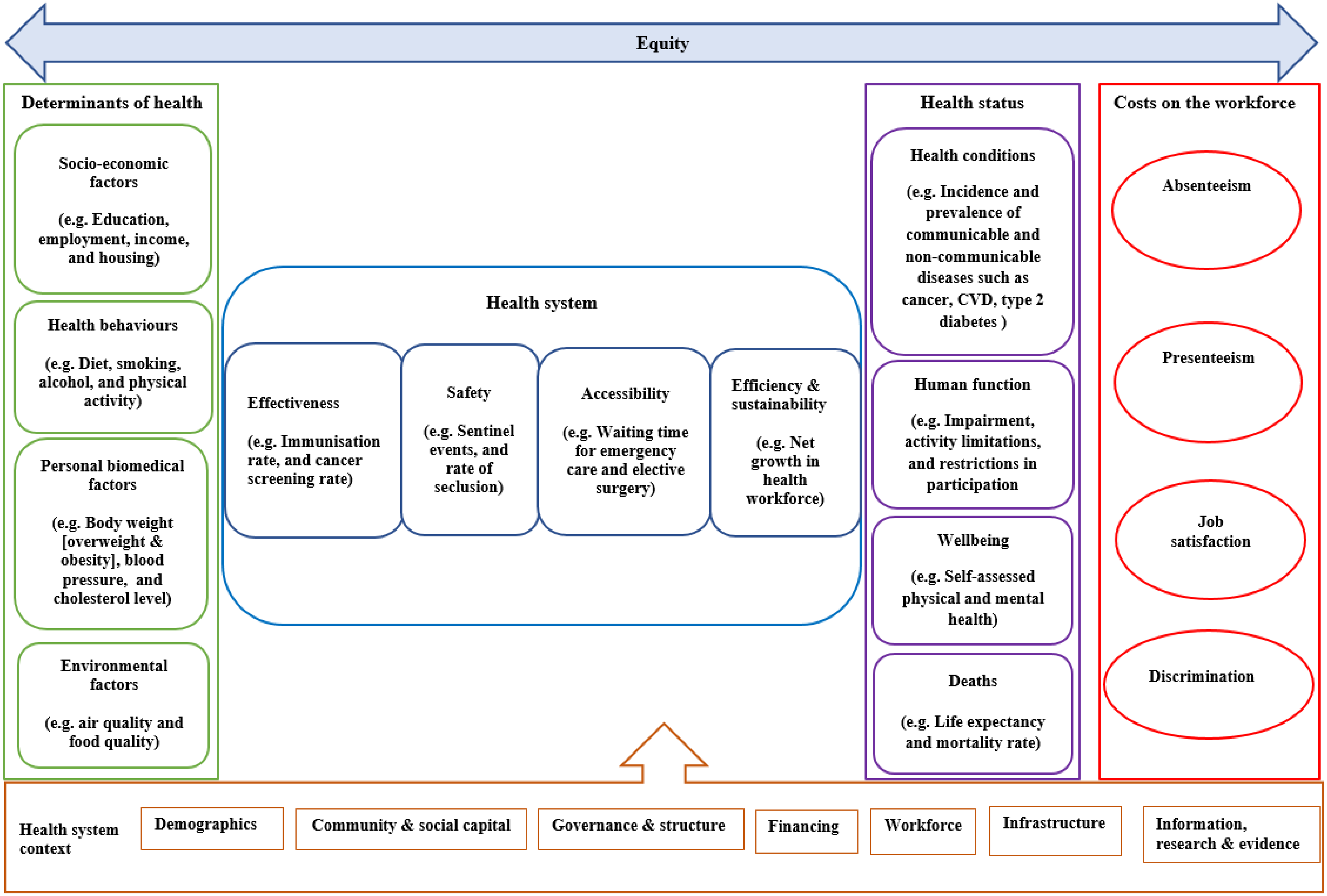

Figure 10: Conceptual framework for risk factors of overweight and obesity and its adverse health and labour market outcomes

1.13 Thesis structure

This PhD is a thesis by publication. There are five chapters in the thesis. The working titles and a brief of each chapter are outlined below.

Chapter 1: Introduction

This section outlines the background of the study, problem statement, study objectives, research questions, literature review, research gap, theoretical framework, and conceptual framework of the study.

Chapter 2: The rising prevalence and risk factors of adult obesity in Australia

This section reveals the trend in the prevalence of adult obesity and associated risk factors in Australia. This chapter consists of three research papers. The details of each study are displayed below.

Article I: Keramat, S. A., Alam, K., Al-Hanawi, M. K., Gow, J., Biddle, S. J. H, & Hashmi, R. (2021). Trends in the prevalence of adult overweight and obesity in Australia, and its association with geographic remoteness. Scientific Reports, 11(1), 1-9.
DOI: https://doi.org/10.1038/s41598-021-90750-1

Article II: Keramat, S. A., Alam, K., Gow, J., & Biddle, S. J. H. (2020). Impact of Disadvantaged Neighborhoods and Lifestyle Factors on Adult Obesity: Evidence From a 5-Year Cohort Study in Australia. American Journal of Health Promotion, 0890117120928790.
DOI: https://doi.org/10.1177%2F0890117120928790

Article III: Keramat, S. A., Alam, K., Gow, J., & Biddle, S. J. H. (2020). Job-Related Characteristics and Obesity in Australian Employees: Evidence From a Longitudinal Nationally Representative Sample. American Journal of Health Promotion, 0890117119901093.
DOI: https://doi.org/10.1177/0890117119901093

Chapter 3: Untangling the health consequences of adult obesity in Australia

This chapter reveals the health burden of adult obesity in Australia. This chapter consists of five research papers. The details of each study are displayed below.

Article IV: Keramat, S. A., Alam, K., Rana, R. H., Chowdhury. R., Farjana, F., Hashmi, R., Gow, J., & Biddle, S. J. H. (2021). Obesity and the risk of developing chronic diseases in middle-aged and older adults: Findings from an Australian longitudinal population survey, 2009-2017. PloS one (under review).

Article V: Keramat, S. A., Alam, K., Sathi, N. J., Gow, J., Biddle, S. J. H., & Al-Hanawi, M. K. (2021). Self-reported disability and its association with obesity and physical activity in Australian adults: Results from a longitudinal study. SSM-Population Health, 14, 100765.

DOI: https://doi.org/10.1016/j.ssmph.2021.100765

Article VI: Keramat, S. A., Alam, K., Halim. S.F.B., Sathi, N. J., Gow, J., & Biddle, S. J. H. (2021). Obesity, multimorbidity, and patterns of healthcare services utilisation in Australia: evidence from a longitudinal study of 20,000 adults. BMJ Open (under review).

Article VII: Keramat, S. A., Alam, K., Ahinkorah, B. O., Islam, M. S., Islam, M. I., Hossain, M. Z., Ahmed, S., Gow, J., & Biddle, S. J. (2021). Obesity, Disability and Self-Perceived Health Outcomes in Australian Adults: A Longitudinal Analysis Using 14 Annual Waves of the HILDA Cohort. ClinicoEconomics and Outcomes Research, 13, 777-788.

DOI: https://doi.org/10.2147/ceor.s318094

Article VIII: Keramat, S. A., Alam, K., Ahinkorah, B.O., Aboagye, R.G., Saha, M., Samad, N., Gow, J., Biddle, S. J. H. and Seidu, A. A. (2021). Comorbid Chronic Diseases and Health-related Quality of Life in the Obese Population: a Longitudinal Analysis of a Nationally Representative Household Survey in Australia. Patient Preference and Adherence (under review).

Chapter 4: The impact of obesity on adverse labour market outcomes

This chapter reveals the effects of adult obesity on labour market outcomes in Australia. This chapter consists of four research papers. The details of each study are displayed below.

Article IX: Keramat, S. A., Alam, K., Gow, J., & Biddle, S. J. H. (2020). Gender differences in the longitudinal association between obesity, and disability with workplace absenteeism in the Australian working population. PloS one, 15(5), e0233512.

DOI: https://doi.org/10.1371/journal.pone.0233512

Article X: Keramat, S. A., Alam, K., Gow, J., & Biddle, S. J. H. (2020). A longitudinal exploration of the relationship between obesity, and long-term health condition with presenteeism in Australian workplaces, 2006-2018. PloS one, 15(8), e0238260.

DOI: https://doi.org/10.1371/journal.pone.0238260

Article XI: Keramat, S. A., Alam, K., Gow, J., & Biddle, S. J. H. (2020). Obesity, long-term health problems, and workplace satisfaction: a longitudinal study of Australian workers. Journal of Community Health, 45(2), 288-300.

DOI: https://doi.org/10.1007/s10900-019-00735-5

Article XII: Keramat, S. A., Alam, K., Rana, R. H., Shuvo, S. D., Gow, J., Biddle, S. J., & Keating, B. (2021). Age and gender differences in the relationship between obesity and disability with self-perceived employment discrimination: Results from a retrospective study of an Australian national sample. SSM-Population Health, 100923.

DOI: https://doi.org/10.1016/j.ssmph.2021.100923

Chapter 5: Conclusion and policy implications

This section contains chapter summary, key findings, policy recommendations, contributions to the field of research, limitations and future research, and conclusion of the study.

CHAPTER 2: THE RISING PREVALENCE AND RISK FACTORS OF ADULT OBESITY IN AUSTRALIA

CHAPTER 2: STUDY 1

Trends in the prevalence of adult overweight and obesity in Australia, and its association with geographic remoteness

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DOI: https://doi.org/10.1038/s41598-021-90750-1

Abstract

Background: The prevalence of overweight and obesity has been increasing globally and has become a significant public health concern in Australia in the two past decades.

Objective: This study explores the most recent national prevalence and trends of adult overweight and obesity in Australia. It also will investigate geographic remoteness as a potential risk factor for an individual being overweight or obese in adulthood.

Design: A retrospective longitudinal study that utilised 14 successive waves (wave 6 through 19) of a nationally representative linked individual-level survey.

Methods: Data was obtained from the Household, Income and Labour Dynamics in Australia (HILDA) survey. The data on 199,675 observations from 26,713 individuals aged ≥ 15 years over the period 2006 to 2019 was analysed. Random-effects logit model was employed to estimate the association between geographic remoteness and the risk of excessive weight gain.

Results: The results reveal that the prevalence of overweight, obesity and combined overweight and obesity among Australian adults in 2019 were 34%, 26% and 60%, respectively. The analysis shows that the prevalence of overweight and obesity varies by geographic remoteness. Adults from regional city urban (OR = 1.53, 95% CI: 1.16-2.03) and rural areas (OR = 1.32, 95% CI: 1.18-1.47) were more likely to be obese compared with their counterparts from major city urban areas. The results also show that adults living in major city urban areas, regional city urban areas, and regional city rural areas in Australia were 1.53 (OR = 1.53, 95% CI: 1.16-2.03), 1.32 (OR = 1.32, 95% CI: 1.18-1.47), and 1.18 (OR = 1.18, 95% CI: 1.08-1.29) times more likely to be overweight compared with their counterparts from major city urban areas in Australia.

Conclusion: Substantial geographic variation in the prevalence of overweight and obesity exists among Australian adults and appears to be increasing. Public health measures should focus on contextual obesogenic factors and behavioural characteristics to curb the rising prevalence of adult obesity.

Keywords: Australia; geographic remoteness; HILDA; Obesity; Overweight

Introduction

Obesity has been defined as the accumulation of excessive body fat that has adverse health effects. In 2016, 13% (over 650 million) of adults aged ≥ 18 years were obese worldwide (World Health Organization, 2020a). In 2017-18, the combined rate of adult overweight and obesity was 67% in Australia (Australian Bureau of Statistics, 2018a). It is predicted that the Australian adult obesity rate alone will reach 35% by 2025. It is also projected that the rate of severe obesity (Body Mass Index [BMI] ≥ 35) will reach 13% by 2025 from just 5% in 1995 (Hayes et al., 2017).

Obesity is an emerging public health concern in Australia (Australian Institute of Health and Welfare, 2020c). Overweight and obesity together is the second leading risk factor contributing 8.4% of the total disease burden in Australia, behind tobacco use (Australian Institute of Health and Welfare, 2019b). Overweight and obesity are linked with an increased risk of non-communicable diseases (NCDs), such as cancers, cardiovascular diseases, musculoskeletal disorders, kidney disease, diabetes, asthma, dementia, sleep apnea (Australian Institute of Health and Welfare, 2017b; Peeters and Backholer, 2012; World Health Organization, 2020a) and long-term health conditions or disability (Keramat et al., 2021d). Further, obesity contributes substantially to labour productivity losses in the form of high absenteeism (Keramat et al., 2020a), presenteeism (Keramat et al., 2020b) and low job satisfaction (Keramat et al., 2020c) in the workplace. Therefore, the future direct (health burden) and indirect (productivity loss) costs will more likely increase with obesity's rising prevalence in Australian society.

Analyses of geographic disparity in the prevalence of NCDs are essential for public health intervention as they identify the conditions' above-average prevalence or 'hot spots'. Geographical disparity also exists in the prevalence of adult obesity. Discordant results have been found in the literature regarding the association between geographic remoteness and obesity in developed countries (Befort et al., 2012; Gong et al., 2018; He et al., 2017; Neovius and Rasmussen, 2008; Padez, 2006; Peytremann-Bridevaux et al., 2007; Svensson et al., 2007). A recent United States (US) study confirmed that substantial geographic differences exist in obesity prevalence among Asian Americans (Gong et al., 2018). Four empirical studies conducted in the US and European countries indicate that living in rural settings is positively associated with overweight and obesity (Befort et al., 2012; Neovius and Rasmussen, 2008; Padez, 2006; Svensson et al., 2007). However, a study of 10

European countries provides evidence that the prevalence of obesity does not vary between rural and urban settings (Peytremann-Bridevaux et al., 2007). Moreover, some studies have documented within-country (e.g., state-level or region-level) variation in overweight and obesity prevalence in developed countries, such as the US, Canada and Finland (Gurka et al., 2018; Lahti-Koski et al., 2008; Pouliou and Elliott, 2009).

The prevalence of overweight and obesity in all age groups has risen dramatically over the last three decades in Australia. The Australian Institute of Health and Welfare reports the adulthood obesity rate at the national level (Australian Institute of Health and Welfare, 2020c); however, little is known about geographic remoteness, within-country variations, such as remoteness and urban-rural settings. Furthermore, previous studies have not examined geographic remoteness and individual characteristics in tandem when determining the risk factors of obesity. Limited efforts have been made to explore the association between geographic remoteness and obesity using longitudinal data. Given the high prevalence in the trends of adulthood obesity in Australia and the large geographic distances and contexts experienced, it would be prudent to investigate the longitudinal association between geographic remoteness and increased risk of being obese. Therefore, the present study aims to document the prevalence of adult overweight and obesity in Australia and report the longitudinal association between geographic remoteness with the risk of being overweight and obese.

The present study is novel because it captures the association between geographic remoteness and adulthood obesity along with the distribution and comparison of obesity prevalence within Australian cities and rural-urban areas. The findings will be valuable in supporting public health initiatives to halt the obesity epidemic.

Methods

Data source and sample selection

The present study data were extracted from the nationally representative Household, Income and Labour Dynamics in Australia (HILDA) survey. HILDA is a large-scale household-based longitudinal survey that collects data annually from over 13,000 individuals within over 7,000 households. Since 2001, it has collected information on various aspects of the individuals' lives, including income, wealth, labour status, fertility, health, education, skills and more. The survey collects data from individuals aged 15 years and above in the household using a combination of self-completed questionnaires and face-to-face and telephone interviews by trained interviewers. The details of the HILDA survey design have been described elsewhere (Freidin et al., 2002).

Information concerning BMI, the primary variable of interest, is available from wave 6 onwards in the HILDA survey. Therefore, this study considered data from wave 6 through 19 of the HILDA survey, spanning from 2006 to 2019. The entire HILDA cohort (waves 6 through 19) consists of 297,120 person-year observations. However, a total of 97,445 observations were dropped due to non-response (73,952) and non-matching (23,493) for the self-completion paper questionnaire (SCQ). After excluding non-response and non-matching observations from the original sample, the working sample comprises of 199,675 yearly observations from 26,713 individuals at (up to) fourteen different time points. The present analysis utilised supplied responded person SCQ weights to retain the national representativeness of the study sample. After using supplied responded person SCQ weights, the estimated population size ranged from 15,115,558 (corresponding unweighted sample size of 11,716 individuals in wave 6) to 19,109,375 (corresponding unweighted sample size of 16,150 in wave 19). Year-wise unweighted sample and weighted population size have been provided in Table 1 of Appendix A. A detailed description of the HILDA survey weights has been outlined elsewhere (Summerfield, M., Bevitt, A., Fok, Y., Hahn, M., La, N., Macalalad, N., & Wooden, 2018). The present study conducted a missing observation analysis and found that nearly 5% of responses were missing for the variable, BMI (please refer to Table 2 of Appendix A). This study utilised the last observation carried forward (LOCF) method after controlling individual for imputing missing responses to produce conservative estimates.

Outcome variable

The present study is primarily interested in adult overweight and obesity, measured through an internationally standardised BMI measure. This study used self-reported height and weight to compute BMI using the formula, weight (kg) / height^2 (metre). To define the participant's weight status, this study categorised BMI into underweight (BMI<18.50), healthy weight (BMI 18.50 to <25), overweight (BMI 25 to <30) and obese (BMI ≥30) following the World Health Organization (WHO) cut off points(World Health Organization, 2020a). BMI was further recoded into binary form ('healthy' weight versus overweight or obese) as the two possible outcomes for the multivariate regression analysis.

Exposure variable

The primary exposure variable investigated in this study is geographic remoteness, measured through remoteness (major city, regional city, and remote areas), and place of residence (urban and rural settings). These two variables were used to construct the variable, geographic remoteness. One of the significant geographical units of analysis in the HILDA survey is remoteness. Remoteness is measured through the Australian Statistical Geography Standard (ASGS) Remoteness Structure, which divides remoteness into five groups: major cities, inner regional, outer regional, remote, and very remote based on the road distances that people have to travel to access key services (Australian Bureau of Statistics, 2016). This study collapsed remoteness into two categories: major cities and regional cities (merging inner regional, outer regional, remote and very remote areas). Another geographical unit of measurement in HILDA is residence, a binary variable of urban and rural settings. This measure is quite different from the remoteness area measure. During the survey, each individual's household was assigned according to the 2001 Census Collection District (CD). Population counts from the 2001 Census were then used to classify CDs as urban or rural settings (Australian Bureau of Statistics, 2001). Using these two variables (remoteness and place of residence), this study formed a new mutually exclusive variable, geographic remoteness. This study categorised geographic remoteness into four groups: major city urban areas, major city rural areas, regional city urban areas, and regional city rural areas.

Covariates

This study considered covariates based on previous research on the risk factors of adult obesity in Australia (Keramat et al., 2020d, 2020e). The socio-demographic covariates included age (15-24, 25-54, 55-64 and 65 or above years), gender (male and female), education (year 12 or below, professional qualification and university qualification), civil status (single, married/living together, and divorced/widow/separated), household income quintile (quintile 1 referring to the lowest income group and quintile 5 referring to the highest income group), labour force status (employed, unemployed and not in the labour force), and ethnicity (not of indigenous origin and Aboriginal or Torres Strait Islander [ATSI] or both). Behavioural characteristics included alcohol consumption (former or non-drinker or current drinker) and smoking cigarettes or tobacco products (former/non-smoker or current smoker).

Estimation strategy

An unbalanced panel data set was constructed through the individual's record's linkage, with most participants included in the analytic sample up to fourteen times (wave 6 through 19). The study participants' characteristics have been summarised in the form of frequency (n) and percentages (%) with 95% confidence intervals (CIs). The prevalence of obesity is reported in the form of percentages (%) by geographic remoteness. The bivariate association between the main variables of interests and covariates with the outcome variable were checked through chi-square tests. All the predictors were entered into the final model only when a predictor was significant at a 5% or less statistical significance level in the bivariate analysis. Two separate regressions were fitted to check the association between overweight and obesity with geographic remoteness adjusted for age, gender, education, civil status, household income, labour force status, ethnicity, smoking status, and alcohol consumption.

To estimate the association between BMI and geographic remoteness, random-effects logit models were deployed. For ease of interpretation of the results, adjusted odds ratio (aOR) with 95% CIs were reported. This study assessed all multivariate models at the 5% level of statistical significance and performed all statistical analyses using Stata 16 (StataCorp LLC).

Results

Table 1 describes the pooled BMI classification, geographic remoteness, socio-demographic and behavioural characteristics for the 199,675 person-year observations. The pooled prevalence of overweight and obesity was nearly 34% and 24%, respectively. Among the participants, 50% were in the age group 25 to 54 years, 53% were female, 59% were married, 25% had university qualifications, 33% were not in the labour force, 97% were not of Indigenous origin, 18% were current smoker, and 82% consumed alcohol. A large majority of the respondents lived in major city urban areas (65%) in Australia, followed by regional city rural areas (22%).

Table 1: Background characteristics of the study participants

Variables	**n**	**% (95% CI)**
Body Mass Index (BMI)		
Underweight (<18.50)	5,355	2.68 (2.61-2.75)
Healthy weight (18.50 to <25.00)	78,330	39.23 (39.01-39.44)
Overweight (25.00 to <30.00)	68,358	34.23 (34.03-34.44)
Obesity (≥30)	47,632	23.85 (23.67-24.04)
Age		
15-24 years	34,365	17.21 (17.05-17.38)

25-54 years	100,079	50.12 (49.90-50.34)
55-64 years	29,344	14.70 (14.54-14.85)
≥ 65 years	35,887	17.97 (17.80-18.14)
Gender		
Male	93,455	46.80 (46.58-47.02)
Female	106,220	53.20 (52.98-53.42)
Education		
Year 12 or below	88,795	44.47 (44.25-44.69)
Professional qualifications	61,703	30.90 (30.70-31.10)
University qualifications	49,177	24.63 (24.44-24.82)
Civil Status		
Single	46,335	23.21 (23.02-23.39)
Married/living together	118,494	59.34 (59.13-59.56)
Divorced/Widow/Separated	34,846	17.45 (17.29-17.62)
Household income quintile		
Quintile 1 (lowest)	39,935	20 (19.83-20.18)
Quintile 2	39,935	20 (19.83-20.18)
Quintile 3	39,935	20 (19.83-20.18)
Quintile 4	39,935	20 (19.83-20.18)
Quintile 5 (highest)	39,935	20 (19.83-20.18)
Labour force status		
Employed	126,686	63.45 (63.23-63.66)
Unemployed	7,479	3.75 (3.66-3.83)
Not in the labor force	65,510	32.81 (32.6-33.01)
Ethnicity		
Non-indigenous	194,582	97.45 (97.38-97.52)
Aboriginal/Torres Strait Islander	5,093	2.55 (2.48-2.62)
Geographic remoteness		
Major city urban areas	129,473	64.84 (64.63-65.05)
Major city rural areas	2,256	1.13 (1.08-1.18)
Regional city urban areas	23,433	11.74 (11.60-11.88)
Regional city rural areas	44,513	22.29 (22.11-22.48)
Smoking status		
Former/non-smoker	162,937	81.60 (81.43-81.77)
Current smoker	36,738	18.40 (18.23-18.57)
Alcohol consumption		
Former/non-drinker	38,315	19.19 (19.02-19.36)
Current drinker	161,360	80.81 (80.64-80.98)

Figure 1 displays the trends in overweight, obesity, combined rates of adult overweight and obesity from 2006 to 2019 in Australia. The prevalence of overweight and obesity in Australia were 34% and 26%, respectively, in 2019. Figure 1 also shows that the prevalence of combined overweight and obesity rate increased by five percentage points (55% in 2006 to 60% in 2019), and obesity alone increased by five percentage points (from 21% in 2006 to 26% in 2019) over the 14-year study period.

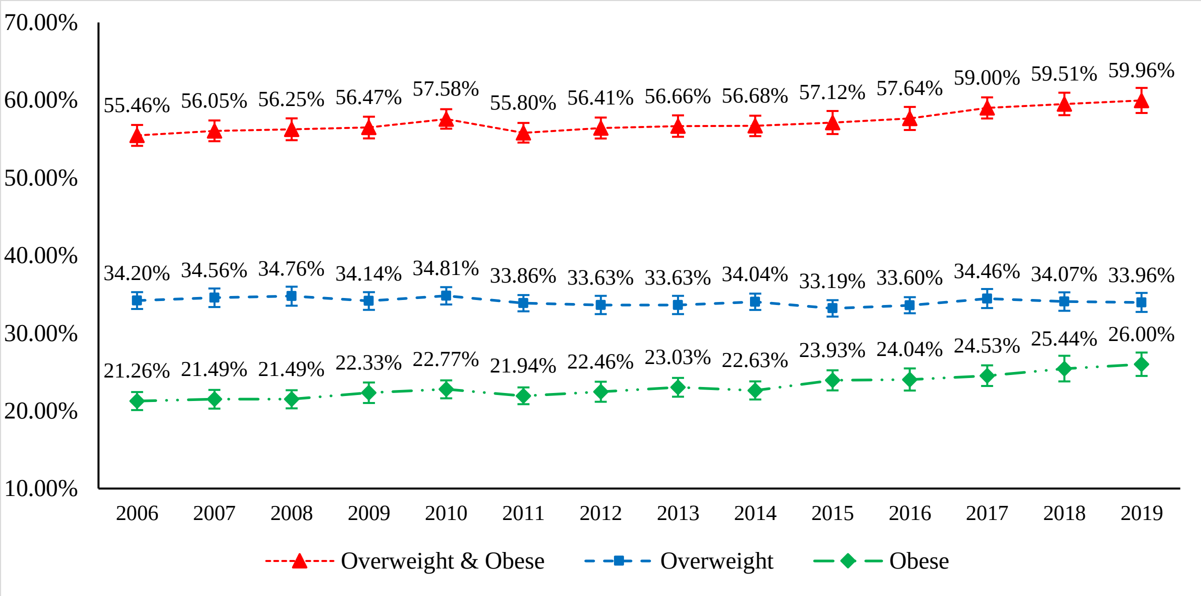

Figure 1: Overweight and obesity trends in Australia, 2006-2019

Figure 2 demonstrates the trends in the prevalence of obesity among Australian adults from 2006 to 2019 by geographic remoteness. A high variation in the prevalence of obesity regarding major and regional cities has been observed, along with an increasing trend in obesity from regional city urban and rural areas. Figure 2 reveals that rates of adult obesity in major city urban area, major city rural area, regional city urban area, and regional city rural area were 24%, 23%, 32%, and 32%, respectively, in 2019. Further, it shows that obesity rates ranged from 22% to 32% in regional city urban areas and 24% to 32% in regional city rural areas over the study period (2006-2019).

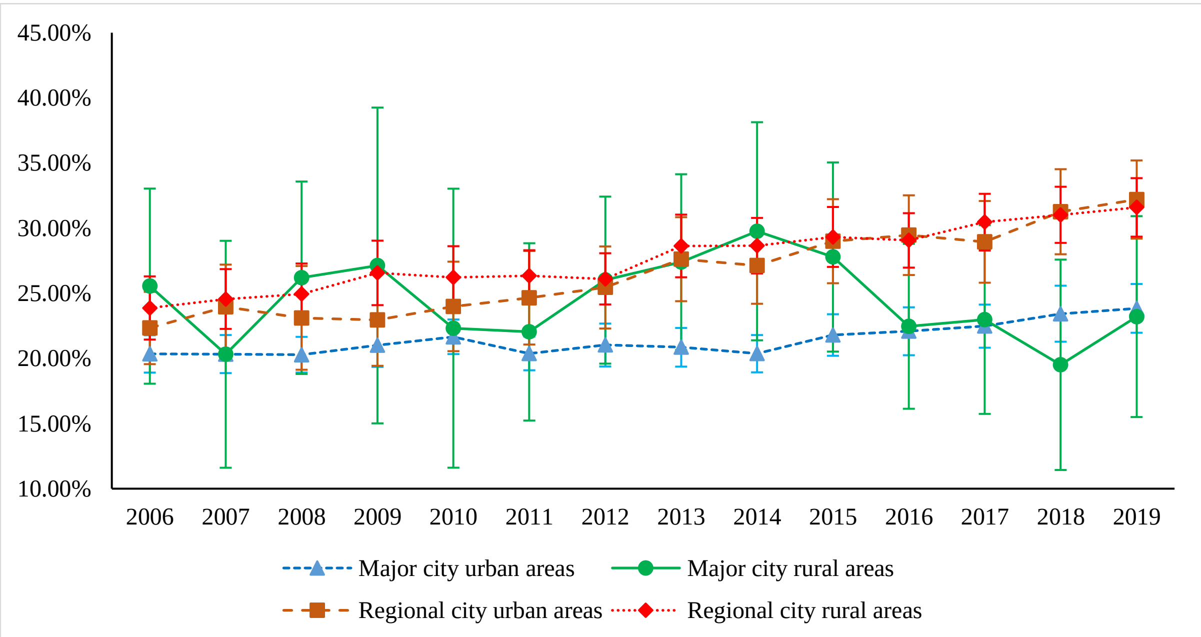

Figure 2: Trends in the prevalence of obesity by geographic remoteness in Australia, 2006-2019

Table 2 displays the results of the adjusted multivariate regression analyses for the longitudinal association between geographic remoteness, overweight, and obesity. The results showed that adults living in major city urban areas, regional city urban areas, and regional city rural areas in Australia were 1.53 (OR = 1.53, 95% CI: 1.16-2.03), 1.32 (OR = 1.32, 95% CI: 1.18-1.47), and 1.18 (OR = 1.18, 95% CI: 1.08-1.29) times more likely to be overweight compared with their counterparts from major cities urban areas in Australia (model 1). The results also showed that geographic remoteness is positively associated with a higher risk of being obese. The results revealed that the likelihood of being obese were 1.49 (OR = 1.49, 95% CI: 1.16-1.92) and 1.31 (OR = 1.31, 95% CI: 1.07-1.60) times higher among adults living in regional city urban and regional city rural areas of Australia, respectively, compared with their peers living in major city urban areas (model 2).

Table 2: Multivariate analysis for the adjusted associations between overweight and obesity with geographic remoteness

	Model 1	**Model 2**
Variables	**Overweight versus healthy weight**	**Obesity versus healthy weight**
Geographic remoteness		
Major city urban areas (ref)		
Major city rural areas	**1.53 (1.16-2.03), 0.003**	1.63 (0.85-3.13), 0.14
Regional city urban areas	**1.32 (1.18-1.47), <0.001**	**1.49 (1.16-1.92), 0.002**
Regional city rural areas	**1.18 (1.08-1.29), <0.001**	**1.31 (1.07-1.60), 0.01**
Age		
15-24 years (ref)		
25-54 years	**3.73 (3.40-4.08), <0.001**	**6.32 (5.16-7.74), <0.001**
55-64 years	**6.46 (5.73-7.29), <0.001**	**9.61 (7.29-12.67), <0.001**
≥ 65 years	**7.26 (6.30-8.36), <0.001**	**10.06 (7.30-13.87), <0.001**
Gender		
Male (ref)		
Female	**0.26 (0.24-0.30), <0.001**	**0.53 (0.43-0.66), <0.001**
Education		
Year 12 or below (ref)		
Professional qualifications	**1.70 (1.54-1.88), <0.001**	**3.27 (2.63-4.07), <0.001**
University qualifications	1.10 (0.99-1.24), 0.09	**0.64 (0.50-0.81), <0.001**
Civil Status		
Single (ref)		
Married/living together	**2.42 (2.22-2.65), <0.001**	**5.04 (4.14-6.13), <0.001**
Divorced/Widow/Separated	**2.39 (2.1-2.72), <0.001**	**5.18 (3.91-6.84), <0.001**
Household income quintile		
Quintile 1 (lowest)	**0.71 (0.65-0.77), <0.001**	**0.35 (0.28-0.43), <0.001**
Quintile 2	**0.71 (0.65-0.76), <0.001**	**0.52 (0.43-0.63), <0.001**
Quintile 3	**0.80 (0.75-0.86), <0.001**	**0.60 (0.49-0.72), <0.001**
Quintile 4	**0.91 (0.86-0.97), 0.01**	0.86 (0.72-1.03), 0.09
Quintile 5 (highest) (ref)		
Labor force status		

Employed (ref)		
Unemployed	**0.89 (0.80-0.99), 0.04**	1.25 (0.97-1.60), 0.08
Not in the labor force	**0.93 (0.87-0.99), 0.03**	**1.51 (1.29-1.77), <0.001**
Ethnicity		
Non-indigenous (ref)		
Aboriginal/Torres Strait Islander	**4.02 (2.88-5.60), <0.001**	**14.34 (6.67-30.84), <0.001**
Smoking status		
Former/non-smoker (ref)		
Current smoker	**1.34 (1.25-1.43), <0.001**	**0.52 (0.44-0.62), <0.001**
Alcohol consumption		
Former/non-drinker (ref)		
Current drinker	**0.77 (0.71-0.83), <0.001**	**1.58 (1.35-1.84), <0.001**

Abbreviation: ref reference,

Values in bold are statistically significant at p <0.05

Discussion

The present study firstly observed geographic disparities in the prevalence of adult overweight in Australia. Secondly, it checked the association between geographic remoteness and adult obesity. The results have provided further evidence that the prevalence of adult obesity across Australia has been increasing over time and that large geographic disparities exist in the prevalence of obesity. A substantial geographic difference in the prevalence, along with an increasing trend in obesity, has been observed over the 14-year study period. The prevalence of overweight and obesity combined in the present study is 60%, which is slightly lower than the national estimates. According to the National Health Survey (NHS) conducted every five years by the Australian Bureau of Statistics (ABS), the prevalence of overweight and obesity combined was 67% in 2017–18 among Australians aged 18 and over. One of the possible reasons for the underreported overweight and obesity rates could be that the present study considered adults aged 15 years and over. The prevalence of overweight and obesity is usually low in the younger age group. Sensitivity analysis was performed and it was found that the combined prevalence of overweight and obesity was 63% among Australians aged 18 years or over. The present study findings suggest that the prevalence of obesity in Australia has increased from 21% in 2006 to 26% in 2019. Further, the results revealed that the prevalence of adult obesity in regional city urban areas (22% to 32%) and regional city rural areas (24% to 32%) had increased sharply over the 14-year study period.

The study findings strongly support the hypothesis that there is a positive association between remoteness and excess body weight. The results reveal that the prevalence of adult obesity is greater in both regional city urban and rural areas compared with major city urban areas in Australia. The findings have been corroborated by a past study from Australia, which reported that living in regional towns and remote regions was associated with a higher probability of being obese (Keramat et al., 2020d). The present study finding supports the hypothesis that geographic disparity persists in the prevalence of adult obesity in Australia. An earlier US-based study also supports this finding, where substantial geographical differences (by US census division and region) in the prevalence of obesity have been reported (Gurka et al., 2018). Further, within-country variation in the prevalence of obesity has also been observed in the Canadian and Finnish populations (Lahti-Koski et al., 2008; Pouliou and Elliott, 2009). Moreover, this finding is in line with the conclusion of two studies conducted in Norway and the US, wherein the risk of being obese was higher among rural dwellers than urban counterparts (Befort et al., 2012; Svensson et al., 2007). However, this finding contradicts a study of 10 European countries in which no significant association between excess body weight and place of residence was detected (Peytremann-Bridevaux et al., 2007).

The geographic disparity in obesity might be due to more risky behaviours, such as poor diet, excessive alcohol consumption and physical inactivity among regional residents than their peers in major cities. A potential explanation for the variation in the prevalence of obesity across remoteness might be due to ethnicity. For example, the higher presence of Aboriginal people in a particular geographical area or a higher proportion of people born overseas in some geographic locations (Pouliou and Elliott, 2009). Furthermore, obesogenic factors, such as social pressure and limited opportunities for physical activities, could be potential risk factors for obesity. Besides, substantial geographic disparities in the prevalence of adult obesity could be attributed to socio-economic position, lifestyle, culture and genetic factors (He et al., 2017).

The study findings have some important public health implications since they revealed a statistically significant association between geographic remoteness and obesity. Australian federal, state, territory and local governments can play an important role in formulating and implementing health-related policies for maintaining a healthy weight, especially targeting adults living in regional cities and remote areas. Mass media for creating awareness, educational campaigns, and workplace health promotion could help reduce obesity level (Siddiqui et al., 2015). Public health intervention should focus on improving contextual obesogenic factors associated with geographic remotenesses, such as creating opportunities for physical activity and access to healthy foods, especially in rural areas. It should be recognised that obesity is associated with many factors and that this area is complex and will require taking a whole systems approach (Morshed et al., 2019).

The study findings have several strengths. Much of the information regarding the prevalence and trend in adult obesity in Australia comes from studies conducted at the national level. However, very little is known about the obesity rate in small geographical units such as regional cities or remote areas, and urban or rural locations in Australia. The present study is one of the largest epidemiological undertakings on geographical variation in adult obesity in a nationwide sample of the Australian adult population. Further, this study has considered a new geographical characteristic, geographic remoteness (by merging remoteness [major city versus regional city and remote areas] and place of residence [urban versus rural]) to check the geographical disparity in adult overweight and obesity. Another strength of this study is the considerable sample size (n = 199,675), which enables getting the precise estimates of the association between geographic remoteness and obesity, as well as the nationally representative prevalence of obesity.

This study has some limitations that should be considered. This research cannot identify causal pathways between geographic remoteness and obesity due to the unbalanced longitudinal research design. Control over the selection of covariates was also limited as several relevant factors, such as dietary habits, exercise patterns, sedentary behaviours, sleep patterns and quality and the presence of comorbidity, were not considered due to the unavailability of data. Another potential limitation is self-reported BMI to measure overweight and obesity that might underestimate the true prevalence as people systematically underreport weight and over-report height, resulting in lower BMI estimates (Gorber et al., 2007b; Maukonen, M., Männistö, S., Tolonen, 2018). Besides, there is a possibility of misreporting of height and weight that differed by the geographic remoteness. In taking these limitations into account, the findings suggest that future research should focus on a prospective longitudinal study to explain further the role of geographic remoteness concerning excessive weight gain over time.

Conclusion

This study has revealed the trend and obesity risk among Australian adults by examining individual and geographical characteristics using a nationally representative data set. It was revealed that substantial variance persists in the prevalence of adult obesity across geographic areas in Australia. Geographic remoteness is positively associated with a higher likelihood of obesity. Estimates from random-effects logit models confirm that living in both regional city urban areas and rural areas were associated with higher odds of being obese compared with living in major city urban areas. The risk of being overweight has been found to be higher among adults living in major city rural areas, regional city urban, and rural areas than their peers living in major city urban areas. Geographically targeted public health interventions and health education for creating awareness and promoting a healthier lifestyle might help combat the obesity epidemic in Australia. This study contributes to the limited literature regarding geographical variation in adult overweight and obesity in Australia.

Abbreviations

ATSI	Aboriginal or Torres Strait Islander
BMI	Body Mass Index
HILDA	Household, Income and Labour Dynamics in Australia Survey
OR	Odds Ratios
WHO	World Health Organization

Authors' contributions

SAK and RH initiated the study, conducted the data analysis and drafted the manuscript. KA, MKA, JG and SB offered advice, critical comments and edited the draft manuscript. All the authors read and approved the final manuscript.

Ethics approval

This paper uses unit record data from Household, Income and Labour Dynamics in Australia Survey (HILDA) conducted by the Australian Government Department of Social Services (DSS). However, the findings and views reported in this paper are those of the authors and should not be attributed to the Australian Government, DSS, or any of DSS contractors or partners. DOI: 10.26193/OFRKRH, ADA Dataverse, V2.

This study did not require ethical approval as the analysis used only de-identified existing unit record data from the HILDA survey. However, the authors completed and signed the Confidentiality Deed Poll and sent it to NCLD (ncldresearch@dss.gov.au) and ADA (ada@anu.edu.au) before the data applications' approval. Therefore, the datasets analysed and/or generated during the current study are subject to the signed confidentiality deed.

Conflict of interest

The authors declare that they have no conflicts of interest.

Availability of data and materials

The data used for the study was collected from the Melbourne Institute of Applied Economic and Social Research. There are some restrictions on this data and it is not available to the public. Those interested in accessing this data should contact the Melbourne Institute of Applied Economic and Social Research, The University of Melbourne, VIC 3010, Australia.

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CHAPTER 2: STUDY 2

Impact of disadvantaged neighbourhoods and lifestyle factors on adult obesity: evidence from a 5-year cohort study in Australia

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Abstract

Purpose: This study aims to investigate the impact of disadvantaged neighborhoods and lifestyle factors on obesity amongst Australian adults.

Design: Quantitative, Longitudinal research design.

Setting: Cohort.

Sample: Data for this study came from a cohort of 10,734 adults (21,468 observations) who participated in the Household, Income and Labour Dynamics in Australia (HILDA) survey. The participants were interviewed at baseline in 2013-2014 and were followed up in 2017-2018.

Measures: Generalized Estimating Equation (GEE) model with logistic link function was employed to examine within-person changes in obesity due to disadvantaged neighborhoods and lifestyle factors at two-time points over a four years follow-up period.

Results: Adults living in the most disadvantaged area were 1.22 (OR: 1.22, 95% CI: 1.08-1.38) and 1.30 (OR: 1.30, 95% CI: 1.20-1.42) times, respectively, more prone to be overweight and obese compared with peers living at least disadvantaged area. Study results also revealed that adults who consume fruit regularly and perform high levels of physical activity were 6% (OR: 0.94, 95% CI: 0.91-0.98) and 12% (OR: 0.88, 95% CI: 0.85-0.92) less likely to be obese, respectively, compared to their counterparts. Current alcohol drinkers were 1.07 (OR: 1.07, 95% CI: 1.01-1.13) times more likely to be obese compared to peers not consuming alcohol. Highly psychologically distressed adults were 1.08 times (OR: 1.08, 95% CI: 1.02-1.13) more likely to be obese than their peers.

Conclusion: This study contributes to the literature regarding disadvantaged neighborhoods and lifestyle factors, which have an influence on adult obesity rates and thus help health decision-makers to formulate effective obesity prevention strategies.

Keywords: Australia, lifestyle factors, disadvantaged neighborhoods, longitudinal study, obesity

Introduction

The worldwide prevalence of obesity has increased substantially from 3% to 11% among men and from 6% to 15% among women over the period 1975-2016 (Jaacks et al., 2019). In 2016, over 1.9 billion (39%) adults were overweight, and of these, 650 million (13%) were obese (World Health Organization, 2020a). In the Organisation for Economic Co-operation and Development (OECD) countries, more than one in two adults are either overweight or obese (OECD, 2017). The prevalence of obesity among Australian adults increased by 2.5 times between 1980 and 2000 (Cameron et al., 2004). This trend has continued, and the current prevalence of adult overweight (35.5%) and obesity (27.9%) is a total of 63.4% in Australia according to the latest available figures (2014-2015) (Huse et al., 2018). There is a prediction that future obesity prevalence in Australia will increase beyond 65% by 2025 (Walls et al., 2012). This rapid progression of obesity in the community has serious implications for health, productivity, and quality of life. At the national level, it imposes a tremendous economic burden on the health system (Hayes et al., 2017). This situation provokes a growing demand for research that will identify the diverse risk factors of obesity (Au et al., 2013).

Previous studies focusing on the prevalence of overweight and obesity in Australia have examined a particular dimension. For instance, projections of overweight and obesity trends (Haby et al., 2012; Hayes et al., 2017; Walls et al., 2012), prevalence and associated factors for child obesity (Olds et al., 2010; Wolfenden et al., 2011), factors influencing the probability of being obese (Avsar et al., 2017), socioeconomic disparities in obesity (Backholer et al., 2012), costs of obesity (Van Baal et al., 2008), modeling of obesity prevention (Sacks et al., 2011; Veerman et al., 2011), and the association between place and weight (Feng and Wilson, 2015; King et al., 2006) are the most prominent. Some studies (Cois and Day, 2015; Gong et al., 2018; Hu et al., 2017; Samouda et al., 2018) conducted in other countries have attempted to identify the risk factors of obesity based on cross-sectional data. Existing evidence reveals that aging (Gong et al., 2018), being male (Gong et al., 2018), being non-partnered (Samouda et al., 2018), having a low level of education (Gong et al., 2018; Samouda et al., 2018), consuming alcohol (Sung et al., 2007) and low physical activity (Samouda et al., 2018) were positively associated with higher Body Mass Index (BMI). However, some studies did not find an association between alcohol intake and obesity (Hu et al., 2017; Samouda et al., 2018). The primary limitation of these studies was causal inferences cannot be drawn due to the utilization of cross-sectional data. Longitudinal data as opposed to cross-sectional data assists in producing a more informed analysis as it can estimate variation within individuals. Previous efforts on the risk factors of obesity using longitudinal data are lacking. However, a recent well-designed longitudinal study concluded that neighborhood socioeconomic disadvantage is associated with higher BMI among middle and older aged (40-65 years) Australians (Rachele et al., 2017). Further, a recent study provided evidence that neighborhoods disadvantage is positively associated with the BMI of immigrants to Australia (Menigoz et al., 2018). Moreover, a longitudinal study conducted in China revealed that age, education, residence, and ethnicity are significantly associated with overweight and obesity (He et al., 2017). However, the main limitation of the existing studies is that longitudinal association was figured out by pooling cross-sectional surveys instead of capturing the within-person change in obesity by utilizing a cohort study design. Further, past studies conducted in Australia did not cover either the general population or adults of all age groups. Additionally, these longitudinal studies ignore some important lifestyle factors when modeled risk factors of obesity.

At the individual level, lifestyle factors (e.g., diet and physical activity) play an important role in maintaining human body's energy balance (National Health and Medical Research Council, 2013). Negative health behaviors such as low vegetable and fruit consumption contribute to gain weight (Allender et al., 2012). Further, the disadvantaged neighborhood is a major factor associated with a higher BMI (Australian Institute of Health and Welfare, 2018b). In 2014-2015, it was observed that adults living in the socioeconomically most disadvantaged areas (34%) were more obese compared to adults living in the least disadvantaged areas (22%) (Australian Institute of Health and Welfare, 2018a). These data indicate that disadvantaged neighborhoods might influence the weight status of Australian adults. One of the main methods through which living in a disadvantaged neighborhood affects overweight and obesity is easy access to unhealthy foods, less availability of nutritious foods, lack of recreational spaces or parks, limited opportunities for physical activities, and higher exposure to chemicals that increase fatty tissue in the human body (Black and Macinko, 2008; The National Institutes of Health (NIH), 2020). However, no study has yet exclusively studied the role of disadvantaged neighborhoods and lifestyle factors on adult weight status in a longitudinal setting. Given the lack of evidence that addresses this issue, this study attempts to examine the impact of disadvantaged neighborhoods and lifestyle factors on obesity among Australian adults. The main strength of the study is that it offers a comprehensive update of the influence of disadvantaged neighborhoods and lifestyle factors on the within-person change in obesity in Australia.

Theoretical Framework

To examine the effect of disadvantaged neighborhoods and lifestyle factors on adult obesity, the present study utilised the Social-Ecological Model (SEM) framework. A four-level social-ecological model was constructed to better understand the complex etiology of adult obesity. The SEM shows the complex interplay among individual, relationship, community, and societal factors and helps to discover the risk factors for and strategies for prevention of obesity. Different levels of the SEM helps to clarify how adult weight outcome is influenced by multiple factors and their interaction.

Individual: The first layer of the SEM identifies personal characteristics, biological factors, and individual behaviors that increase the likelihood of obesity. Example of individual factors that increase the likelihood of obesity includes age, gender, education, income and employment status.

Relationships: The second layer reveals the interaction between two or more people that may increase the risk of being obese. An individual's behavior is influenced by their closest people.

Some of these risk factors are tensions or struggles among family members, marital instability, and emotionally unsupportive family members.

Community: The third level explores the settings or institutions, such as schools, workplaces, and neighborhoods, in which social relations take place. Examples include the income level of neighborhoods, the extent of economic and recreational opportunities, and the physical layout of a neighborhood. The third layer of the SEM identifies the characteristics of these settings that might have an influence on adult weight status.

Societal: The fourth level focuses on the broad societal factors that influence an individual's health status. The factors include social and cultural norms, health, economic and educational policies. These important societal factors can be used to promote healthy living and remove health-related inequalities.

Methods

Data

The present study utilized data from the Household, Income and Labour Dynamics in Australia (HILDA) survey. HILDA is a nationally representative, household-based panel study that collects detailed information annually on over 13,000 individuals within over 7,000 households using a multi-stage sampling approach (Wilkins, 2013). The survey collects data on three main areas: economic and subjective well-being, labour market dynamics, and family life. More specifically, it collects data on a wide range of topics covering family relationships, wealth, income, employment, health, and education (Freidin et al., 2002). Data were collected from individuals aged 15 or over in the household using personal face-to-face interviews by trained interviewers and self-completed questionnaires. The details of the study design, sampling method and data collection strategies have been described elsewhere (Freidin et al., 2002).

The study participants were selected from two waves (wave 13 and wave 17) of the HILDA survey and information was collected during 2013-2014 and 2017-2018. The reason for this selection is that these two waves have extensively collected information on lifestyle characteristics. The present study imposed some exclusion criteria on these data to restrict the sample size. Individuals aged 15 or over were initially selected for the study. In order to reduce potential bias, this study excludes women who were pregnant during the survey. Further, this study restricts the sample to those with completed data on the outcome variable of BMI and exposure variables (i.e. fruit consumption and physical activity) at baseline and follow-up. This resulted in a cohort of 10,734 participants and 21,468 observations available for the subsample analyses.

Outcome variable

The main outcome variable of the study is BMI. This variable was constructed using self-reported height and weight following the formula weight (in kilograms) divided by height (in meters squared). World Health Organization (WHO) categorises BMI into four groups, <18.50 (underweight), 18.50-24.99 (normal weight), 25.00-29.99 (overweight), and ≥30 (obese) (World Health Organization, 2020a). However, underweight is not a topic of interest of the present study. To make the analysis simpler, the current study merged underweight and normal weight category to form a new category, <25 BMI, following a relevant study conducted in Australia (Au and Hollingsworth, 2011). The validity of self-reported height and weight as a measure of obesity has been addressed elsewhere (Bowring et al., 2012; Spencer et al., 2002).

Exposure variables

The main variables of interest of this study are the disadvantaged neighborhoods and lifestyle factors. This study used the Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) as a measure of disadvantaged neighborhoods. The IRSAD is one of the four indexes of the Socio-Economic Indexes for Areas (SEIFA) that captures the socio-economic conditions of people and households in an area considering relative locational advantages and disadvantages. This index considers those that fall into the following categories as disadvantaged: people with stated annual household equivalised income between $1 and $25,999; people occupying private dwellings paying rent less than $215 per week; those without internet connection; those without a motor vehicle; people aged under 70 who have a disability; people aged 15 and over who are separated; one-parent families with dependent offspring;, families with children under 15 years of age who live with jobless parents; those living in private dwellings requiring one or more extra bedrooms (based on Canadian National Occupancy Standard); people aged 15 years and over whose highest level of education is Year 11 or lower, or a certificate III or IV qualification; those with no educational attainment; employed people classified as 'labourers', machinery operators, drivers, sales, low skill community and personal service workers; people who are unemployed. In a similar fashion, the IRSD index considered the following information as indicators of advantage: people with stated annual household equivalised income greater than $78,000; people occupying private dwellings paying mortgages greater than $2,800 per month; paying rent greater than $470 per week; living in dwellings with four or more bedrooms; people aged 15 years and over whose highest level of education attainment is a diploma qualification or university qualification; employed people classified as professionals or managers. The Australian Bureau of Statistics (ABS) assigns a particular value for each designated area across Australia and ranks it according to its relative socio-economic advantage and disadvantage (Australian Bureau of Statistics, 2018b)**.** The lowest geographical unit is known as Statistical Area Level 1 which contains a population ranging from 200 to 800 persons, averaging approximately 400 persons. Each statistical area level is ranked on a decile score ranging from 1 (most disadvantaged) to 10 (least disadvantaged). Low and high index scores indicate that an area has a relatively greater disadvantage or greater advantage, respectively (Australian Bureau of Statistics, 2018b). For example, an area will have a low index score if many low-income households or many persons in unskilled occupations lived there and vice versa. The validity of the IRSAD has been confirmed by the ABS (Trewin, 2004). The present study collapsed IRSAD deciles into quintiles of disadvantaged neighborhoods where Quintile 1 represents the most disadvantaged area, and Quintile 5 denotes the least disadvantaged areas.

The present study included four lifestyle factors: vegetable consumption, fruit consumption, alcohol consumption and physical activity to examine their effect on adult obesity. Information on vegetable and fruit consumption were collected by asking the number of days in a usual week when an individual eats vegetables and fruit. Both variables were categorized into two groups (0-3 and 4-7 days in a usual week). Alcohol consumption patterns of the participants were self-reported and categorized into non-drinkers or former drinkers (either have never drunk alcohol or no longer drink) and current drinkers (ranging from only rarely to drinking every day). The covariate 'physical activity' is a derived variable which was measured through Metabolic Equivalent of Task (MET) minutes per week and categorized into low (<600 MET-minutes/week), moderate (600-<1500 MET-minutes/week) and high (≥ 1500 MET-minutes/week). The details of the measurement of physical activity are explained elsewhere (Wooden, 2014).

Other covariates

This study selected covariates based on previous studies on the risk factors for obesity (Cois and Day, 2015; Gong et al., 2018; Rawal et al., 2018; Samouda et al., 2018). The present study considered psychological distress as a health factor. Information on the participant's psychological distress was collected through the Kessler Psychological Distress Scale (K10). K10 is a 10 item questionnaire on anxiety and depression symptoms that respondent reported experiencing in the past four weeks. The test score ranges from 10 (no distress) to 50 (severe distress). The present study categorized psychological distress into three groups: low (score range 10-15), moderate (score range 16-21), and high (score range 22-50). Additional covariates included in the study are age (15-35, 36-55, and >55 years), sex (male and female), and marital status (married/partnered and non-cohabitating), education (year 12 or below, professional qualifications, and university qualifications), labor force status (not in the labor force, employed, and unemployed) and ethnic origin (not of Indigenous origin, and Aboriginal, or Torres Strait Islander [ATSI]). Additionally, this study categorizes remoteness as major cities, regional Australia (comprised of inner and outer regional), and remote Australia (comprised of remote or very remote) following the Australian Standard Geographical Classification (ASGC) (Australian Institute of Health and Welfare, 2004). The ASGC classified remoteness by road distances to the nearest urban localities of different sizes.

Statistical Analyses

The authors constructed a balanced longitudinal data set by linking an individual's record who participated in both wave 13 and wave 17 of the HILDA survey. The characteristics of the cohort were outlined by descriptive statistics in the form of frequency (n) and percentages (%) with 95% Confidence Intervals (CI) according to weight status, socio-demographic, and lifestyle factors. Further, chi-square tests were deployed to examine the bivariate association between obesity and related risk factors. Predictors were included in the adjusted model only if a predictor was significant at 5% or less risk level at any level in the bivariate analyses. A three-step modeling approach was followed to identify the impact of disadvantaged neighborhoods and lifestyle factors on adult obesity after controlling other covariates. In model 1, BMI was regressed on disadvantaged neighborhoods without adjustment. In models 2 and 3, regression analyses were repeated after adjusting lifestyle factors and socio-demographic factors, respectively. To model the association between disadvantaged neighborhoods, lifestyle factors, and obesity, this study used the Generalized Estimating Equation (GEE) model with logistic link function. This study evaluated all multivariate models at a 95% significance level ($p < 0.05$). All statistical analyses were conducted using Stata 14, Windows version.

Results

Background characteristics of the study participants

The general characteristics of the cohort were detailed in Table 1. The cohort comprised of 10,734 adults (21,468 observations) where the same subjects participated both at the baseline and at the 4-year follow-up. At the baseline, 35% of participants were overweight, and 25% of participants were obese. It is also observed that the obesity rate among the cohort increased from 25% (baseline) to 27% (follow-up). The distribution of the participants in terms of the IRSAD was: quintile 1 (18%), quintile 2 (20%), quintile 3 (19%), quintile 4 (21%), and quintile 5 (22%) at the baseline and this distribution was found nearly same in the follow-up period. In both waves, approximately 89% and 70% of the participants reported that they consumed vegetables and fruits, respectively, 4 to 7 days per week. It is also noticed that the percentage of current alcohol drinkers increased slightly in the follow-up (83%) from baseline (82%). With regard to physical activity, the percentage of adults who performed high levels of physical activity decreased in the follow-up (32%) from 36% (baseline).

Table 1: Background characteristics of the study participants

Variables	**n (%) at baseline**	**n (%) at 4-year follow-up**
Outcome Variable: Body Mass Index (BMI)		
BMI (<25)	4378 (40.79)	4010 (37.36)
Overweight (25.00-29.99)	3713 (34.59)	3798 (35.38)
Obesity (≥30)	2643 (24.62)	2926 (27.26)
Explanatory variables		
Disadvantaged neighborhoods (IRSD index)		
Quintile 1 (most disadvantaged)	1971 (18.36)	1907 (17.77)
Quintile 2	2094 (19.51)	2145 (19.98)
Quintile 3	2082 (19.40)	2068 (19.27)
Quintile 4	2279 (21.23)	2314 (21.56)

Quintile 5 (least disadvantaged)	2308 (21.50)	2300 (21.43)
Lifestyle factors		
Vegetable consumption		
1-3 days/week	1160 (10.81)	1225 (11.41)
4-7 days/week	9574 (89.19)	9509 (88.59)
Fruit consumption		
1-3 days/week	3224 (30.04)	3257 (30.34)
4-7 days/week	7510 (69.96)	7477 (69.66)
Alcohol consumption		
Former/non-drinker	1952 (18.19)	1869 (17.41)
Current drinker	8782 (81.81)	8865 (82.59)
Physical activity (Met-minutes/week)		
Low (<600)	3244 (30.22)	3643 (33.94)
Moderate (600-<1500)	3671 (34.20)	3707 (34.54)
High (≥1500)	3819 (35.58)	3384 (31.53)
Health factors		
Psychological distress		
low	7067 (65.84)	6823 (63.56)
Moderate	2147 (20.00)	2216 (20.64)
High	1520 (34.20)	1695 (15.79)
Socio-demographic factors		
Age		
15-35 years	3022 (28.15)	2524 (23.51)
36-55 years	3990 (37.17)	3641 (33.92)
>55 years	3722 (34.67)	4569 (42.57)
Sex		
Male	5078 (47.31)	5078 (47.31)
Female	5656 (52.69)	5656 (52.69)
Marital status		
Married / partnered	6537 (60.90)	6673 (62.17)
Non-cohabitating	4197 (39.10)	4061 (37.83)
Education		
Year 12 or below	4583 (42.70)	3950 (36.80)
Professional qualifications	3411 (31.78)	3692 (34.40)
University qualifications	2740 (25.53)	3092 (28.81)
Labor force status		
Not in the labor force	3513 (32.73)	3714 (34.60)
Employed	6852 (63.83)	6744 (62.83)
Unemployed	369 (3.44)	276 (2.57)
Ethnicity		
Not of indigenous origin	10485 (97.69)	10485 (97.69)
ATSI	248 (2.31)	248 (2.31)
Remoteness		
Major cities	7129 (66.42)	7114 (66.28)
Regional	3462 (32.25)	3477 (32.39)
Remote	143 (1.33)	143 (1.33)

Prevalence of obesity by socio-demographic and lifestyle factors

Table 2 shows the breakdown of the participants' weight status: BMI (<25), overweight, and obesity by disadvantaged neighborhoods and lifestyle factors along with several other socio-demographic factors. Further, chi-square test results showed that there was a significant association between these factors and the weight status of the participants. Table 2 revealed that obesity rates were highest amongst adults from the most disadvantaged areas (36%), whereas the prevalence is lowest for those from the least disadvantaged areas (19%) in the follow-up.

With regard to lifestyle factors, obesity rates among the adults who consumed vegetables (26% at baseline) and fruits (29% at baseline) 0 to 3 days per week have increased to 33% in the follow-up. The obesity rate among current alcohol drinkers has slightly increased in the follow-up (26%) from baseline (25%). Obesity rates among the cohort who performed low and high physical activity were 36% and 20%, in order, in the follow-up.

Table 2: Prevalence of overweight and obesity by disadvantaged neighborhoods, lifestyle, health, and socio-demographic factors

Variables	BMI (<25)		Overweight		Obesity		P-Value
	n (%) at baseline	n (%) at 4-year follow-up	n (%) at baseline	n (%) at 4-year follow-up	n (%) at baseline	n (%) at 4-year follow-up	
Disadvantaged neighborhoods (IRSD index)							<0.001
Quintile 1 (most disadvantaged)	679 (34.45)	586 (30.73)	657 (33.33)	629 (32.98)	635 (32.22)	692 (36.29)	
Quintile 2	777 (37.11)	757 (35.29)	724 (34.57)	749 (34.92)	593 (28.32)	639 (29.79)	
Quintile 3	826 (39.67)	753 (36.41)	725 (34.82)	739 (35.74)	531 (25.50)	576 (27.85)	
Quintile 4	988 (43.35)	891 (38.50)	801 (35.15)	851 (36.78)	490 (21.50)	572 (24.72)	
Quintile 5 (least disadvantaged)	1108 (48.01)	1023 (44.48)	806 (34.92)	830 (36.09)	394 (17.07)	447 (19.43)	
Lifestyle factors							
Vegetable consumption							<0.001
1-3 days/week	458 (39.48)	401 (32.73)	403 (34.74)	420 (34.29)	299 (25.78)	404 (32.98)	
4-7 days/week	3920 (40.94)	3609 (37.95)	3310 (34.57)	3378 (35.52)	2344 (24.48)	2522 (26.52)	
Fruit consumption							<0.001
1-3 days/week	1212 (37.59)	1084 (33.28)	1071 (33.22)	1107 (33.99)	941 (29.19)	1066 (32.73)	
4-7 days/week	3166 (42.16)	2926 (39.13)	2642 (35.18)	2691 (35.99)	1702 (22.66)	1860 (24.88)	
Alcohol consumption							<0.001
Former/non-drinker	902 (46.21)	710 (37.99)	564 (28.89)	578 (30.93)	486 (24.90)	581 (31.09)	
Current drinker	3476 (39.58)	3300 (37.23)	3149 (35.86)	3220 (36.32)	2157 (24.56)	2345 (26.45)	
Physical activity (Met-minutes/week)							<0.001
Low (<600)	1130 (34.83)	1135 (31.16)	1087 (33.51)	1198 (32.88)	1027 (31.66)	1310 (35.96)	
Moderate (600-<1500)	1504 (40.97)	1463 (39.47)	1282 (34.92)	1307 (35.26)	885 (24.11)	937 (25.28)	
High (≥1500)	1744 (45.67)	1412 (41.73)	1344 (35.19)	1293 (38.21)	731 (19.14)	679 (20.07)	
Health factors							
Psychological distress							<0.001
low	2898 (41.01)	2566 (37.61)	2558 (36.19)	2566 (37.61)	1611 (22.80)	1691 (24.78)	
Moderate	879 (40.94)	852 (38.45)	708 (32.98)	717 (32.35)	560 (26.08)	647 (29.20)	
High	601 (39.54)	592 (34.93)	447 (29.41)	515 (30.38)	472 (31.05)	588 (34.69)	
Socio-demographic factors							

Age							<0.001
15-35 years	1771 (58.60)	1312 (51.98)	790 (26.14)	722 (28.61)	461 (15.25)	490 (19.41)	
36-55 years	1450 (36.34)	1220 (33.51)	1426 (35.74)	1317 (36.17)	1114 (27.92)	1104 (30.32)	
>55 years	1157 (31.09)	1478 (32.35)	1497 (40.22)	1759 (38.50)	1068 (28.69)	1332 (29.15)	
Sex							<0.001
Male	1765 (34.76)	1599 (31.49)	2127 (41.89)	2159 (42.52)	1186 (23.36)	1320 (25.99)	
Female	2613 (46.20)	2411 (42.63)	1586 (28.04)	1639 (28.98)	1457 (25.76)	1606 (28.39)	
Marital status							<0.001
Married / partnered	2392 (36.59)	2332 (34.95)	2470 (37.78)	2510 (37.61)	1675 (25.62)	1831 (27.44)	
Non-cohabitating	1986 (47.32)	1678 (41.32)	1243 (29.62)	1288 (31.72)	968 (23.06)	1095 (26.96)	
Education							<0.001
Year 12 and below	1935 (42.22)	1445 (36.58)	1430 (31.20)	1295 (32.78)	1218 (26.58)	1210 (30.63)	
Professional qualifications	1164 (34.12)	1182 (32.02)	1296 (37.99)	1372 (37.16)	951 (27.88)	1138 (30.82)	
University qualifications	1279 (46.68)	1383 (44.73)	987 (36.02)	1131 (36.58)	474 (17.30)	578 (18.69)	
Labor force status							<0.001
Not in the labor force	1370 (39.00)	1299 (34.98)	1182 (33.65)	1273 (34.28)	961 (27.36)	1142 (30.75)	
Employed	2839 (41.43)	2609 (38.69)	2414 (35.23)	2441 (36.20)	1599 (23.34)	1694 (25.12)	
Unemployed	169 (45.80)	102 (36.96)	117 (31.71)	84 (30.43)	83 (22.49)	90 (32.61)	
Ethnicity							0.018
Not of indigenous origin	4292 (40.93)	3939 (37.57)	3629 (34.61)	3712 (35.40)	2564 (24.45)	2834 (27.03)	
ATSI	85 (34.27)	70 (28.23)	84 (33.87)	86 (34.68)	79 (31.85)	92 (37.10)	
Remoteness							<0.001
Major cities	3080 (43.20)	2835 (39.85)	2453 (34.41)	2482 (34.89)	1596 (22.39)	1797 (25.26)	
Regional	1257 (36.31)	1133 (32.59)	1204 (34.78)	1261 (36.27)	1001 (28.91)	1083 (31.15)	
Remote	41 (28.67)	42 (29.37)	56 (39.16)	55 (38.46)	46 (32.17)	46 (32.17)	

P-value was derived using chi-square test

*P < 0.05, **P < 0.01, ***P < 0.001

Risk factors of overweight and obesity

Table 3 displayed the adjusted association between disadvantaged neighborhoods, lifestyle risk factors, and obesity. Adults who live in the most disadvantaged area were 1.30 (OR: 1.30, 95% CI: 1.20-1.42) times more at risk of being obese compared to their peers living in the least disadvantaged areas. Further, participants belong to quintile 2 (OR: 1.21, 95% CI: 1.12-1.30), quintile 3 (OR: 1.14, 95% CI: 1.07-1.22), and quintile 4 (OR: 1.09, 95% CI: 1.02-1.15) were also 1.21, 1.14 and 1.09 times more likely, respectively, to be obese compared with peers belong to quintile 5. In addition, the study results showed that adults who lived in the most disadvantaged area were 1.22 (OR: 1.22, 95% CI: 1.08-1.38) times highly likely to be overweight compared with peers living at least disadvantaged neighborhoods. This indicates that living in a disadvantaged neighborhood is a major risk factor for both overweight and obesity.

Lifestyle factors, such as fruit consumption, alcohol consumption, and physical activity, have been found as significant risk factors of obesity. Adults who consumed fruit 4-7 days per week were 6% (OR: 0.94, 95% CI: 0.91-0.98) less likely to be obese than adults who consumed fruit 0 to 3 days per week. Current alcohol drinkers were 1.24 (OR: 1.24, 95% CI: 1.13-1.36) and 1.07 (OR: 1.07, 95% CI: 1.01-1.13) times more prone to be overweight and obese, respectively. Among all the lifestyle factors, this study found physical activity has the most influence on both overweight and obesity. Adults who performed high physical activity were 17% (OR: 0.83, 95% CI: 0.77-0.90) and 12% (OR: 0.88, 95% CI: 0.85-0.92) less likely to be overweight and obese, respectively, compared with counterparts who had low levels of physical activity. Additionally, the results reveal that adults having high psychological distress were 1.08 (OR: 1.08, 95% CI: 1.02-1.13) times more prone to be obese than their counterparts having low psychological distress.

Table 3: Disadvantaged neighborhoods, lifestyle factors and weight status among Australian adults

Variables	**Model 1**		**Model 2**		**Model 3**	
	OR (95% CI), P Value		**OR (95% CI), P Value**		**OR (95% CI), P Value**	
	Overweight	**Obesity**	**Overweight**	**Obesity**	**Overweight**	**Obesity**
Disadvantaged neighborhoods (IRSD index)						
Quintile 1 (most disadvantaged)	1.23 (1.10-1.37), **<.001**	1.31 (1.21-1.41), **<.001**	1.26 (1.13-1.41), **<.001**	1.31 (1.21-1.41), **<.001**	1.22 (1.08-1.38), **0.002**	1.30 (1.20-1.42), **<.001**
Quintile 2	1.20 (1.08-1.33), **<.001**	1.22 (1.15-1.31), **<.001**	1.21 (1.10-1.35), **<.001**	1.22 (1.15-1.31), **<.001**	1.19 (1.06-1.33), **0.003**	1.21 (1.12-1.30), **<.001**
Quintile 3	1.17 (1.05-1.29), **.003**	1.15 (1.09-1.22), **<.001**	1.17 (1.06-1.30), **0.002**	1.15 (1.09-1.22), **<.001**	1.17 (1.05-1.30), **0.006**	1.14 (1.07-1.22), **<.001**
Quintile 4	1.08 (0.98-1.19), 0.109	1.10 (1.04-1.16), **.001**	1.09 (0.99-1.20), 0.072	1.10 (1.04-1.16), **<.001**	1.08 (0.98-1.20), 0.116	1.09 (1.02-1.15), **0.007**
Quintile 5 (least disadvantaged) (ref)						
Lifestyle factors						
Vegetable consumption						
1-3 days/week (ref)						
4-7 days/week			0.94 (0.85-1.04), 0.228	0.99 (0.94-1.06), 0.959	0.91 (0.82-1.02), 0.096	0.99 (0.93-1.05), 0.719
Fruit consumption						
1-3 days/week (ref)						
4-7 days/week			0.97 (0.92-1.05), 0.543	0.95 (0.92-0.99), **0.016**	0.99 (0.92-1.07), 0.860	0.94 (0.91-0.98), **0.005**
Alcohol consumption						
Former/non-drinker (ref)						
Current drinker			1.33 (1.22-1.45), **<.001**	1.07 (1.02-1.13), **0.008**	1.24 (1.13-1.36), **<.001**	1.07 (1.01-1.13), **0.015**
Physical activity (Met-minutes/week)						
Low (<600) (ref)						
Moderate (600-<1500)			0.93 (0.87-0.99), **0.033**	0.97 (0.94-0.99), **0.050**	0.92 (0.86-0.99), **0.026**	0.96 (0.93-0.99), **0.025**
High (≥1500)			0.85 (0.79-0.91), **<.001**	0.90 (0.87-0.93), **<.001**	0.83 (0.77-0.90), **<.001**	0.88 (0.85-0.92), **<.001**
Health factors						
Psychological distress						
Low (ref)						
Moderate			0.90 (0.84-0.97), **0.005**	1.02 (0.98-1.05), 0.421	0.97 (0.90-1.05), 0.488	1.04 (0.99-1.08), 0.056
High			0.89 (0.81-0.98), **0.013**	1.04 (0.99-1.09), 0.158	1.04 (0.94-1.14), 0.473	1.08 (1.02-1.13), **0.008**
Socio-demographic factors						
Age						
15-35 years (ref)						
36-55 years					1.85 (1.68-2.02), **<.001**	1.56 (1.46-1.67), **<.001**
>55 years					2.39 (2.16-2.65), **<.001**	1.72 (1.59-1.86), **<.001**
Sex						

Male (ref)		
Female	0.52 (0.48-0.56), **<.001**	0.84 (0.77-0.92), **<.001**
Marital status		
Married / partnered (ref)		
Non-cohabitating	0.82 (0.76-0.88), **<.001**	0.86 (0.81-0.91), **<.001**
Education		
Year 12 and below (ref)		
Professional qualifications	1.20 (1.09-1.32), **<.001**	1.21 (1.11-1.31), **<.001**
University qualifications	0.99 (0.89-1.09), 0.859	0.76 (0.71-0.82), **<.001**
Labor force status		
Not in the labor force (ref)		
Employed	1.18 (1.09-1.29), **<.001**	1.02 (0.98-1.06), 0.340
Unemployed	1.22 (1.02-1.46), **0.034**	1.00 (0.91-1.10), 0.964
Ethnicity		
Not of indigenous origin (ref)		
ATSI	1.28 (0.97-1.70), 0.078	1.60 (1.20-2.14), **0.001**
Remoteness		
Major Cities (ref)		
Regional	1.10 (1.01-1.20), **0.027**	1.12 (1.04-1.21), **0.002**
Remote	1.18 (0.84-1.65), 0.335	1.29 (1.05-1.58), **0.015**

OR, Odds Ratio; CI, Confidence Interval; ref, Reference

Discussion

This study aims to examine the impact of living in disadvantaged neighborhoods and lifestyle factors on adult overweight and obesity in Australia. This study used two waves of data collected over a four year follow-up period from the nationally representative HILDA survey. This study used the GEE logit estimate to examine the within-person change in obesity due to living in disadvantaged neighborhoods and lifestyle factors. The study results showed that disadvantaged neighborhoods, fruit consumption, alcohol consumption, and physical activity have a significant influence on adult obesity levels.

The study results revealed that adults living in the most socio-economically disadvantaged areas were highly likely to be obese compared with adults living in the least disadvantaged areas. This finding supports the existing evidence that reported socioeconomically disadvantaged neighborhoods accounted for most BMI variation (Feng and Wilson, 2015; King et al., 2006; Menigoz et al., 2018; Rachele et al., 2017). The design of the neighborhoods has a great influence on people's physical activity, physical health, mental health and wellbeing outcomes (Local Government Association, 2018). Hence, the possible reasons could be people from disadvantaged neighborhoods eat less healthy food and perform lower levels of physical activity. There is evidence that low-income households usually follow unhealthy lifestyles like consuming nutrient-poor and energy-dense foods (Kalkunte et al., 2012).

In previous studies, very often lifestyle factors were ignored when examining the risk factors associated with obesity (Rawal et al., 2018). This study found evidence that regular fruit consumption prevents weight gain which supports other study findings (Schröder et al., 2007). The possible mechanism is the consumption of fruit helps adults to absorb vitamins, minerals and dietary fiber that help to reduce the risk of weight gain (World Health Organization (WHO), 2019). Alcohol is an important source of energy, but the relationship between alcohol intake and weight gain is unclear, with the existing evidence revealing positive, negative, and no association (Suter and Tremblay, 2005). However, this study found that alcohol intake increases the risk of being overweight or obese. This finding aligns with other studies (Traversy and Chaput, 2015) and the possible explanation is that moderate or high consumption of alcohol increases the chance of weight gain through a positive energy balance (Suter, 2005; Traversy and Chaput, 2015).

This study showed that physical activity is a significant predictor of the weight status of Australian adults. The study revealed that overweight or obesity rates are significantly lower amongst adults who performed moderate or high levels of physical activity. A recent study also concluded that physical activity can reduce weight gain and thus reduce the risk of becoming overweight or obese (Samouda et al., 2018). Physical activity plays a vital role in reducing weight by creating a negative energy balance (Jakicic and Otto, 2005; Swift et al., 2018).

Based on the findings, this study proposes some measures that the Australia government should consider to tackle the overweight and obesity epidemic. First, the authors' emphasis is on the establishment of healthier places so that people can lead a healthier lifestyle. Healthier places keep space for children to play and engaged with recreational activities, and encourages people to perform a modest exercise in the form of walking, cycling, and sports. The creation of healthier places helps people to maintain a healthy lifestyle to prevent the risk of weight gain along with other illnesses (Local Government Association, 2018). This suggestion is in line with the Australian Health and Wellbeing Strategic Framework 2017-2026 where the emphasis has also been on creating healthier places so that people can lead a healthy lifestyle. Second, implementing comprehensive science-based nutrition interventions that promote healthy weight. For example, public education and outreach programs help adults to follow a healthy lifestyle through healthy eating habits (reduce calorie intake, more consumption of fruit and vegetable, reduce alcohol intake etc). This study recommends adults to enjoy a wide variety of nutritious foods from the following five groups every day: i. vegetables, and legumes/beans; ii. fruit; ii. wholegrain (cereal) foods, such as bread, cereals, oats, quinoa and barley; iv. lean meats and poultry, fish, eggs, tofu, nuts and seeds; and v. milk, yoghurt, cheese and/or their alternatives, mostly reduced fat. Additionally, adults should drink plenty of water, and limit intake of foods containing saturated fat, added salt, added sugars and alcohol. This suggestion also aligns with the specific targets of the Australian Health and Wellbeing Strategic Framework 2017-2026 to reduce adult obesity.

This study has contributed to the existing literature in a number of ways. To capture the within-person change in weight due to disadvantaged neighborhoods and lifestyle factors, this study used a longitudinal design where cohorts were followed-up for four years. Lifestyle factors are major determinants of body weight. However, lifestyle factors were often ignored in past studies due to the paucity of data (Rawal et al., 2018). Unlike many previous studies on the risk factors of obesity, the present study considered a wide range of lifestyle factors. For example, this study considered lifestyle factors like vegetable and fruit consumption, alcohol intake, and levels of physical activity to examine its impact on adult obesity in a longitudinal setting. Further, the analysis deliberately separated overweight and obesity to check the impact of selected factors had on individuals' weight status, whilst most previous studies have merged overweight and obesity together.

This study also acknowledges some limitations. First, this study used self-reported BMI, vegetable consumption, fruit consumption, alcohol consumption, and physical activity that may underestimate or overestimate the study findings. Second, the majority of the study participants were from major cities and from non-Indigenous backgrounds. Hence, the true effect of remoteness and ethnicity could be overestimated.

Conclusion

Obesity is highly preventable. Hence, having evidence on the risk factors of overweight and obesity is imperative to identify the potential nature and scale of obesity prevention strategies. The evidence in this study may help policymakers to develop effective health interventions to reduce the current unsustainable level of overweight and obesity in society and thus lower its economic and health burden. The study results serve as a piece of evidence to health policymakers to identify the 'hot spots' of obesity and the related risk factors of overweight and obesity in Australian society. The authors suggest that area-level interventions should be tailored in a way that considers the needs of adults living in a disadvantaged neighborhood and is at the greatest risk of excessive weight gain. The authors envisage the findings of the study may contribute to the formulation of context-specific interventions or preventive efforts to reduce the current levels of weight gain and reduce the burden of obesity in the near future from Australian society.

Abbreviations

ATSI	Aboriginal or Torres Strait Islander
BMI	Body Mass Index
GEE	Generalized Estimating Equation
HILDA	Household, Income and Labor Dynamics in Australia survey
IRSAD	Index of Relative Socio-economic Advantage and Disadvantage
OR	Odds Ratio
SEIFA	Socio-Economic Indexes for Areas
WHO	World Health Organization

Ethics approval

This paper uses unit record data from Household, Income and Labour Dynamics in Australia Survey (HILDA) conducted by the Australian Government Department of Social Services (DSS). However, the findings and views reported in this paper are those of the

authors and should not be attributed to the Australian Government, DSS, or any of DSS contractors or partners. DOI: 10.26193/OFRKRH, ADA Dataverse, V2.

This study did not require ethical approval as the analysis used only de-identified existing unit record data from the HILDA survey. However, the authors completed and signed the Confidentiality Deed Poll and sent it to NCLD (ncldresearch@dss.gov.au) and ADA (ada@anu.edu.au) before the data applications' approval. Therefore, the datasets analysed and/or generated during the current study are subject to the signed confidentiality deed.

Conflict of interest

The authors declare that they have no conflicts of interest.

Availability of data and materials

The data used for the study was collected from the Melbourne Institute of Applied Economic and Social Research. There are some restrictions on this data and it is not available to the public. Those interested in accessing this data should contact the Melbourne Institute of Applied Economic and Social Research, The University of Melbourne, VIC 3010, Australia.

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CHAPTER 2: STUDY 3

Job-related characteristics and obesity in Australian employees: evidence from a longitudinal nationally representative sample

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Abstract

Objective: This study aimed to examine the longitudinal association between nine job-related characteristics and obesity among Australian employees using a nationally representative sample.

Design: Longitudinal research design

Setting: Workplace

Participants: This study was conducted by pooling two cross-sectional surveys of nationally representative longitudinal data collected across two-time points in 2013-14 and 2017-2018. This study limited the sample to current employees aged 15 to 64 years. The total number of observations included in the analysis is 16,980 for 11,521 employees.

Measures: The outcome variable is weight status and the main exposure variables are nine workplace characteristics (work hours per week, work schedule, job type, employment contract type, firm size, supervisory responsibility, paid sick leave, self-perceived job stress, and self-perceived job insecurity). Generalized Estimating Equation (GEE) logistic regression was employed to explore the association between job-related characteristics associated and obesity.

Results: This study found that 59% of Australian employees were either overweight or obese. Employees working more than 40 hours per week were 1.11 times (OR: 1.11, 95% CI: 1.03-1.21) and 1.07 times (OR: 1.07, 95% CI: 1.01-1.13) more prone to become overweight and obese, respectively, compared to their counterparts who work 31-40 hours per week. The study also revealed that self-perceived job insecurity was positively associated with obesity (OR: 1.03, 95% CI: 1.02-1.04). However, this study did not find evidence that work schedule, job type, employment contract, firm size, supervisory role, paid sick leave, and self-perceived job stress were associated with obesity.

Conclusion: Working more than 40 hours per week and self-perceived job insecurity were significantly associated with obesity among Australian employees. A better understanding of why prolonged work hours and self-perceived job insecurity are associated with obesity may help policymakers to implement workplace wellness policies and for employers to take measures to tackle the obesity problem of their employees.

Keywords: Obesity, employees, job-related characteristics, work hours, self-perceived job insecurity, Australia, longitudinal association

Introduction

Australia has the eighth highest proportion of overweight and obese adults in the world (Australian Institute of Health and Welfare, 2019a). Nearly 67% of Australian adults were either overweight or obese in 2018-19 (Australian Institute of Health and Welfare, 2019c). This high prevalence is a serious public health concern for Australia (Australian Institute of Health and Welfare, 2019d) as it is a major risk factor for chronic diseases such as cardiovascular disease, type 2 diabetes, high blood pressure, musculoskeletal conditions, and cancers (Australian Institute of Health and Welfare, 2019a). In Australia, 8.4% of the total health burden was due to overweight and obesity in 2015 (Australian Institute of Health and Welfare, 2019b). Moreover, obesity and associated comorbidities impose significant costs on the Australian health system (Australian Institute of Health and Welfare, 2019d). The estimated costs to the Australian economy in 2011-12 totaled AUD$8.6 billion (Australian Institute of Health and Welfare, 2017a).

In 2018, there were about 12.5 million Australian adults engaged in paid work of which two-thirds were full-time employees (Australian Government Department of Jobs and Small Business, 2018). In Australia, full-time workers perform over 35 hours or more of work per week (Australian Bureau of Statistics, 2018c). Genetics, behavioral characteristics such as diet and physical activities, socio-economic status, and education are the major risk factors for obesity (Centers for Disease Control and Prevention, 2017). Apart from these common causes and contributing factors, job-related characteristics might have an influence on the risk of obesity as workers spend much of their time at their worksite (Choi et al., 2010). Therefore, the workplace is an important venue to promote and support healthy behaviors to maintain healthy weight levels amongst workers (Park et al., 2014).

Existing evidence on the association between job-related characteristics and obesity have focused on particular job-related characteristics. For example, numerous studies have attempted to explain the association between long work hours and obesity. These studies have reported mixed results. Studies conducted in the USA and Australia have confirmed that long work hours significantly increased the odds of obesity in workers irrespective of gender (Di Milia et al., 2013; Di Milia and Mummery, 2009; Park et al., 2014). Other studies also demonstrated that prolonged work hours are significantly associated with obesity in male, but not female, manual workers (Escoto et al., 2010; Jang et al., 2013). However, a Korean study revealed that long work hours heightens the risk of obesity among female workers (Yoon et al., 2016).

The demand for shift workers is growing in Australia as it gives employers greater flexibility to maximize production and provide services around the clock (Australian Bureau of Statistics, 2010). The number of shift workers in Australia grew from 1.5 million in 2012 to 1.7 million in 2015 (Connery, 2017). Some studies have attempted to estimate if shift work is a contributing factor to obesity, (Di Milia et al., 2013; Jang et al., 2013; Lee et al., 2016; Miaomiao Sun et al., 2018; Yoon et al., 2016) but the results have not been consistent. Some of these studies found that the odds of being obese are significantly higher among shift workers (Lee et al., 2016; Miaomiao Sun et al., 2018; Yoon et al., 2016). Other studies concluded that shift work is not associated with workers' obesity status (Di Milia et al., 2013; Jang et al., 2013).

Apart from the most common job-related characteristics, some cross-sectional studies have examined the influence of employment contracts (permanent, fixed-term and casual contract) (Artazcoz et al., 2016), firm size (large, medium or small) (Park et al., 2014), supervisory responsibility (or not) (Artazcoz et al., 2016), and whether or not if paid sick leave is available (Park et al., 2014) on workers' obesity status. A recent study conducted among American workers reported a confusing association between firm size and obesity (Park et al., 2014) and also reported no significant association between paid sick leave and obesity. Similarly, Artazcoz et al. (Artazcoz et al., 2016) pointed out that employment contract types and supervisory roles were not associated with health status in European workers.

The influence of job-related characteristics on the weight status of employees requires further investigation due to these mixed findings. One possible reason for these inconsistent results could be attributed to the incorporation of just a few control variables in the empirical analytic models. In addition, to the best of our knowledge, most previous studies, which have investigated the association between job-related characteristics and obesity have used a cross-sectional research design. One of the main limitations of cross-sectional studies is that causality cannot be inferred (Park et al., 2014). Unlike cross-sectional studies, a prospective cohort study where the same individuals are followed over time can identify within-person changes (Caruana et al., 2015). However, very few studies have attempted to explore the longitudinal relationship between job-related characteristics and the risk of obesity. Moreover, longitudinal studies that focus on these associations have not considered sufficient job-related confounding factors (Lee et al., 2016). To fill this research gap, the present study examines the longitudinal association between nine job-related characteristics and the risk of being obese, utilizing longitudinal data on Australian employees.

The objective of this study is to identify the prevalence of obesity among Australian adult workers and examine the association between job-related characteristics and weight status after controlling for the socio-demographic and behavioral characteristics of the workers. This analysis will utilize longitudinal data drawn from the Household, Income and Labour Dynamics in Australia (HILDA) survey to address two research questions. First, is to estimate what percentage of employees aged 15-64 years are obese in Australia. Second, is to examine which aspects of job-related characteristics (worked hours per week, work schedule, job type, employment contract type, firm size, supervisory responsibilities, paid sick leave, self-perceived job stress, and self-perceived job insecurity) are associated with an increased risk of obesity.

Methods

Data

Data for the present study were extracted from the HILDA individual person dataset. HILDA is a large-scale nationally representative panel survey of Australian households that collects data on family, wealth, health, education, and labour market dynamics (Freidin et al., 2002). The survey has been conducted annually since 2001 following the University of Melbourne's ethical guidelines. HILDA collects data of all individuals aged 15 or older in the household using personal face-to-face interviews by trained interviewers and self-completed questionnaires. The survey used a multi-stage sampling approach, sampling within dwellings within administrative areas. The detail of the study design has been described elsewhere (Freidin et al., 2002).

The present study pooled two waves of HILDA survey data that were collected across two time periods of 2013-14 (wave 13) and 2017-2018 (wave 17). The principal reason for choosing these two waves is that data on some of the behavioural characteristics of interest are only available in these two waves. The analysis in this study is restricted to currently employed persons aged 15 to 64 years. This results in 18,053 study observations. Further exclusion of 1,073 observations of women employees who were pregnant during the survey left 16,980 observations of 11,521 subjects for the subsample analyses.

Outcome variable

The main outcome variable of the study is weight status, operationally defined here as self-reported body mass index (BMI). BMI was calculated using the formula weight in kilograms divided by height in meters squared. Following the guidelines of the World

Health Organization (WHO), this study categorized BMI as normal weight (BMI 18.50 to <25), overweight (BMI 25.00 to <30) and obese (BMI ≥30) (World Health Organization, 2020a).

Exposure variables

Nine job-related characteristics served as the main exposure variables: worked hours per week, work schedule, job type, employment contract type, firm size, supervisory responsibilities, paid sick leave, self-perceived job stress, and self-perceived job insecurity. Hours usually worked per week were categorized as 0-30, 31-40, and >40 hours per week (Di Milia et al., 2013; Park et al., 2014; Miaomiao Sun et al., 2018). The current work schedule was classified into day work (a regular daytime schedule) or shift work (includes a regular evening shift, night shift, rotating shift, split shift, on-call, and irregular schedule) (Di Milia et al., 2013; Jang et al., 2013; Lee et al., 2016; Miaomiao Sun et al., 2018; Yoon et al., 2016). The variable 'job type' was created from workers' occupation and classified into non-manual and manual workers (Jang et al., 2013; Yoon et al., 2016). Non-manual workers include managers, professionals, and clerical and administrative workers. Manual workers include technicians and trade workers, community and personal service workers, sales workers, machinery operators and drivers, and labourers. Workers' contract was categorized into permanent, fixed-term and casual (Artazcoz et al., 2016). Firm size was classified as small (1-19 employees), medium (20-99 employees) and large (≥100 employees) (Park et al., 2014). Workers were asked if they normally supervise the work of other employees and their responses were characterized as yes/no (Artazcoz et al., 2016). Paid sick leave was determined using the question: 'Does your employer provide paid sick leave?' and the responses were characterized in binary form (yes/no) (Park et al., 2014). Self-perceived job stress is a continuous variable based on workers' opinions about their job and was created from the response "my job is more stressful than I had ever imagined". It captures workers' perceptions regarding job stress ranging from 1 (strongly disagree) to 7 (strongly agree). Self-perceived job insecurity is a continuous variable that was created from the response "I worry about the future of my job". The variable captures workers' subjective view of job insecurity ranging from 1 (strongly disagree) to 7 (strongly agree).

Other covariates

Mutually exclusive response categories were formed for socio-demographic and behavioral characteristics of workers. Covariates included in the study are age (17-35, 36-55, and 56-64 years); sex (male and female); marital status (married and non-cohabitant), education (year 12 or below, professional qualification, and university qualification) and index of economic resources (IER) (categorized into five quintiles, quintile 1 to quintile 5). IER consisted of variables related to financial aspects (mainly income and wealth) to calculate relative socio-economic advantage and disadvantage (Australian Bureau of Statistics, 2018b). Low index scores indicate participants have a relative lack of access to economic resources and a high index score indicates participants have relatively greater access to economic resources.

Behavioural characteristics of the workers included sleep duration, vegetable consumption, fruit consumption, alcohol consumption, and physical activity.

Sleep duration was a derived variable that counted average hours of sleep per day. For employed people, the calculation is 5*workday sleep + 2*non-workday sleep + naps / 7. The study then categorizes the sleep duration variable into three categories (<6, 6-8, and >8 hours per day). Vegetable consumption variable was categorized into two groups (0-3 and 4-7 days per week) based on the response "number of days in a usual week eats vegetables (including tinned, frozen and fresh)". In a similar fashion, fruit consumption was categorized into two groups (0-3 and 4-7 days per week) based on the response "number of days in a usual week eats fruit (including tinned, frozen and fresh)". Alcohol consumption was categorized into two groups: non-drinker or former drinker (have never drunk alcohol and no longer drink) and current drinker (drink alcohol every day, drink alcohol 5 or 6 days per week, drink alcohol 3 or 4 days per week, drink alcohol 1 or 2 days per week, drink alcohol 2 or 3 days per month and only rarely) based on the response "do you drink alcohol?".

The covariate 'physical activity' is a derived variable that is classified into three groups (low, moderate and high). The categories were measured in metabolic equivalent of task (MET) minutes. Achieving a minimum total physical activity of at least 1500 MET-minutes per week indicates high, at least 600 MET-minutes per week indicates moderate, and less than this indicates low physical activity. The details of the measurement of physical activity are explained elsewhere (Wooden, 2014).

Statistical analyses

Descriptive analysis of the study participants are reported in the form of frequency (n) and percentages (%) with 95% confidence intervals (CI) according to weight status, socio-demographic, behavioral, and job-related characteristics. Chi-square tests were used to examine the bivariate association between participants' weight status and job-related characteristics. This study selected predictors for the adjusted model when a predictor was significant at 5% or less risk at any level in the bivariate analyses.

Multivariate analysis was performed using a generalized estimating equation (GEE) model to estimate the intra-participant effects of job-related risk factors on overweight and obesity. The odds ratios with 95% confidence intervals for overweight and obesity were estimated separately for the main variables of interests using the link function (binary logistic regression) of GEE. The main advantage of employing GEE is that it offers precise estimates in case of correlated data. In addition, GEE has a simple computation technique in the case of categorical variables compared with other estimation techniques.

In the analyses, some missing data in the explanatory variables have been imputed following the last value carry forward method. All statistical analyses were performed using Stata 14 windows version. The statistical level of significance was set at a p-value of <0.05.

Results

Table 1 shows the pooled characteristics of the employees in terms of socio-demographic, behavioral and job-related factors. The study participants comprised of 16,980 employees. Among the participants, around 41% of employees were normal weight, 35% were overweight and 24% were obese. Participants of the present study are predominantly in the age group 36-55 years (45%), were male (51%), were married or cohabitating (63%), and had a professional qualification (35%). Of the participants, nearly 40% of the workers usually worked 31-40 hours per week. The vast majority of employees were day workers (77%), did non-manual jobs (52%), had permanent employment contracts (68%), worked in small firms (43%), did not have supervisory responsibilities (55%), and enjoyed paid sick leave (75%). The average level of self-perceived job stress and self-perceived job insecurity of the workers were 3.15 and 2.99, respectively on a scale of 1 to 7.

Table 1: Participant characteristics

Variables	**n**	**Mean (SD)/ % (95%CI)**
Outcome Variable: Body Mass Index (BMI)		
Healthy weight (18.50-24.99)	6,994	41.19 (40.45-41.93)
Overweight or pre-obese (25.00-29.99)	5,970	35.16 (34.44-35.88)
Obesity (≥30)	4,016	23.65 (23.02-24.30)
Explanatory variables		
Socio-demographic characteristics		
Age		
15-35 years	6,788	39.98 (39.24-40.72)
36-55 years	7,688	45.28 (44.53-46.03)
56-64 years	2,504	14.75 (14.22-15.29)
Sex		
Male	8,637	50.87 (50.11-51.62)
Female	8,343	49.13 (48.38-49.89)
Marital status		

Married/Cohabitating	10,676	62.87 (62.14-63.60)
Non-cohabitating	6,304	37.13 (36.40-37.86)
Education		
Year 12 or below	5,604	33.00 (32.30-33.71)
Professional qualification	5,883	34.65 (33.93-35.37)
University qualification	5,493	32.35 (31.65-33.06)
Index of Economic Resources (IER)		
Quintile 1 (least advantaged)	2,659	15.66 (15.12-16.21)
Quintile 2	3,326	19.59 (19.00-20.19)
Quintile 3	3,394	19.99 (19.39-20.60)
Quintile 4	3,890	22.91 (22.28-23.55)
Quintile 5 (most advantaged)	3,711	21.86 (21.24-22.48)
Behavioural characteristics		
Sleep duration		
<6 hours/day	2,771	16.32 (15.77-16.88)
6-8 hours/day	11,016	64.88 (64.15-65.59)
>8 hours/day	3,193	18.80 (18.22-19.40)
Vegetable consumption		
0-3 days/week	2,042	12.03 (11.55-12.52)
4-7 days/week	14,938	87.97 (87.48-88.45)
Fruit consumption		
0-3 days/week	5,475	32.24 (31.54-32.95)
4-7 days/week	11,505	67.76 (67.05-68.46)
Alcohol consumption		
Former/non-drinker	2,160	12.72 (12.23-13.23)
Current drinker	14,820	87.28 (86.77-87.77)
Physical activity		
Low (<600 MET-minutes/week)	4,392	25.87 (25.21-26.53)
Moderate (≥600 MET-minutes/week)	5,521	32.51 (31.81-33.22)
High (≥1500 MET-minutes/week)	7,067	41.62 (40.88-42.36)
Job-related characteristics		
Hours per week usually worked		
0-30 hours/week	4,898	28.85 (28.17-29.53)
31-40 hours/week	6,810	40.11 (39.37-40.85)
>40 hours/week	5,272	31.05 (30.36-31.75)
Work schedule		
Day work	12,927	76.13 (75.48-76.77)
Shift work	4,053	23.87 (23.23-24.52)
Job type		
Non-manual	8,899	52.41 (51.66-53.16)
Manual	8,081	47.59 (46.84-48.34)
Employment contract		
Permanent	11,537	67.94 (67.24-68.64)
Fixed-term	1,727	10.17 (9.73-10.63)
Casual	3,716	21.88 (21.27-22.51)
Firm size		
Small (1-19 employees)	7,260	42.76 (42.01-43.50)

Medium (20-99 employees)	4,664	27.47 (26.80-28.14)
Large (≥100 employees)	5,056	29.78 (29.09-30.47)
Supervisory responsibilities		
Yes	7,627	44.92 (44.17-45.67)
No	9,353	55.08 (54.33-55.83)
Paid sick leave		
Yes	12,794	75.35 (74.69-75.99)
No	4,186	24.65 (24.01-25.31)
Self-perceived job stress	16,980	3.15 (1.66)
Self-perceived job insecurity	16,980	2.99 (1.79)

Abbreviations: SD Standard Deviation; CI Confidence Interval

Table 2 shows that the weight status of the subjects varied by socio-demographic, behavioral and job-related characteristics. It also shows that a significant bivariate relationship exists between all the selected covariates except firm size and weight status which were captured using chi-square and ANOVA tests. The study included the variable firm size in the multivariate analysis to explore the level of magnitude of the variable, although it was not significant in the bivariate analysis. Table 2 reports that the prevalence of obesity is highest among those workers who were aged 56-64 years (30%), were female (24%), were married (25%), have professional qualification (29%), and were from the first quintile of index of economic resources (27%). Table 2 also showed that the prevalence of obesity is higher among employees who worked over 40 hours a week (25%), were shift workers (25%), did manual jobs (25%), have permanent employment contracts (25%), worked in large firms (25%), had supervisory responsibilities (25%), and worked in firms with paid sick leave (25%). The average level of self-perceived job stress and self-perceived job insecurity among obese workers were 3.24 and 3.14, respectively.

Table 2: Association between weight status and participant characteristics

Variables	Healthy weight		Overweight		Obesity		P-value[1]
	n	Mean (SD)/ % (CI)	n	Mean (SD)/ % (CI)	n	Mean (SD)/ % (CI)	
Socio-demographic characteristics							
Age							<0.001
15-35 years	3,628	53.45 (52.26-54.63)	2,024	29.82 (28.74-30.92)	1,136	16.74 (15.87-17.64)	
36-55 years	2,632	34.24 (33.18-35.30)	2,933	38.15 (37.07-39.24)	2,123	27.61 (26.63-28.63)	
56-64 years	734	29.31 (27.56-31.13)	1,013	40.46 (38.55-42.39)	757	30.23 (28.46-32.06)	
Sex							<0.001
Male	2,958	34.25 (33.25-35.26)	3,660	42.38 (41.34-43.42)	2,019	23.38 (22.50-24.28)	
Female	4,036	48.38 (47.30-49.45)	2,310	27.69 (26.74-28.66)	1,997	23.94 (23.03-24.86)	
Marital status							<0.001
Married/Cohabitating	4,042	37.86 (36.94-38.79)	4,016	37.62 (36.70-38.54)	2,618	24.52 (23.72-25.35)	
Non-cohabitating	2,952	46.83 (45.60-48.06)	1,954	31.00 (29.87-32.15)	1,398	22.17 (21.17-23.22)	
Education							<0.001
Year 12 or below	2,450	43.72 (42.42-45.02)	1,767	31.53 (30.33-32.76)	1,387	24.75 (23.64-25.90)	
Professional qualification	1,997	33.95 (32.75-35.17)	2,207	37.51 (36.29-38.76)	1,679	28.54 (27.40-29.71)	
University qualification	2,547	46.37 (45.05-47.69)	1,996	36.34 (35.07-37.62)	950	17.29 (16.32-18.32)	
Index of Economic Resources (IER)							<0.001
Quintile 1 (least advantaged)	1,103	41.48 (39.62-43.37)	845	31.78 (30.04-33.57)	711	26.74 (25.09-28.46)	
Quintile 2	1,302	39.15 (37.50-40.82)	1,181	35.51 (33.90-37.15)	843	25.35 (23.90-26.85)	
Quintile 3	1,399	41.22 (39.57-42.89)	1,211	35.68 (34.09-37.31)	784	23.10 (21.71-24.55)	
Quintile 4	1,625	41.77 (40.23-43.33)	1,367	35.14 (33.66-36.66)	898	23.08 (21.79-24.44)	
Quintile 5 (most advantaged)	1,565	42.17 (40.59-43.77)	1,366	36.81 (35.27-38.37)	780	21.02 (19.74-22.36)	
Behavioural characteristics							
Sleep duration							<0.001
<6 hours/day	914	32.98 (31.26-34.76)	1,003	36.20 (34.43-38.00)	854	30.82 (29.13-32.56)	
6-8 hours/day	4,579	41.57 (40.65-42.49)	3,924	35.62 (34.73-36.52)	2,513	22.81 (22.04-23.61)	
>8 hours/day	1,501	47.01 (45.28-48.74)	1,043	32.67 (31.06-34.31)	649	20.33 (18.97-21.76)	
Vegetable consumption							<0.001

0-3 days/week	764	37.41 (35.34-39.54)	566	34.87 (32.83-36.96)	2,042	27.72 (25.82-29.70)	
4-7 days/week	6,230	41.71 (40.92-42.50)	3,450	35.20 (34.44-35.97)	14,938	23.10 (22.43-23.78)	
Fruit consumption							<0.001
0-3 days/week	1,993	36.40 (35.14-37.69)	1,888	34.48 (33.24-35.75)	1,594	29.11 (27.93-30.33)	
4-7 days/week	5,001	43.47 (42.56-44.38)	4,082	35.48 (34.61-36.36)	2,422	21.05 (20.32-21.81)	
Alcohol consumption							<0.001
Former/non-drinker	962	44.54 (42.45-46.64)	655	30.32 (28.42-32.30)	543	25.14 (23.35-27.01)	
Current drinker	6,032	40.70 (39.91-41.50)	5,315	35.86 (35.10-36.64)	3,473	23.43 (22.76-24.12)	
Physical activity							<0.001
Low (<600 MET-minutes/week)	1,504	34.24 (32.85-35.66)	1,527	34.77 (33.37-36.19)	1,361	30.99 (29.64-32.37)	
Moderate (≥600 MET-minutes/week)	2,299	41.64 (40.35-42.95)	1,883	34.11 (32.87-35.37)	1,339	24.25 (23.14-25.40)	
High (≥1500 MET-minutes/week)	3,191	45.15 (44.00-46.32)	2,560	36.22 (35.11-37.35)	1,316	18.62 (17.73-19.55)	
Job-related characteristics							
Hours per week usually worked							<0.001
0-30 hours/week	2,445	49.92 (48.52-51.32)	1,370	27.97 (26.73-29.24)	1,083	22.11 (20.97-23.30)	
31-40 hours/week	2,771	40.69 (39.53-41.86)	2,439	35.81 (34.68-36.96)	1,600	23.49 (22.50-24.52)	
>40 hours/week	1,778	33.73 (32.46-35.01)	2,161	40.99 (39.67-42.32)	1,333	25.28 (24.13-26.48)	
Work schedule							0.030
Day work	5,282	40.86 (40.02-41.71)	4,634	35.85 (35.02-36.68)	3,011	23.29 (22.57-24.03)	
Shift work	1,712	42.24 (40.73-43.77)	1,336	32.96 (31.53-34.43)	1,005	24.80 (23.49-26.15)	
Job type							0.001
Non-manual	3648	40.99 (39.98-42.02)	3233	36.33 (35.34-37.34)	2,018	22.68 (21.82-23.56)	
Manual	3346	41.41 (40.34-42.48)	2737	33.87 (32.85-34.91)	1,998	24.72 (23.80-25.68)	
Employment contract							<0.001
Permanent	4,395	38.09 (37.21-38.98)	4,283	37.12 (36.25-38.01)	2,859	24.78 (24.00-25.58)	
Fixed-term	738	42.73 (40.42-45.08)	590	34.16 (31.96-36.43)	399	23.10 (21.18-25.15)	
Casual	1,861	50.08 (48.47-51.69)	1,097	29.52 (28.08-31.01)	758	20.40 (19.13-21.72)	
Firm size							0.140
Small (1-19 employees)	3,037	41.83 (40.70-42.97)	2540	34.99 (33.9-36.09)	1,683	23.18 (22.23-24.17)	
Medium (20-99 employees)	1,947	41.75 (40.34-43.17)	1630	34.95 (33.59-36.33)	1,087	23.31 (22.11-24.54)	
Large (≥100 employees)	2,010	39.75 (38.41-41.11)	1800	35.60 (34.29-36.93)	1,246	24.64 (23.48-25.85)	

Supervisory responsibilities							<0.001
Yes	2,875	37.7 (36.61-38.79)	2,879	37.75 (36.67-38.84)	1,873	24.56 (23.60-25.54)	
No	4,119	44.04 (43.04-45.05)	3,091	33.05 (32.10-34.01)	2,143	22.91 (22.07-23.78)	
Paid sick leave							<0.001
Yes	4,938	38.6 (37.76-39.44)	4,683	36.60 (35.77-37.44)	3,173	24.80 (24.06-25.56)	
No	2,056	49.12 (47.60-50.63)	1,287	30.75 (29.37-32.16)	843	20.14 (18.95-21.38)	
Self-perceived job stress	6,994	3.05 (1.65)	5,970	3.19 (1.65)	4,016	3.24 (1.68)	<0.001
Self-perceived job insecurity	6,994	2.88 (1.76)	5,970	3.03 (1.79)	4,016	3.14 (1.84)	<0.001

[1]P-values were derived from Chi-square test for all variables except self-perceived job stress and job insecurity (ANOVA test).

Table 3 displays the association between job-related characteristics and obesity. The odds of being obese were 1.07 times (OR: 1.07, 95% CI: 1.01-1.13) higher among employees who worked over 40 hours relative to those who worked 31-40 hours a week. The study also revealed that employees who worked over 40 hours/week were 1.11 times (OR: 1.11, 95% CI: 1.03-1.21) more likely to be overweight than their counterparts. The findings suggest that prolonged work hours over and above standard work hours were significantly associated with obesity.

Table 3 demonstrates that some job-related characteristics were significantly associated with obesity but not with overweight. For example, the result shows that an increase in self-perceived job insecurity is positively associated with the risk of being obese (OR: 1.03, 95% CI: 1.02-1.04), but not associated with overweight. Further, this study does not find any evidence that work schedule, job type, employment contract, firm size, supervisory responsibility, provision of paid sick leave in the workplace and self-perceived job stress have a significant influence on obesity. However, the result shows that job-related characteristics such as job type, employment contract, and provision of paid sick leave in the workplace are linked with the overweight status of the Australian workers.

With respect to other covariates, age, sex, marital status, education, and physical activity were found to be significantly associated with the excessive weight of workers. Socio-demographic covariates like the index of economic resources were found to be associated with obesity but not with overweight.

Table 3: Multivariate analysis using generalized estimating equation for overweight and obesity

Variables	**Model-1: Overweight versus healthy weight**	**Model-2: Obesity versus healthy weight**
	OR (95% CI), P Value	**OR (95% CI), P Value**
Socio-demographic characteristics		
Age		
15-35 years (ref)		
36-55 years	1.77 (1.63-1.93), **<0.001**	1.68 (1.56-1.82), **<0.001**
56-64 years	2.22 (1.98-2.50), **<0.001**	1.90 (1.73-2.07), **<0.001**
Sex		
Male (ref)		
Female	0.50 (0.46-0.54), **<0.001**	0.80 (0.73-0.87), **<0.001**
Marital status		
Married/Cohabitating (ref)		
Non-cohabitating	0.85 (0.78-0.92), **<0.001**	0.86 (0.80-0.92), **<0.001**
Education		
Year 12 or below (ref)		

Professional qualification	1.22 (1.10-1.35), <**0.001**	1.28 (1.15-1.42), <**0.001**
University qualification	0.92 (0.82-1.03), 0.132	0.69 (0.62-0.76), <**0.001**
Index of Economic Resources (IER)		
Quintile 1 (least advantaged)	0.97 (0.85-1.10), 0.628	1.19 (1.06-1.33), **0.003**
Quintile 2	1.09 (0.97-1.23), 0.131	1.16 (1.07-1.27), **0.001**
Quintile 3	1.09 (0.97-1.22), 0.161	1.11 (1.01-1.23), **0.050**
Quintile 4	0.96 (0.86-1.08), 0.512	1.04 (0.96-1.14), 0.320
Quintile 5 (most advantaged) (ref)		
Behavioural characteristics		
Sleep duration		
<6 hours/day	1.16 (1.05-1.28), **0.003**	1.06 (0.98-1.14), 0.121
6-8 hours/day (ref)		
>8 hours/day	1.04 (0.95-1.13), 0.410	0.96 (0.91-1.01), 0.144
Vegetable consumption		
0-3 days/week (ref)		
4-7 days/week	0.97 (0.85-1.08), 0.603	1.02 (0.92-1.12), 0.725
Fruit consumption		
0-3 days/week (ref)		
4-7 days/week	0.94 (0.86-1.01), 0.110	0.91 (0.86-0.96), **0.001**
Alcohol consumption		
Former/non-drinker (ref)		
Current drinker	1.15 (1.02-1.29), **0.019**	0.97 (0.89-1.04), 0.379
Physical activity		
Low (<600 MET-minutes/week) (ref)		
Moderate (≥600 MET-minutes/week)	0.83 (0.76-0.91), <**0.001**	0.93 (0.88-0.98), **0.006**
High (≥1500 MET-minutes/week)	0.76 (0.69-0.83), <**0.001**	0.80 (0.76-0.85), <**0.001**
Job-related characteristics		
Hours per week usually worked		
0-30 hours/week	0.86 (0.78-0.94), **0.001**	0.93 (0.87-0.99), **0.047**
31-40 hours/week (ref)		
>40 hours/week	1.11 (1.03-1.21), **0.011**	1.07 (1.01-1.13), **0.017**
Work schedule		
Day work (ref)		
Shift work	1.02 (0.93-1.11), 0.679	1.01 (0.95-1.07), 0.803
Job type		
Non-manual (ref)		
Manual	0.91 (0.83-0.99), **0.037**	1.01 (0.96-1.08), 0.648
Employment contract		
Permanent (ref)		
Fixed-term	0.94 (0.84-1.05), 0.268	1.01 (0.95-1.08), 0.761
Casual	0.79 (0.66-0.95), **0.010**	0.94 (0.80-1.10), 0.425
Firm size		
Small (1-19 employees) (ref)		
Medium (20-99 employees)	1.04 (0.95-1.13), 0.390	0.98 (0.92-1.04), 0.506
Large (≥100 employees)	1.07 (0.98-1.17), 0.159	1.04 (0.97-1.10), 0.271
Supervisory responsibilities		
Yes (ref)		

No	0.91 (0.85-0.98), **0.012**	0.99 (0.94-1.04), 0.624
Paid sick leave		
Yes (ref)		
No	1.12 (0.95-1.32), 0.167	0.97 (0.85-1.11), 0.680
Self-perceived job stress	1.01 (0.99-1.03), 0.188	1.00 (0.99-1.02), 0.575
Self-perceived job insecurity	1.01 (0.99-1.04), 0.163	1.03 (1.02-1.04), **<0.001**

Abbreviations: OR Odds Ratio; CI Confidence Interval; Ref Reference
Note: Values in bold are statistically significant

Discussion

The present study examined the effects of job-related characteristics on obesity among Australian adult employees during a 5-year period. Among the workers, around 24% were obese and 31% worked more than 40 hours per week. The results of the present study revealed five significant findings. First, there is a significant association between prolonged work hours and obesity. Second, there is no association between shift work and obesity. Third, there is no significant relationship between firm size and obesity. Fourth, no link between the provisions of paid sick leave in the workplace and obesity. Fifth, self-perceived job insecurity among the workers was significantly associated with obesity.

The most striking result that emerged from this study was that employees who worked over 40 hours/week had higher odds of becoming obese compared with those who worked 31-40 hours or less per week. Previously, a number of studies also identified a significant association between long work hours and obesity (Choi et al., 2010; Di Milia et al., 2013; Escoto et al., 2010; Jang et al., 2013; Park et al., 2014; Yoon et al., 2016). Prolonged work hours are associated with obesity through several mechanisms including short sleep cycles, high-calorie intake, low levels of physical activity, long periods of occupational sitting, and psychological stress (Di Milia et al., 2013; Spiegel et al., 2004). Prolonged work hours reduce the duration of sleep hours (Di Milia et al., 2013). Short sleep cycles may mediate the association between long work hours and obesity as short sleep time decreases leptin and increase grehlin hormones resulting in greater hunger (Spiegel et al., 2004) and higher calorie intake (Di Milia et al., 2013). Energy expenditure is an essential part of preventing obesity (Yoon et al., 2016) and physical activity is one of the important ways of reducing energy expenditure. An Australian study reported that long work hours were indirectly associated with obesity as it reduces the likelihood of performing physical activity (Di Milia and Mummery, 2009). A possible mechanism that could underlie the association between long work hours and obesity is psychological stress (Jang et al., 2013). Past studies revealed that individuals working long hours are more stressed (Johnson and Lipscomb, 2006;

Wardle et al., 2000) and had negative health behaviors such as smoking tobacco, consuming more calories, and drinking alcohol as a means of reducing stress (Caruso, 2006; Wallis and Hetherington, 2009; Wardle et al., 2000).

Currently, evidence concerning the relationship between shift work and obesity is mixed. The results of the present study suggest that there is no association between shift work and obesity after controlling a wide range of socio-demographic and behavioural variables and this finding is consistent with the literature (Di Milia et al., 2013; Min-Ju et al., 2013; Thomas et al., 2009). However, this outcome is contrary to previous studies which have suggested that rotating shift work is positively associated with obesity (Grundy et al., 2017; Lee et al., 2016; Liu et al., 2018; M. Sun et al., 2018; Yoon et al., 2016). Contradictory results are rampant in nonrandomized studies. The difference in the findings might be explained by the fact that past studies were mostly based on cross-sectional data and the present study is based on longitudinal data.

This study found no relationship between firm size and obesity. A cross-sectional study conducted in the USA found ambiguous results (Park et al., 2014). Park et al. reported that workers in medium-sized firms (100-499 employees) were highly obese compared to small firm employees (1-24 employees), but no significant association between workers in the large firm (≥500 employees) and obesity was found (Park et al., 2014). It is difficult to clarify the underlying reasons for the dissimilarities in the results of the present study and the literature, as there are a limited number of studies. Consistent with previous findings (Park et al., 2014), the current study found that the provision of paid sick leave in the worksite is not associated with obesity. Paid sick leave helps workers to access health care facilities (DeRigne et al., 2016). However, little is known about the association between paid sick-leave and obesity.

In line with the existing evidence, the present study also found evidence that self-perceived job insecurity is significantly associated with obesity (Muenster et al., 2011). Job insecurity is a major source of stress and positively associated with obesity through the alteration of eating behaviour (Muenster et al., 2011).

The findings of the present study have significant implications for worksite obesity prevention programs. It is tempting to conclude that interventions aimed at reducing work hours may be helpful to reduce the risk of being obese. The risk of being overweight and obese depends on many other factors. Hence, a particular intervention to tackle excessive weight might not be effective. Keeping this in mind, the present study suggests that firms should focus on improving their workers' health by implementing integrated lifestyle programs. For example, a firm may implement workplace wellness policies, such as offering foodservice facilities following healthy nutrition guidelines, provide incentives for weight-management, and promote physical activities in the workplace. These suggestions are in line with the Australian Health and Wellbeing Strategic Framework 2017-2026 where the emphasis is on creating healthier environments and ensuring healthy behaviors through healthy diets and increased physical activity (State of Queensland, 2018). These suggestions are also consistent with the 'Healthy Workers' project that was undertaken earlier in Australia to improve workers health and wellbeing through modifiable lifestyle behaviors in the workplace (Australian Institute of Health and Welfare, 2017a).

The current study has a number of strengths. First, most of the existing studies that focus on the association between job-related characteristics and obesity are based on cross-sectional data. Unlike those studies, the present study pooled cross-sectional surveys of nationally representative longitudinal data collected across two-time points to identify the longitudinal association between job-related characteristics and risk of being obese among Australian adult workers. Second, in the existing literature, inconsistent findings in the relationship between job-related characteristics and obesity may be due to considering too few confounding variables (Di Milia et al., 2013; Thomas et al., 2009). The present study addressed this issue by incorporating a large number of confounding variables in assessing the relationship between job-related characteristics and the risk of obesity. Third, this study tried to capture the effect of unidentified intra-participant factors using GEE analysis on the longitudinal dataset to provide estimates that are more precise.

This study also acknowledges some limitations. First, the study findings might be vulnerable to self-reported bias, as data on BMI, sleep duration, vegetables and fruit consumption, alcohol consumption, physical activity, work hours, self-perceived job stress and self-perceived job insecurity were self-reported. Self-reported bias is high among overweight and obese adults, as they tend to overestimate their height and underestimate their weight (Gorber et al., 2007a; Maukonen et al., 2018). Second, although the HILDA survey is nationally representative, the sample of the present study is not necessarily representative of the entire Australian workforce as participants were recruited from different occupations and industries. Third, loss to follow-up of some workers may bias the study findings.

The present study reveals a significant longitudinal relationship between prolonged work hours and obesity. Nevertheless, the authors call for a well-designed prospective cohort study that can explore the effect of prolonged work hours on the risk of being obese. For example, a study may follow a cohort of employees from a particular occupation for 5-years who vary in terms of work hours to test the hypothesis that the risk of being obese will be highest among employees working long work hours.

Conclusion

This study found that the prevalence of overweight and obesity is high (60%, combined) among Australian workers. This study hypothesizes that some job-related characteristics might be associated with workers' weight status. The present study provides some support for the hypothesis that job-related characteristics contribute to the obesity epidemic among Australian adults. The study has identified a significant association between prolonged work hours and obesity. This study also found a positive association between self-perceived job insecurity and obesity. However, the results of this study show that work schedule, job type, employment contract, firm size, supervisory responsibilities, provision of paid sick leave and self-perceived job stress do not have a significant influence on the risk of being obese. These findings might be helpful for designing effective policies to prevent obesity in the workplace. A better understanding of the underlying relationship between work hours, self-perceived job insecurity and obesity may help employers to implement more effective obesity prevention programs in the workplace.

CHAPTER 3: UNTANGLING THE HEALTH CONSEQUENCES OF ADULT OBESITY IN AUSTRALIA

CHAPTER 3: STUDY 1

Obesity and the risk of developing chronic diseases in middle-aged and older adults: Findings from an Australian longitudinal population survey, 2009-2017

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Abstract

Background

Overweight and obesity impose a significant health burden in Australia, predominantly the middle-aged and older adults. Studies of the association between obesity and chronic diseases are primarily based on cross-sectional data, which is insufficient to deduce a temporal relationship. Using nationally representative panel data, this study aims to investigate whether obesity is a significant risk factor for type 2 diabetes, heart diseases, asthma, arthritis, and depression in Australian middle-aged and older adults.

Methods

Longitudinal data comprising three waves (waves 9, 13 and 17) of the Household, Income and Labour Dynamics in Australia (HILDA) survey were used in this study. This study fitted longitudinal random-effect logistic regression models to estimate the between-person differences in the association between obesity and chronic diseases.

Results

The findings indicated that obesity was associated with a higher prevalence of chronic diseases among Australian middle-aged and older adults. Obese adults (Body Mass Index [BMI] ≥ 30) were at 12.76, 2.05, 1.97, 2.25, and 1.96, times of higher risks of having type 2 diabetes (OR: 12.76, CI 95%: 8.88-18.36), heart disease (OR: 2.05, CI 95%: 1.54-2.74), asthma (OR: 1.97, CI 95%: 1.49-2.62), arthritis (OR: 2.25, 95% CI: 1.90-2.68) and depression (OR: 1.96, CI 95%: 1.56-2.48), respectively, compared with healthy weight counterparts. However, the study did not find any evidence of a statistically significant association between obesity and cancer. Besides, gender stratified regression results showed that obesity is associated with a higher likelihood of asthma (OR: 2.64, 95% CI: 1.84-3.80) among female adults, but not in the case of male adults.

Conclusion

Excessive weight is strongly associated with a higher incidence of chronic disease in Australian middle-aged and older adults. This finding has clear public health implications. Health promotion programs and strategies would be helpful to meet the challenge of excessive weight gain and thus contribute to the prevention of chronic diseases.

Keywords: Obesity, type 2 diabetes, heart disease, asthma, cancer, arthritis, depression, Australia

Introduction

According to the World Health Organisation (WHO), 1.9 billion adults in the world were either overweight or obese in 2016, and the prevalence of obesity has increased threefold since 1975 (World Health Organization, 2020a). It is also estimated that at least 7% of deaths from all causes globally in 2015 were related to overweight or obesity (GBD 2015 Obesity Collaborators, 2017). In 2017-2018, 67% (12.5 million) of Australian adults were overweight or obese, increasing from 63.4% in 2014-2015. In Australia, the prevalence of severe obesity (BMI≥ 35kg/m^2) has almost doubled between 1995 and 2014-15 (Australian Institute of Health and Welfare, 2017b). A recent study also confirmed that over one in four Australian adults (26 %) were obese in 2019 (Keramat et al., 2021b). Overweight and obesity impose a considerable burden (both direct and indirect) in Australia. Overweight and obesity contributed 8.4% of the risk factor of the burden of diseases in Australia in 2015 (Australian Institute of Health and Welfare, 2019b). Besides, there is evidence that obesity is strongly associated with a higher acquisition of disability (Keramat et al., 2021d). Further, obese Australias are more likely to report poor general health and mental health (Keramat et al., 2021a). Moreover, obesity has a substantial negative impact on diverse labour market outcomes, such as high absenteeism (Keramat et al., 2020a), increased presenteeism (Keramat et al., 2020b), job dissatisfaction (Keramat et al., 2020c), and a higher rate of job discrimination (Keramat et al., 2021c).

There is increasing empirical evidence that obesity triggers the likelihood of different non-communicable diseases (NCDs), such as type 2 diabetes, high blood pressure, cardiovascular disease (CVD), cancer, asthma, sleep apnea, and poor mental health (Atlantis et al., 2009). An excessive gain of body weight from early childhood to adulthood is consistently associated with the risk of heart disease (Bjerregaard et al., 2020). Obesity is also significantly related to the risk of heart disease-related morbidity and mortality (Akil and Ahmad, 2011). Further, it is strongly associated with the incidence of type 2 diabetes (Guh et al., 2009) and depression (Preiss et al., 2013). Furthermore, the likelihood of different patterns of arthritis, such as osteoarthritis, rheumatoid arthritis, and psoriatic arthritis, is often associated with increased body weight (Blagojevic et al., 2010). The burden of these chronic diseases includes low quality of life, productivity loss, and increased healthcare costs (Chooi et al., 2019; Jia and Lubetkin, 2005).

While the prevalence of obesity and chronic diseases is high across Australia, people from lower socioeconomic backgrounds are often disproportionately affected (Hardy et al., 2017). Although there is a clear link between obesity and chronic health conditions, the severity of the burden of risk might vary based on an individual's socioeconomic and demographic conditions as well as lifestyle characteristics. For policy-making purposes, it is crucial to understand whether obesity causes an increase in specific types of chronic disease among the poor, the elderly, and physically inactive compared to the affluent, younger and/or physically active population. Previous studies estimating the obesity and chronic disease nexus in Australia often focused on a single disease using cross-sectional survey data, which is insufficient to deduce a temporal relationship. Besides, there is a lack of emphasis on the critical confounding factors (e.g. socioeconomic and demographic) that might explain the severity of the risks of obesity for a specific cohort of people, but not others. There is also a lack of literature that has employed nationally representative longitudinal survey data to study the association between obesity and chronic disease burden. Longitudinal designs are essential for the understanding of the dynamics of the relationship and interdependence (e.g., the link between obesity and chronic diseases) and to better identify the influence of one factor (e.g., obesity) over the other (e.g., chronic diseases). Therefore, this study aims to fill these gaps in the literature by employing the longitudinal study design. The main objective of this study is to estimate the between-person differences in the relationship between obesity and chronic diseases in Australian adults. To the best of the authors' knowledge, no previous research has focused on the obesity and chronic disease nexus from the Australian perspective, especially for middle-aged and older adults using longitudinal data.

Materials and methods

Data source and sample selection

The study utilised nationally representative data from the Household, Income and Labor Dynamics in Australia (HILDA) survey. The HILDA survey was initiated in 2001 by collecting detailed information on 13,000 individuals within 7,000 households using a multistage sampling approach. Since then, the survey has gathered information on a wide range of topics: wealth, retirement, fertility, health, education, skills and abilities from members of households aged 15 years or over through a self-completed questionnaire (SCQ) and face-to-face interviews by trained interviewers. The description of the HILDA survey design is shown elsewhere (Wooden et al., 2002).

Participants of this longitudinal study were selected from three waves (waves 9, 13 and 17) of the HILDA survey, and data were collected during the years 2009, 2013 and 2017, respectively. The reason behind considering these waves was that these three waves substantially capture the respondents' health and lifestyle-related characteristics. Figure 1 demonstrates the procedure of obtaining the final analytic sample. The analytical sample is restricted to adults aged 45 years and over. The inclusion criteria for the subsample analyses were no missing information on participants' Body Mass Index (BMI) and chronic diseases. This study also excludes pregnant women's data to avoid potential biases. The final analytic sample consisting of 20,538 person-year observations from 9,822 unique participants was achieved by applying inclusion and exclusion criteria.

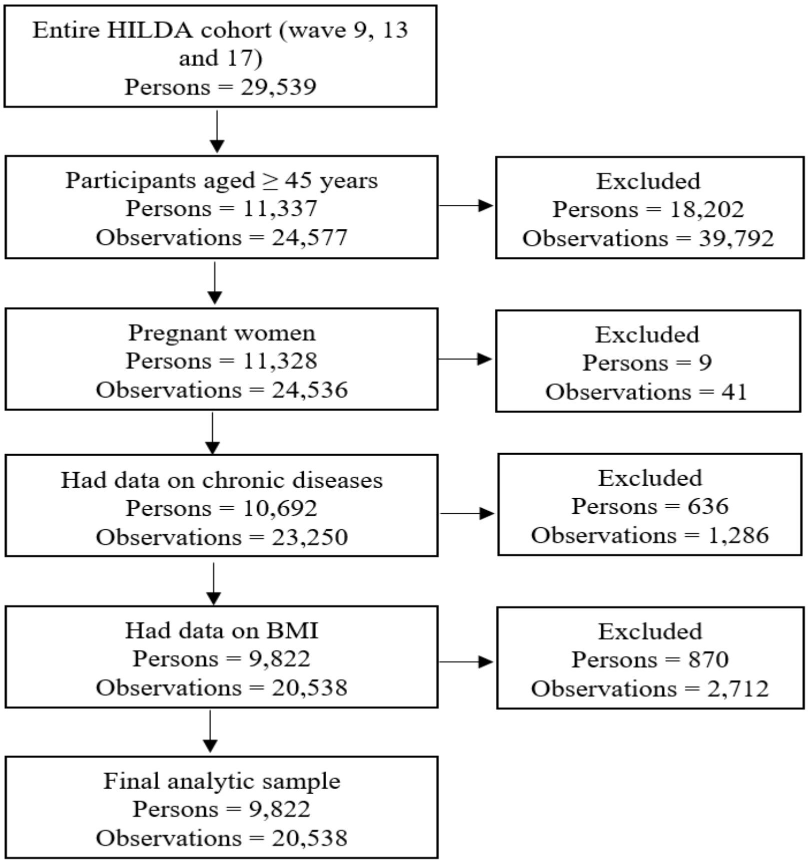

Figure 1: Flow chart of sample selection and missing data

Outcome variable

The outcome variable of the study is self-reported chronic disease. The HILDA survey collects information on an individual's chronic disease status by asking questions, 'are you diagnosed with a serious illness?' This study considered six types of chronic diseases, including type 2 diabetes, heart disease, asthma, cancer, arthritis and depression, as the outcome variables of interest. Responses on the outcome variables were taken in binary form (0 = no, 1 = yes).

Exposure variable

This study checks if obesity is a significant risk factor for chronic diseases among Australian middle-aged and older adults. The current study measures obesity through BMI. HILDA survey collects data on BMI using self-reported weight and height following the formula of weight (in kilograms) divided by height (in metres) square. The authors categorised BMI as underweight (<18.50), normal/healthy weight (18.50–24.99), overweight (25.00–29.99), and obese (≥ 30.00) following WHO guidelines (World Health Organization, 2020a). This classification allows an assessment of how and in what context underweight, overweight and obese participants are susceptible to different chronic diseases compared with their healthy weight counterparts.

Other covariates

This study considered potential confounders following previous studies (Kearns et al., 2014; Must, 1999). One significant advantage of the HILDA survey is that it provides a considerable amount of data on the demographic characteristics of respondents, such as age, gender, income level, education, area of residence and other behavioural factors. Table 1 clearly shows the set of the confounders with their nature and categories considered for the present study. For instance, age is categorised as middle-aged (45 to 59 years) and older adults (≥ 60 years). Other socio-demographic confounders include gender (male and female), civil status (partnered, unpartnered), education (year 12 or below, professional qualifications, and university qualifications), household yearly disposable income (expressed in quintiles), labour force status (employed, unemployed, and not in the labour force), Indigenous status (non-Indigenous, and Aboriginal/Torres Strait Islander [ATSI]), location (major city, regional city and remote areas).

Besides, three behavioural factors: smoking status, alcohol consumption and physical activity, served as the confounders. Smoking status was categorised as never smoked, ex-smoker, and current smoker. The variable alcohol consumption was classified as never drink, ex-drinker, only rarely to four days and more than four days per week. Physical activity-related information was collected by questioning how often the respondent participates in physical activity each week for at least 30 minutes. This study categorised physical activity as: not at all to less than one, 1 to 3 times, and more than three times per week.

Table 1: Description of other covariates

Covariates	Categories
Age	Middle-aged (45 to 59 years), and older adults (≥ 60 years).
Gender	Male and female.
Civil status	Partnered (married, and never married but living with someone in a relationship), and unpartnered (separated but not divorced, divorced, widowed, and never married and not living with someone in a relationship).
Education	Year 12 and below (year 12, and Year 11 and below), professional qualifications (advance diploma or diploma, and certificate III or IV), and university qualifications (postgraduate - masters or doctorate, graduate diploma or certificate, bachelor or honours).
Household yearly disposable income quintile	Quintiles (quintile 1 [lowest] to quintile 5 [highest]).
Labour force status	Employed, unemployed, and not in the labour force.
Indigenous status	Non-Indigenous, and Aboriginal/Torres Strait Islander (ATSI) or both.
Location	Major city, regional city (inner and outer regional) and remote areas (remote and very remote).
Smoking status	never smoked, a former smoker and current smoker.
Alcohol consumption	Never drank, ex-drinker, only rarely to 4 days/week, and 4+ days/week.
Physical activity (≥ 30 minutes)	not at all to <1/week, 1-3 times/week, and ≥ 4 times/week.

Estimation strategy

The authors prepared an unbalanced longitudinal data set consisting of 20,538 person-year observations by linking de-identified records of 9,822 unique adults. This study considered three distinct waves (waves 9, 13, and 17) of the HILDA survey covering the period from 2009 to 2017. Due to the longitudinal nature of the data, repeated observations on the same individual were used for subsample analyses. This study reports baseline, final wave, and pooled prevalence of obesity, six chronic diseases, socio-demographic and behavioural characteristics in the form of frequency(n) and percentages (%) with 95% confidence intervals (CI). The relationships between the exposure and other covariates with chronic diseases were first identified through bivariate analysis (test results not reported here). Statistically significant (P-value <0.05) variables in the bivariate analyses were then considered for the final regression model.

This study employed the longitudinal random-effects logistic regression model to capture between-person variation as the study data were derived from a longitudinal dataset (repeated measures). The outcome variables (type 2 diabetes, heart disease, asthma, cancer, arthritis and depression) are binary (whether they have a particular chronic condition or not). Therefore, this study utilised the logistic link. To ease the interpretation, this study reports regression results in the form of adjusted Odds Ratios (AOR) along with the 95% confidence interval. This study sets p-value <0.05 for the statistical significance of a variable. A variable will be considered statistically significant if the p-value for the variable is less than the significance level in the regression models. All statistical analyses were performed using Stata, version 16 (StataCorp LLC).

Ethics approval

This study did not require ethical approval as the analysis used only de-identified existing unit record data from the HILDA survey. However, the authors completed and signed the Confidentiality Deed Poll and sent it to NCLD (ncldresearch@dss.gov.au) and ADA (ada@anu.edu.au) before the data applications' approval. Therefore, datasets analysed and/or generated during the current study are subject to the signed confidentiality deed.

Results

Table 2 displays the characteristics of the study participants in terms of their chronic diseases, socio-demographic, and behavioural characteristics at the baseline, final, and pooled in all waves. Among the study participants, 47% were male, and 53% were female, a higher proportion (53.26%) were middle-aged, nearly two-thirds (65.53%) were unpartnered, over one-fifth (21.86%) had university qualifications, over half were employed (53.22%), primarily non-Indigenous and lived in major cities (61.96%) at the baseline. The results also show that nearly 48% of participants never smoke, 59% consume alcohol from rarely to four days per week, and 35% performed physical activities that last at least 30 minutes over three times per week (baseline wave).

Of 9,822 participants, approximately 38.48% were overweight, and 28.11% were obese. The pooled prevalence of chronic conditions, such as type 2 diabetes, heart diseases, asthma, cancer, arthritis, and depression in study participants was approximately 9.01%, 8.35%, 9.96%, 5.68%, 30.64%, and 13.0%, respectively (pooled in all waves).

Table 2: Distribution of the analytic sample: Baseline, final and pooled across all waves (persons = 9,822; observations = 20,538)

Characteristics	**Baseline wave (2009)**		**Final wave (2017)**		**Pooled in all waves (2009, 2013 & 2017)**	
	n	**%**	**n**	**%**	**n**	**%**
Outcome variables						
Type 2 diabetes						
No	4,946	91.56	7,082	90.82	18,688	90.99
Yes	456	8.44	716	9.18	1,850	9.01
Heart disease						
No	4,981	92.21	7,120	91.31	18,824	91.65
Yes	421	7.79	678	8.69	1,714	8.35
Asthma						
No	4,876	90.26	6,986	89.59	18,492	90.04
Yes	526	9.74	812	10.41	2,046	9.96
Cancer						
No	5,096	94.34	7,339	94.11	19,372	94.32
Yes	306	5.66	459	5.89	1,166	5.68
Arthritis						
No	3,747	69.36	5,406	69.33	14,246	69.36
Yes	1,655	30.64	2,392	30.67	6,292	30.64
Depression						
No	4,835	89.5	6,633	85.06	17,869	87.00
Yes	567	10.5	1,165	14.94	2,669	13.00
Exposure and covariates						
BMI						
Underweight	83	1.54	95	1.22	289	1.41
Healthy weight	1,815	33.6	2,428	31.14	6,574	32.01
Overweight	2,133	39.49	2,942	37.73	7,902	38.48
Obesity	1,371	25.38	2,333	29.92	5,773	28.11
Age						
Middle-aged (45-59 years)	2,877	53.26	3,713	47.61	10,304	50.17
Older adults (≥ 60 years)	2,525	46.74	4,085	52.39	10,234	49.83
Gender						
Male	2,546	47.13	3,676	47.14	9,684	47.15
Female	2,856	52.87	4,122	52.86	10,854	52.85
Civil Status						
Partnered	1,862	34.47	2,770	35.52	7,140	34.76
Unpartnered	3,540	65.53	5,028	64.48	13,398	65.24
Education						
Year 12 and below	2,511	46.48	2,999	38.46	8,624	41.99
Professional qualifications	1,710	31.65	2,780	35.65	6,974	33.96
University qualifications	1,181	21.86	2,019	25.89	4,940	24.05
Household yearly disposable income quintile						
Quintile 1 (lowest)	1,081	20.01	1,561	20.02	4,109	20.01
Quintile 2	1,081	20.01	1,559	19.99	4,107	20.00

Quintile 3	1,081	20.01	1,559	19.99	4,107	20.00
Quintile 4	1,079	19.97	1,561	20.02	4,109	20.01
Quintile 5 (highest)	1,080	19.99	1,558	19.98	4,106	19.99
Labour force status						
Employed	2,875	53.22	4,006	51.37	10,665	51.93
Unemployed	75	1.39	122	1.56	326	1.59
Not in the labour force	2,452	45.39	3,670	47.06	9,547	46.48
Indigenous status						
Non-Indigenous	5,317	98.43	7,653	98.14	20,181	98.26
Aboriginal or Torres Strait Islander	85	1.57	145	1.86	357	1.74
Location						
Major city	3,347	61.96	4,885	62.64	12,865	62.64
Regional	1,968	36.43	2,792	35.8	7,352	35.80
Remote	87	1.61	121	1.55	321	1.56
Smoking status						
Never smoked	2,597	48.07	3,878	49.73	10,034	48.86
Former smoker	2,004	37.10	2,855	36.61	7,609	37.04
Current smoker	801	14.83	1,065	13.66	2,895	14.10
Alcohol consumption						
Never drank	562	10.4	785	10.07	2,101	10.23
Ex-drinker	379	7.02	759	9.73	1,788	8.71
Only rarely to 4 days/week	3,203	59.29	4,650	59.63	12,210	59.45
4+ days/week	1,258	23.29	1,604	20.57	4,439	21.61
Physical activity (≥ 30 minutes)						
Not at all to <1/week	1,502	27.80	2,473	31.71	6,121	29.80
1-3 times/week	2,009	37.19	2,832	36.32	7,493	36.49
≥4 times/week	1,891	35.01	2,493	31.97	6,924	33.71

Figure 2 displays the overall prevalence of various chronic diseases among Australia's middle-aged and older adults at three different periods: 2009, 2013 and 2017. Figure 2 manifests that the prevalence of chronic conditions and obesity among the study population had increased from 2009 to 2017. Among all of them, depression increased sharply from 10% to 15% approximately. Incidence of type 2 diabetes, asthma, and arthritis marginally increased over the period, and the prevalence of heart diseases and cancer also increased over time. The prevalence of obesity was almost 25% in 2009, which increased to nearly 30% in less than ten years.

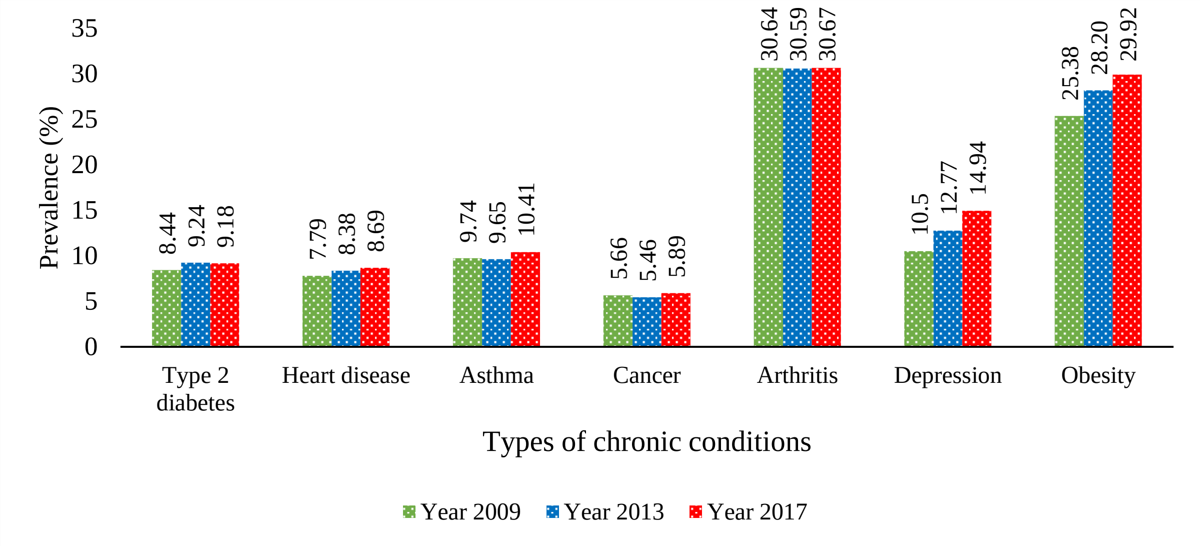

Figure 2: Prevalence of chronic conditions among middle-aged and older adults

Figure 3 illustrates the percentage of chronic diseases among middle-aged and older adults based on their weight status. Prevalence of chronic conditions, such as type 2 diabetes (16.18%), asthma (12.99%) and arthritis (37.52%), was highest in obese people. However, underweight middle-aged and older adults are more vulnerable to heart diseases (11.76%), cancer (7.96%) and depression (19.72%). For obese people, the percentage is also noticeable, i.e. 10.27%, 5.68% and 17.11% for heart diseases, cancer and depression, respectively.

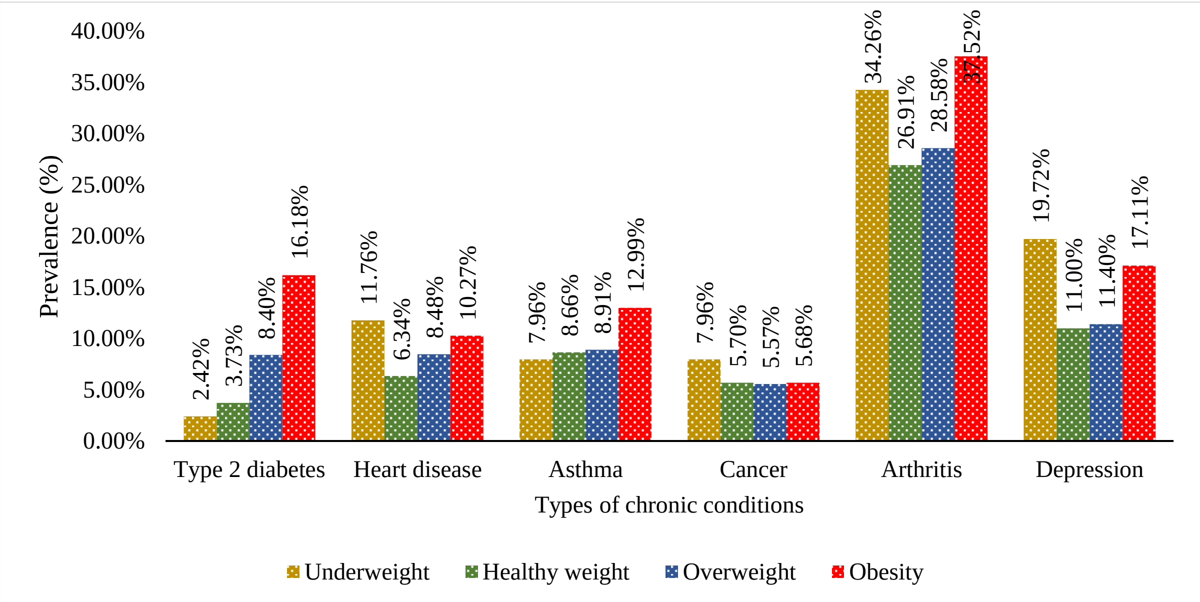

Figure 3: Prevalence of chronic conditions among middle-aged and older adults by weight status

Figure 4 shows the prevalence of co-morbid conditions in middle-aged and older adults stratified by gender (pooled in all waves). It is observed that the prevalence of asthma

(16.77% vs 8.44%), arthritis (44.55% vs 29.06%), and depression (19.53% vs 14.20%) are substantially higher among females than males. However, cancer (6.64% vs 4.88%), heart diseases (13.13% vs 7.89%) and type 2 diabetes (17.72% vs 14.90%) were more prevalent among males than females.

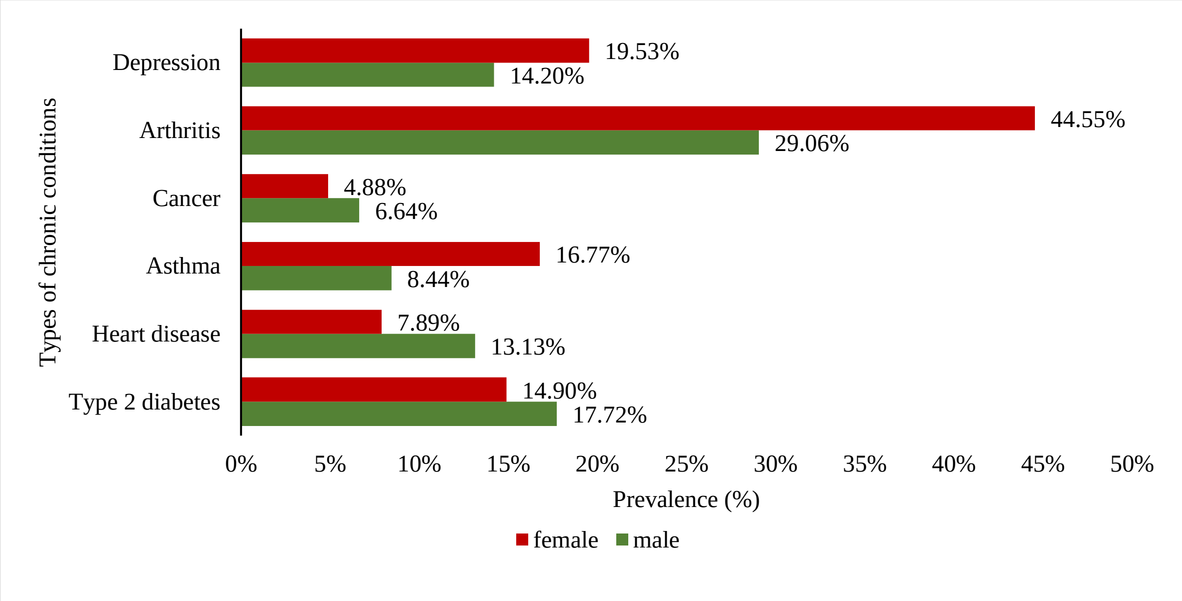

Figure 4: Gender differences in the prevalence of the chronic conditions among obese middle-aged and older adults

Table 3 exhibits the results obtained from the adjusted random-effect logistic regression model to investigate between-person differences in the relationship between obesity and six types of chronic diseases. The results show that the risk of having a chronic disease was more pronounced among obese adults compared with their healthy-weight counterparts. Obese people were at higher risks of suffering from Type 2 diabetes (OR: 12.76, 95% CI: 8.88-18.36), heart diseases (OR: 2.05, 95% CI: 1.54-2.74), asthma (OR: 1.97, 95% CI: 1.49-2.62), and arthritis (OR: 2.25, 95% CI: 1.90-2.68) compared with their healthy-weight counterparts. It is also observed that obese people were at 1.96 times higher risk of suffering from depression (OR: 1.96, 95% CI: 1.56-2.48) than peers with a healthy weight.

Table 3: Adjusted random-effect regression results for the between-person differences in chronic conditions due to obesity; 9,822 persons, 20,538 observations

Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
	Type 2 diabetes	**Heart disease**	**Asthma**	**Cancer**	**Arthritis**	**Depression**
	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
BMI						
Underweight	0.33 (0.07-1.67), 0.18	**2.98 (1.44-6.17), 0.01**	0.49 (0.19-1.23), 0.13	1.36 (0.70-2.67), 0.37	1.07 (0.66-1.74), 0.80	1.46 (0.78-2.71), 0.24
Healthy weight (ref)						
Overweight	**3.81 (2.71-5.36), <0.001**	**1.41 (1.09-1.82), 0.01**	1.21 (0.94-1.56), 0.14	0.82 (0.66-1.01), 0.07	**1.42 (1.22-1.64), <0.001**	**1.25 (1.01-1.54), 0.04**
Obesity	**12.76 (8.88-18.36), <0.001**	**2.05 (1.54-2.74), <0.001**	**1.97 (1.49-2.62), <0.001**	0.89 (0.69-1.13), 0.33	**2.25 (1.90-2.68), <0.001**	**1.96 (1.56-2.48), <0.001**
Socio-demographic characteristics						
Age						
Middle-aged (45-59 years) (ref)						
Older adults (≥ 60 years)	**4.36 (3.23-5.89), <0.001**	**4.83 (3.60-6.48), <0.001**	0.92 (0.72-1.19), 0.54	**2.35 (1.87-2.96), <0.001**	**3.63 (3.12-4.21), <0.001**	**0.39 (0.31-0.48), <0.001**
Gender						
Male (ref)						
Female	**0.29 (0.22-0.04), <0.001**	**0.28 (0.21-0.36), <0.001**	**2.45 (1.89-3.19), <0.001**	**0.53 (0.43-0.65), <0.001**	**2.91 (2.49-3.41), <0.001**	**2.10 (1.7-2.6), <0.001**
Education						
Year 12 or below (ref)						
Professional qualifications	0.89 (0.65-1.23), 0.47	0.88 (0.66-1.17), 0.39	1.07 (0.81-1.42), 0.62	1.25 (0.99-1.57), 0.06	**0.80 (0.68-0.95), 0.01**	1.19 (0.95-1.5), 0.13
University qualifications	**0.62 (0.42-0.94),0.02**	0.92 (0.65-1.30), 0.63	1.08 (0.77-1.51), 0.69	1.05 (0.79-1.39), 0.72	**0.61 (0.50-0.75), <0.001**	1.02 (0.77-1.35), 0.89
Civil Status						
Partnered (ref)						
Unpartnered	**0.68 (0.51-0.89), 0.01**	**0.69 (0.54-0.88), 0.01**	0.82 (0.64-1.04), 0.10	0.92 (0.75-1.13), 0.45	**0.80 (0.69-0.93), 0.01**	**0.46 (0.38-0.56), <0.001**
Household yearly disposable income quintile						

Quintile 1	**1.57 (1.04-2.38), 0.03**	1.23 (0.86-1.75), 0.26	**1.59 (1.12-2.27), 0.01**	1.11 (0.81-1.51), 0.53	**1.43 (1.16-1.77), 0.01**	**1.70 (1.27-2.29), <0.001**
Quintile 2	1.18 (0.79-1.76), 0.42	1.17 (0.83-1.66), 0.36	1.31 (0.94-1.83), 0.12	1.24 (0.92-1.67), 0.15	**1.25 (1.03-1.52), 0.03**	**1.63 (1.23-2.15), 0.01**
Quintile 3	1.28 (0.87-1.89), 0.21	0.95 (0.67-1.35), 0.77	1.08 (0.78-1.49), 0.65	0.92 (0.68-1.25), 0.60	1.07 (0.89-1.29), 0.48	**1.42 (1.09-1.86), 0.01**
Quintile 4	1.11 (0.76-1.64),0.59	1.04 (0.74-1.47), 0.80	1.16 (0.85-1.58), 0.34	1.13 (0.85-1.51), 0.40	1.08 (0.90-1.29), 0.42	1.18 (0.91-1.53), 0.22
Quintile 5 (ref)						
Labour force status						
Employed (ref)						
Unemployed	2.13 (0.88-5.13), 0.09	1.52 (0.65-3.57), 0.34	0.85 (0.40-1.80), 0.67	0.66 (0.26-1.66), 0.37	1.16 (0.74-1.83), 0.52	**4.03 (2.41-6.74), <0.001**
Not in the labor force	**3.40 (2.48-4.66), <0.001**	**5.72 (4.18-7.85), <0.001**	**1.90 (1.45-2.49), <0.001**	**2.44 (1.91-3.11), <0.001**	**3.14 (2.68-3.68), <0.001**	**4.28 (3.41-5.37), <0.001**
Indigenous status						
Non-indigenous (ref)						
Aboriginal/Torres Strait Islander	**8.27 (3.37-20.34), <0.001**	**2.44 (1.08-5.52),0.03**	1.87 (0.82-4.30), 0.14	1.01 (0.47-2.12), 0.99	0.94 (0.55-1.60), 0.81	1.95 (1.00-3.81), 0.05
Location						
Major city (ref)						
Regional	1.04 (0.78-1.37), 0.81	1.02 (0.80-1.30), 0.90	1.20 (0.94-1.54), 0.14	1.03 (0.84-1.26), 0.80	**1.23 (1.07-1.43), 0.01**	1.07 (0.88-1.31), 0.48
Remote	0.45 (0.14-1.45), 0.18	1.31 (0.54-3.16), 0.55	0.72 (0.26-2.03), 0.54	1.28 (0.62-2.63), 0.51	**0.48 (0.27-0.85), 0.01**	0.44 (0.19-1.01), 0.05
Behavioural Characteristics						
Smoking status						
Never smoked (ref)						
ex-smoker	**1.50 (1.12-2.01), 0.01**	**1.56 (1.21-2.02), 0.01**	**1.57 (1.21-2.04), 0.01**	1.09 (0.88-1.35), 0.41	**1.21 (1.04-1.41), 0.01**	**1.42 (1.14-1.76), 0.01**
Current smoker	0.98 (0.64-1.49), 0.92	1.05 (0.72-1.52), 0.80	**2.13 (1.50-30), <0.001**	0.95 (0.69-1.29), 0.72	1.07 (0.86-1.32), 0.55	**2.56 (1.95-3.36), <0.001**
Alcohol consumption						
Never drink (ref)						
Ex-drinker	0.65 (0.40-1.05), 0.08	1.19 (0.78-1.82), 0.42	0.84 (0.54-1.31), 0.44	1.37 (0.92-2.03), 0.12	1.20 (0.91-1.58), 0.19	**2.04 (1.41-2.94), <0.001**
Only rarely to 3 days/week	**0.44 (0.29-0.65), <0.001**	0.71 (0.50-1.02), 0.07	0.72 (0.50-1.04), 0.08	1.18 (0.85-1.64), 0.32	1.17 (0.94-1.46), 0.17	1.12 (0.83-1.52), 0.47

3+ days/week	**0.16 (0.10-0.27), <0.001**	**0.51 (0.33-0.77), 0.01**	0.74 (0.48-1.13), 0.17	1.12 (0.78-1.62), 0.54	1.19 (0.92-1.54), 0.18	1.14 (0.8-1.63), 0.46
Physical activity						
Not at all to <1/week (ref)						
1-3 times/week	**0.73 (0.56-0.94), 0.02**	**0.59 (0.47-0.74), <0.001**	0.93 (0.74-1.16), 0.52	**0.72 (0.59-0.89), 0.01**	**0.78 (0.68-0.89), <0.001**	**0.52 (0.43-0.62), <0.001**
≥ 4 times/week	**0.60 (0.46-0.80), 0.01**	**0.55 (0.43-0.70), <0.001**	**0.67 (0.52-0.86), 0.01**	**0.71 (0.57-0.88), 0.01**	**0.58 (0.50-0.68), <0.001**	**0.34 (0.27-0.41), <0.001**

Abbreviations: aOR, Adjusted Odds Ratio; ref, reference. Values in bold are statistically significant. All models (Models 1 to 6) were adjusted for age, gender, civil status, education, household yearly disposable income, labour force status, indigenous status, location, smoking status, alcohol consumption, and physical activity. Values in bold are statistically significant.

Gender differences in the relationship between obesity and six types of chronic conditions among middle-aged and older Australian adults were reported in Table 4. The results showed that the odds of having chronic conditions, such as type 2 diabetes, heart diseases, arthritis and depression, were higher among obese adults compared to healthy weight counterparts irrespective of gender. However, the magnitudes vary with gender. For example, the risk of having type 2 diabetes were 17.61 (OR: 17.61, 95% CI: 10.49-29.54), and 9.55 (OR: 9.55, 95% CI: 5.69-16.03) times higher among obese female and male adults, respectively, compared to their healthy-weight counterparts. Besides, the results showed that obesity is associated with a higher incidence of asthma (OR: 2.64, 95% CI: 1.84-3.80) among female adults, but not statistically significant in the case of male adults (Table 4).

Table 4: Adjusted random-effect regression results for the between-person differences in chronic conditions due to obesity stratified by gender

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Type 2 diabetes	**Heart disease**	**Asthma**	**Cancer**	**Arthritis**	**Depression**
	aOR (95% CI)	**aOR (95% CI)**	**aOR (95% CI)**	**aOR (95% CI)**	**aOR (95% CI)**	**aOR (95% CI)**
Gender: Male						
BMI Categories						
Underweight	0.46 (0.03-2.61), 0.27	2.11 (0.57-7.78), 0.26	0.19 (0.02-1.57), 0.12	0.53 (0.13-2.18), 0.38	1.22 (0.49-3.09), 0.66	2.15 (0.64-7.19), 0.21
Healthy weight (ref)						
Overweight	**3.01 (1.88-4.81), <0.001**	1.22 (0.85-1.75), 0.27	0.79 (0.53-1.16), 0.23	0.89 (0.66-1.20), 0.45	1.34 (1.07-1.69), 0.01	1.05 (0.75-1.47), 0.78
Obesity (≥30)	**9.55 (5.69-16.03), <0.001**	**2.19 (1.44-3.33), <0.001**	1.17 (0.75-1.84), 0.45	0.92 (0.64-1.31), 0.63	**2.24 (1.71-2.93), <0.001**	**1.96 (1.34-2.87), 0.01**
Gender: Female						
BMI Categories						
Underweight	0.29 (0.04-4.75), 0.51	**3.43 (1.42-8.25), 0.01**	0.70 (0.24-2.01), 0.50	1.92 (0.90-4.09), 0.09	0.99 (0.56-1.77), 0.99	1.33 (0.64-2.76), 0.44
Healthy weight (ref)						
Overweight	**5.02 (3.04-8.28), <0.001**	**1.60 (1.11-2.31), 0.01**	**1.58 (1.14-2.20), 0.01**	0.76 (0.56-1.04), 0.09	**1.46 (1.20-1.78), <0.001**	**1.43 (1.10-1.87), 0.01**
Obesity (≥30)	**17.61 (10.49-29.54), <0.001**	**1.83 (1.22-2.73), 0.01**	**2.64 (1.84-3.80), <0.001**	0.89 (0.64-1.24), 0.50	**2.25 (1.80-2.81), <0.001**	**1.96 (1.46-2.62), <0.001**

Abbreviations: aOR, Adjusted Odds Ratio; ref, reference. All models (Models 1 to 6) were adjusted for age, gender, civil status, education, household yearly disposable income, labour force status, indigenous status, location, smoking status, alcohol consumption, and physical activity. Values in bold are statistically significant.

Discussion

The current study is one of the first pieces of evidence that examined the between-person differences in the association between obesity and common chronic diseases among middle-aged and older Australian adults by utilising three waves spanning nine years of a nationally representative longitudinal survey. After controlling for socio-demographic and behavioural covariates, the longitudinal random-effect logistic regression results reveal that obesity is a major risk factor for chronic diseases (type 2 diabetes, heart disease, asthma, arthritis, and depression).

This study identified obesity as a significant risk factor for type 2 diabetes. This notion fits well with previous findings (Grantham et al., 2013; Guh et al., 2009), wherein the authors concluded that overeating and obesity were strongly associated with type 2 diabetes. The present analysis has also revealed a significant positive relationship between obesity and the risk of heart disease. Identical results are available in numerous past studies showing that increasing BMI increases the risk of heart failure in both men and women (Kenchaiah et al., 2002). Excess weight is a high-risk factor for ischemic stroke and hemorrhagic stroke (Poirier et al., 2006). A recent study demonstrated that the increased risk of heart disease might be due to a higher incidence of hypertension, adverse hemodynamic effects, maladaptive modifications in cardiovascular structure and function and increased atrial fibrillation among obese people (Koliaki et al., 2019).

The finding of a positive association between obesity and asthma is consistent with the existing literature (Ford, 2005). The possible reason could be that obesity affects lung function by superfluous tissues constricting the thoracic cage, increasing the chest wall's insinuation with fat tissue and pulmonary blood volume (Zerah et al., 1993). Besides, obesity also causes changes in lung volume and respiratory muscle function (Biring et al., 1999), leading to asthmatic problems.

Another novel finding of the present study is that obesity is a statistically significant risk factor for arthritis in Australian adults. Other studies estimating the association indicated that obesity is a major risk factor of osteoarthritis for Australian adults (March and Bagga, 2004), and there is evidence that a 5-unit in BMI increases the risk of osteoarthritis (knee) by 35% (King et al., 2013). The possible reason might be obesity causes increased pressure on the knee joints during daily activities, which causes proliferation of periarticular bone, leading to decreased joint space (Lementowski and Zelicof, 2008).

The present study findings reveal that obese adults are more likely to develop depression irrespective of socioeconomic and demographic status. Many studies have come to identical conclusions (Preiss et al., 2013; Scott et al., 2008; Tyrrell et al., 2019). There are several reasons for this association. Obese and overweight people generally have low health status and higher co-morbidities (severe chronic diseases) which might cause depression (Tyrrell et al., 2019). Apart from this, a model developed by Markowitz et al.illustrated that lack of mobility, lower quality of life and physical functionalities, social stigma and dissatisfaction with body size caused by overweight and obesity, contributes to a higher level of depression (Markowitz et al., 2008). The systematic literature review of Preiss et al. (Preiss et al., 2013) identified eating disorders, interpersonal effectiveness and experience of stigma as other key factors influencing the relationship between co-morbid obesity and depression.

Interestingly, this study observed no significant association between obesity and cancer among adults in Australia. The findings are contradictory to some of the existing literature. In an earlier review, Calle et al. commented that obesity increases the risk of selected types of cancer (Calle et al., 2003). Renehan et al.conducted a meta-analysis on BMI and cancer incidence, and they found that obesity is a significant risk factor for developing cancer, and the association was consistent in several continents of the world (Renehan et al., 2008). Besides, several other studies concluded that obesity-related biological mechanisms (e.g. hormones, calorie constraints, growth factors, inflammatory progressions) influence the development of malignant cells in the body (Calle and Kaaks, 2004; Drew, 2012). Therefore, the findings of the lack of association in our study should be interpreted with caution. It should be noted that the HILDA survey does not specify which type of cancer the respondents have developed. Hence, one possibility is that the most common type of cancers (e.g. skin, prostate, colorectal, melanoma and lung) associated with Australian adults are insignificantly impacted by obesity and overweight. Future research should focus on addressing this issue.

Finally, similar to the common knowledge in the public health literature, the results indicate that increased physical activities reduce the risk of chronic diseases irrespective of obesity and socio-demographic status. Noticeably, the most considerable positive impact of physical activities was on the level of depression. Participants engaged in physical activities more than three times a week had a 40% less probability of suffering from chronic depression than those that did not undertake physical activities. An extensive literature related to Australian adults validates this study finding (McKercher et al., 2013; Rebar et al., 2014). Therefore, the present study suggests the promotion of physical activities to prevent chronic diseases in Australian adults. The study's findings suggest that physical activities, community-level gym facilities, and the availability of nutritionists to curb excessive weight are necessary. This study calls for future research that will explore the potential of lifestyle interventions and dietary modification to curb excessive weight gain.

Managing obesity has the potential to reduce the prevalence of and mortality from these chronic diseases (Lemay et al., 2019), and improve health-related quality of life (Lemstra and Rogers, 2016). A previous study has claimed that the prevalence of diabetes, high cholesterol, high blood pressure, and CVD among Australian adults could be reduced significantly by reducing body weight (Atlantis et al., 2009). Policymakers and health practitioners might use these findings to devise appropriate strategies and targeted health programs for overweight and obese Australians to reduce their probable burden of chronic diseases.

Conclusion

This study explores the longitudinal association between obesity and chronic diseases in Australian adults. The longitudinal random-effect logistic regression results showed significant associations between excess body fat (obesity) and chronic diseases. Association between obesity and chronic diseases using longitudinal data is relatively uncommon. This study is one of the few studies that considered six different types of chronic conditions covering nine years of data. The study found that the prevalence and incidence of chronic conditions, such as type 2 diabetes, heart diseases, asthma, arthritis and depression, are higher among obese adults than their healthy-weight counterparts. More specifically, people with obesity are at higher risk of having type 2 diabetes (compared to their healthy counterparts) than any other chronic disease in Australia. The present study has several strengths. Firstly, this study identified which chronic diseases have the strongest association with obesity in Australian adults. Secondly, this study considered a wide range of chronic diseases while checking their relationship with obesity. Thirdly, unlike previous studies, this study employed longitudinal data from the HILDA survey, which is broadly representative of the national population. Fourthly, this study has identified that obesity increase the incidence of chronic diseases differently among men and women.

This study has some drawbacks in estimating the relationships between obesity and chronic diseases. Firstly, this study used self-reported data on BMI, chronic diseases, and lifestyle characteristics. Secondly, this study formed an unbalanced panel data for the subsample analyses. Therefore, causality cannot be drawn from the present study findings. Thirdly, this study did not consider genetic or familial aggregation factors, which are common causes of some chronic diseases, such as type 2 diabetes. Fourthly, the HILDA survey questionnaire does not specify the exact type of cancer or arthritis the participants have developed.

Abbreviations

BMI	Body Mass Index
HILDA	Household, Income and Labour Dynamics in Australia Survey
AOR	Adjusted Odds Ratios
WHO	World Health Organization

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Author's contributions

SAK, RHR, RC, RH, and FF initiated the study, conducted the data analysis, and drafted the manuscript. KA, JG, and SB offered advice, critical comments, and edited the draft manuscript. All the authors read and approved the final manuscript.

Conflict of interest

The authors declare that they have no conflicts of interest.

Availability of data and materials

The data used for the study were collected from the Melbourne Institute of Applied Economic and Social Research. There are some restrictions on this data, and it is not available to the public. Those interested in accessing this data should contact the Melbourne Institute of Applied Economic and Social Research, The University of Melbourne, VIC 3010, Australia (Tel: +61 3 8344 2073 or Fax: +61 3 9347 6739).

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CHAPTER 3: STUDY 2

Self-reported disability and its association with obesity and physical activity in Australian adults: Results from a longitudinal study

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Abstract

Background

A high prevalence of disability has been previously observed in developed countries. Identifying trends in its prevalence and risk, as well as protective factors of disability, are essential to establish effective prevention strategies.

Objective

The purposes of this study are to outline trends in the prevalence of disability among Australian adults and to analyse the relationship between obesity and physical activity with disability.

Design

A retrospective longitudinal research design.

Methods

The study utilised the most recent 14 waves (wave 6 through 19) of the nationally-representative Household, Income and Labour Dynamics in Australia (HILDA) survey (2006-2019). The Generalised Estimating Equation (GEE) with the logistic link function model was employed to estimate the relationships between obesity and physical activity with disability. The final study sample consisted of 189,519 person-year observations from 26,208 participants.

Results

The pooled prevalence of disability in adults is 28%. The prevalence of disability among older adults (65 and above years) is more than 50%, irrespective of gender. Further, it identifies obesity and physical activity as risk and protective factors of disability for adults, respectively. The odds of acquisition of a disability was 1.33 times (Odds Ratios [OR]: 1.33, 95% Confidence Interval [CI]: 1.28–1.39) higher among obese adults than healthy-weight counterparts. However, adults undertaking the recommended level of physical activity (more than thrice a week to every day) per week have 17% (OR: 0.83, 95% CI: 0.81–0.85) lower chances of disability acquisition.

Conclusion

Obesity imposes a significant toll on adult Australians' health. This risk factor of disability can be reduced through public health interventions.

Keywords: Disability, obesity, physical activity, Australia, Generalized Estimating Equation

Introduction

Disability is a crucial health indicator of population health. The term 'disability' refers to a condition of the body or mind that affects a person's normal daily activities and participation, such as vision, hearing, thinking, remembering, learning, communicating, and movement (Centers for Disease Control and Prevention, 2020a). Approximately 15% (over 1 billion) of the global population are living with a disability and is projected to double (2 billion) by 2050 (World Health Organization, 2018). In 2018, over 4.4 million (1 in 5 people) Australians had some form of disability (Australian Institute of Health and Welfare, 2019e), and around 5.7% have a severe disability (Australian Bureau of Statistics, 2018d).

Adults with disabilities experience substantial health disparities. Disabled adults rate their health substantially lower compared with their non-disabled counterparts in Australia (Australian Institute of Health and Welfare, 2019e). Disabled adults are more prone to suffer from chronic diseases, such as heart disease, arthritis, back problems, dementia, intellectual disorders, and neurotic disorders (Australian Bureau of Statistics, 2018d). Moreover, disabled adults experienced discrimination, violence and difficulties in accessing and utilising health services (Australian Institute of Health and Welfare, 2019e). Further, disabled people are less likely to be in the workforce and have substantially less personal income than adults without disability (Australian Bureau of Statistics, 2018d). Additionally, there is evidence that disabled people have lower productivity in the workplace in the form of lower levels of job satisfaction (Keramat et al., 2020c), higher absenteeism (Keramat et al., 2020a) and presenteeism (Keramat et al., 2020b) compared with non-disabled counterparts.

The rising prevalence of disability is, in part, due to the ageing trajectory of the population and higher incidence of chronic diseases (World Health Organization, 2018). Previous research has found that obese, tobacco users, higher alcohol drinkers, and physically inactive people were more likely to be disabled (Mathers and Loncar, 2006; World Health Organization, 2015). A longitudinal study revealed that being obese in mid-life is associated with a higher risk of being physically disabled at an older age (Wong et al., 2015a). A Dutch study identified age, excessive body fat, depression, and joint complaints as the significant risk factors for disability (Taş et al., 2007). Further, a systematic review provides evidence that older age and poor health condition increased the risk of being disabled (Tas et al., 2007). Furthermore, a prospective cohort study provides evidence that obesity, physical inactivity, and hypertension caused disability in Italian adults (Balzi et al., 2009). Moreover, Korean research identified that people with poor physical health, depression, and obesity had a higher tendency of having a disability (Kim et al., 2005). Additionally, other evidence reported that limited daily activities, low physical functioning, multiple physical and psychological conditions were positively associated with disability (Mehta et al., 2002; Sinclair et al., 2001).

The two main limitations of existing studies on the risk and protective factors of adult disability are small sample sizes and solely focused on disability in the elderly (Chen and Guo, 2008; Mehta et al., 2002; Sinclair et al., 2001; Taş et al., 2007). As far as the authors are concerned, this is the first study that reports disability trends among Australian adults using longitudinal data. The benefit of utilising such data is that it can capture within and between-person variation in the study population's characteristics. Moreover, there is little conclusive evidence on the longitudinal relationship between obesity and physical activity with disability in Australian adults. To prevent increasing disability prevalence, it is crucial to gain a better understanding of the risk and protective factors of adults with disability in Australia. Therefore, this study aims to reveal trends in the national prevalence of disability in Australian adults and assess its association with obesity and physical activity.

Data and methods

Data source and sample selection

The data come from the most recent 14 waves (2006 to 2019) of the Household, Income and Labour Dynamics in Australia (HILDA) survey. HILDA is an annual nationally representative longitudinal survey of the Australian adult population that collects a wide variety of information on respondents' socio-demographic, economic, and lifestyle characteristics, along with labour market activity and a range of health topics since 2001. HILDA mostly collects information from participating household members aged 15 years or over through face-to-face interviews by trained interviewers and self-completion questionnaire (SCQ). The HILDA survey used the multistage sampling technique to select the initial sample of households. More detailed information regarding the HILDA survey design and methodology can be found elsewhere (Freidin et al., 2002). The main reason for using the HILDA data set is that it contains information on self-reported disability, weight status, and physical activity. Other advantages of using the data set are that it includes detailed information on socio-demographic and lifestyle characteristics, including age, gender, education, civil status, labour force status, ethnicity, smoking and alcohol consumption at several time points.

This study pooled waves 6 (2006) through 19 (2019) of the HILDA survey to generate a sufficiently large sample to infer the association between overweight, obesity, and physical activity with disability. The main reason for selecting these study waves is that not all interest variables were available from wave 1 through 19. For example, BMI measure has only been collected from wave 6 onwards. The sample is restricted to adults aged 15 years and over that have valid information on disability, weight status, and physical activity. Application of inclusion and exclusion criteria resulted in a final study sample of 189,519 person-year observations from 26,208 participants for the subsample analyses.

Outcome variable

The primary outcome of this study is the self-reported disability status. The survey collected data on respondents' disability status following the International Classification of Functioning, Disability, and Health (ICF) guidelines under the WHO framework (Keramat et al., 2020b, 2020a, 2020c; LaMontagne et al., 2016; Lopez Silva et al., 2020). The term 'disability' has been used as an umbrella term covering impairments, functional limitations, and participation restriction in the definition of ICF (World Health Organization, 2001). The HILDA survey participants reported on their disability status in response to the question: 'do you have any long-term health condition, impairment or disability that restricts your everyday activities, and has lasted, or is likely to last, for six months or more?' The survey presents 17 types of disability, such as sight problems, hearing problems, speech problems, limited use of arms or fingers, difficulty in gripping things, and limited use of feet or legs to the respondents to define their disability status (Cebulla and Zhu, 2016). A binary measurement was used to capture the respondents' disability status. The variable takes the value 1 if the respondent reports that they have a disability and 0 for 'no' disability.

Exposure variables

Body Mass Index (BMI)

The primary exposure variable of interest is BMI, a continuous variable that measures the participant's weight status. The HILDA survey calculates respondents' BMI using the formula of weight (in kilograms) divided by height (in meters) square. For this study, BMI was converted to categorical variable and collapsed into four categories: 'underweight' (<18.50), 'healthy weight' (18.50 to <25), 'overweight' (25 to <30), and 'obese' (≥ 30) following the World Health Organization (WHO) guidelines and previous studies (Keramat et al., 2020d, 2020e; World Health Organization, 2020a).

Physical Activity

Information on physical activity was collected by asking the question: 'In general, how often do you participate in moderate or intensive physical activity for at least 30 minutes?' Participants' responses were pre-coded into six categories: 'not at all', 'less than once/week', '1 or 2 times/week', three times/week', 'more than three times/week but not every day', and 'every day'. This study utilised this information to measure moderate to vigorous physical activity (MVPA) undertaken by the respondents following a previous study (Perales et al., 2014). Responses were collapsed into two levels: undertaking the recommended level of physical activity (more than three times/week but not every day, and every day) and less than the recommended level of physical activity (not at all, less than once/week, 1 or 2 times/week, and three times/week).

Other covariates

This study included several confounders for their potential relationship with adult disability as based on existing literature (Boyle et al., 2007; Kim et al., 2005; Lee and Park, 2008; Taş et al., 2007; Wong et al., 2015b) and the information available in the HILDA survey. Socio-demographic covariates included in the study were age (15-24, 25-34, 35-44, 45-54, 55-64, and ≥ 65 years), gender (male, female), education (year 11 and below, year 12, professional courses, undergraduate, postgraduate), civil status (single, married/living together, widow/separated/divorced), household income quintile (quintile 1 to 5), labour force status (employed, unemployed, not in the labour force), indigenous status (not of indigenous origin, Aboriginal or Torres Strait Islander or both), and remoteness (major city, regional city, remote area). Two lifestyle characteristics considered in this study are smoking status (never smoked, ex-smoker, current smoker), and alcohol consumption (never drank, ex-drinker, only rarely to 3 days per week, over three days per week).

Estimation strategy

This study constructed an unbalanced panel data set consisting of 189,519 person-year observations by linking 26,208 de-identified individuals' records. As there are 14 periods of exposure (2006 to 2019), most participants are included in the analytic sample more than once. Reports of the pooled characteristics of the study sample are in frequency (n) and percentages (%) with 95% confidence intervals (CIs). Bivariate relationships between disability and main variables of interest (obesity and physical activity) along with other covariates were initially examined through chi-square tests (the test results were not reported). Covariates found statistically significant with a P-value <0.05 in the bivariate analyses were incorporated in the final multivariate regression model as independent variables.

In the present analyses, the outcome variable (self-reported disability) was dichotomous (yes versus no) and data were correlated as observations on an individual in the final analytic sample have been utilised more than once. Therefore, this study deployed Generalised Estimating Equation (GEE) technique with a logistic link to check the association between obesity and physical activity with disability. One of the great advantages of using GEE in the case of correlated data is it provides efficient parameter estimates even in the case of misspecification of the correlation structure. Model 1 reports the adjusted association between obesity and physical activity with the self-reported disability after adjusting age, gender, education, civil status, household income, labour force status, indigenous status, remoteness, smoking, and alcohol consumption. For ease of interpretation, this study presents the multivariate regression results in the form of odds ratios with 95% confidence intervals. It has set the p-value at 5% or lower level for statistical significance. All statistical analyses were performed using the statistical software Stata, version 16.0.

Results

Pooled descriptive statistics of the study population are exhibited in Table 1. Of the 189,515 participants, a large number 53,037 (approximately 28%) have some form of disability, 24% were obese, and 66% do not undertake the recommended level of moderate to vigorous physical activity. Among the study participants, 18% were aged over 64 years, 53% were female, 49% were married, 35% have university qualifications (undergraduate and postgraduate combined), 64% were employed, 97% were non-indigenous, and 66% were from major cities. Nearly 18% of respondents currently smoke, and 81% consume alcohol.

Table 1: Descriptive statistics of the study participants

Variables	n	% (95% CI)
Disability status		
No	136,482	72.01 (71.81-72.22)
Yes	53,037	27.99 (27.78-28.19)
BMI categories		
Underweight (<18.50)	4,961	2.62 (2.55-2.69)
Healthy weight (18.50 to <25.00)	74,928	39.54 (39.32-39.76)
Overweight (25.00 to <30.00)	64,656	34.12 (33.90-34.33)
Obesity (≥30)	44,974	23.73 (23.54-23.92)

Moderate to vigorous physical activity (MVPA)		
Less than recommended level	125,546	66.24 (66.03-66.46)
Recommended level	63,973	33.76 (33.54-33.97)
Socio-demographic characteristics		
Age groups		
15-24 years	31,579	16.66 (16.50-16.83)
25-34 years	32,227	17.00 (16.84-17.17)
35-44 years	31,018	16.37 (16.20-16.53)
45-54 years	32,619	17.21 (17.04-17.38)
55-64 years	28,332	14.95 (14.79-15.11)
65 and above years	33,744	17.81 (17.63-17.98)
Gender		
Male	89,695	47.33 (47.10-47.55)
Female	99,824	52.67 (52.45-52.90)
Highest educational qualification		
Year 11 or below	53,825	28.40 (28.20-28.60)
Year 12	28,744	15.17 (15.01-15.33)
Professional courses	41,190	21.73 (21.55-21.92)
Undergraduate	45,201	23.85 (23.66-24.04)
Postgraduate	20,559	10.85 (10.71-10.99)
Civil Status		
Single	42,890	22.63 (22.44-22.82)
Married	113,822	60.06 (59.84-60.28)
Widow/seperated/divorced	32,807	17.31 (17.14-17.48)
Household income quintile		
Quintile 1 (0-20%)	37,904	20.00 (19.82-20.18)
Quintile 2 (20-40%)	37,904	20.00 (19.82-20.18)
Quintile 3 (40-60%)	37,905	20.00 (19.82-20.18)
Quintile 4 (60-80%)	37,903	20.00 (19.82-20.18)
Quintile 5 (80-100%)	37,903	20.00 (19.82-20.18)
Labour force status		
Employed	121,790	64.26 (64.05-64.48)
Unemployed	6,800	3.59 (3.51-3.67)
Not in the labour force	60,929	32.15 (31.93-32.36)
Indigenous status		
Not of indigenous origin	184,009	97.09 (97.02-97.17)
Aboriginal/Torres Strait Islander	5,510	2.91 (2.83-2.98)
Remoteness		
Major city	125,529	66.24 (66.02-66.45)
Regional city	61,293	32.34 (32.13-32.55)
Remote area	2,697	1.42 (1.37-1.48)
Lifestyle characteristics		
Smoking status		
Never smoked	103,051	54.38 (54.15-54.60)
Ex-smoker	52,252	27.57 (27.37-27.77)
Current smoker	34,216	18.05 (17.88-18.23)

Alcohol consumption		
Never drank	20,551	10.84 (10.70-10.98)
Ex-drinker	14,914	7.87 (7.75-7.99)
Only rarely to 3 days/week	103,147	54.43 (54.20-54.65)
3+ days/week	50,907	26.86 (26.66-27.06)

Figure 1 displays the trends in the prevalence of national adult disability in Australia for the period 2006 to 2019. The percentage of adults with disability in Australia has plateaued during the study period. It has been observed that the rate has been increased by nearly three percentage points over the study periods, ranged from 26% (2006) to 29% (2019).

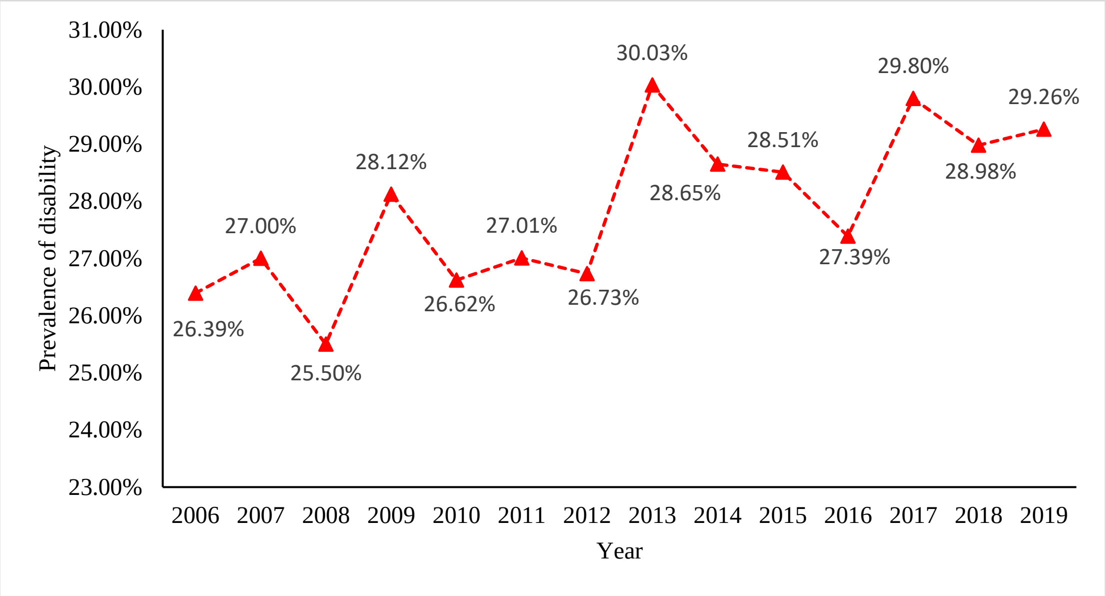

Figure 1: The trend in the prevalence of disability in Australia, 2006-2019

Figure 2 presents the prevalence of disability stratified by participants' BMI. Disability prevalence varies by weight status, and the prevalence of disability has been found highest among obese adults. Figure 2 shows that disability rates among obese, overweight, underweight, and healthy weight adults were 40%, 28%, 32%, and 22%, respectively, in 2019. The prevalence of disability among obese adults increased by five percentage points during the study periods, from 35% (2006) to 40% (2019).

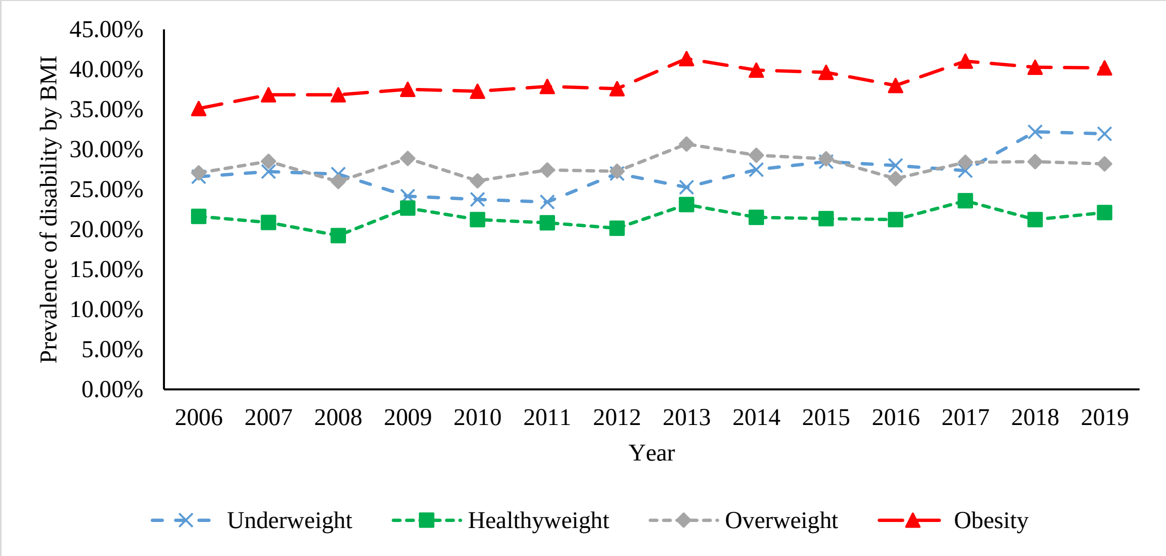

Figure 2: The trend in disability by weight status in Australia, 2006-2019

Figure 3 displays the prevalence of disability stratified by moderate to vigorous physical activity for the period 2006 to 2019. The prevalence of disability is substantially low among the participants undertaking the recommended level of physical activity than peers performing less than the recommended level of physical activity. For example, the prevalence of disability among the participants performing recommended and less than the recommended level of physical activity was 22% and 33%, respectively, in 2019. The prevalence of disability has been found highest among the adults who perform less than the recommended level of physical activity, and it ranged from 28% (2008) to 33% (2013). However, the figure shows that disability prevalence among those physically active (undertaking recommended level) is substantially lower, ranged from 20% (2008) to 24% (2013).

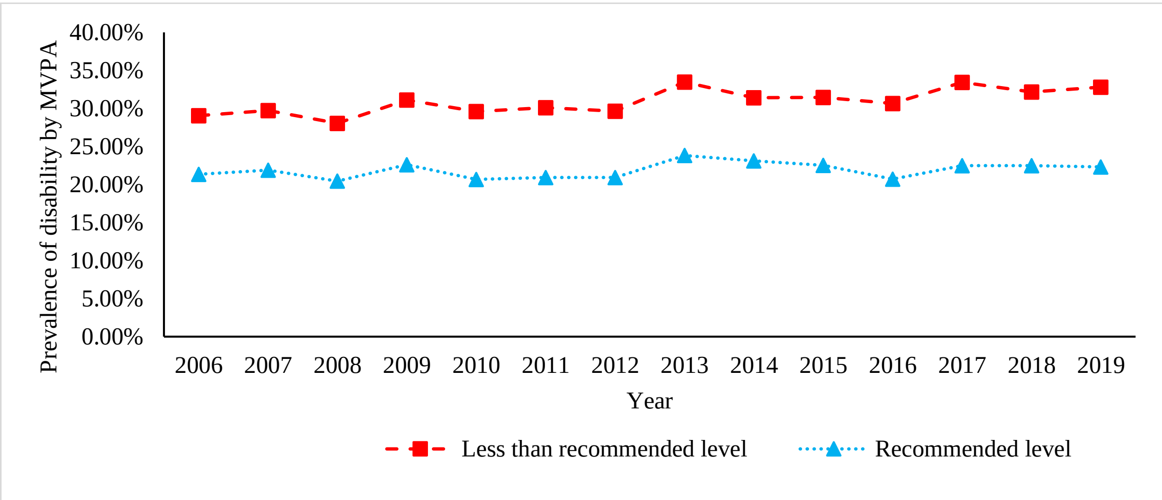

Figure 3: The trend in disability by moderate to vigorous physical activity (MVPA) in Australia

Table 2 reports the pooled prevalence of adults' disability by age and gender at four different time points from 2006 to 2019. The results show that the disability rate among the elderly (65 and above years) was over 50% irrespective of gender. The prevalence of disability is highest among the elderly (65 and above years) followed by middle-aged adults (aged 55-64 years). In 2019, the rate of disability in males aged 15-24, 25-34, 35-44, 45-54, 55-64, and 64+ years were 14, 15, 17, 26, 35, and 55%, respectively.

Table 2: The pooled prevalence of disability by age and gender at four different time points

Year	Age groups	15-24 years	25-34 years	35-44 years	45-54 years	55-64 years	65 and above years
	Gender	prevalence	prevalence	prevalence	prevalence	prevalence	prevalence
2006	Male	11.36%	14.20%	20.55%	24.51%	39.42%	54.74%
	Female	11.57%	15.79%	18.41%	25.62%	36.76%	53.31%
2010	Male	12.19%	10.87%	17.77%	23.40%	37.61%	55.17%
	Female	13.99%	12.85%	19.48%	28.27%	41.00%	53.73%
2014	Male	14.28%	13.22%	18.37%	25.80%	36.81%	58.97%
	Female	15.03%	14.64%	18.54%	27.28%	40.52%	57.29%
2019	Male	14.35%	15.32%	16.73%	26.46%	34.66%	54.83%
	Female	19.08%	17.03%	18.65%	26.93%	37.03%	56.90%

Table 3 presents the adjusted association between excess body weight and physical activity with a disability after controlling for age, gender, education, civil status, household income, labour force status, indigenous status, remoteness, smoking and alcohol consumption. The results from the GEE technique showed that the odds of acquisition of a disability was 1.12 (OR: 1.12, 95% CI: 1.09-1.15) and 1.33 (OR: 1.33, 95% CI: 1.28-1.39) times higher among overweight and obese adults, respectively, compared with their healthy-weight counterparts. It is also observed that adults undertaking the recommended level of moderate to vigorous physical activity (more than thrice to every day) have 17% (OR: 0.83, 95% CI: 0.81-0.85) lower chances of suffering from a disability compared with peers performing less than the recommended level of physical activity.

Table 3: Adjusted relationships between BMI and physical activity with disability among Australian adults

Variables	**Model 1** disability (yes versus no) OR (95% CI)	**P-value**
BMI categories		
Underweight (<18.50)	**1.12 (1.04–1.20)**	**0.01**
Healthy weight (18.50 to <25.00) (ref)		
Overweight (25.00 to <30.00)	**1.12 (1.09-1.15)**	**<0.001**
Obesity (≥30)	**1.33 (1.28-1.39)**	**<0.001**
Moderate to vigorous physical activity (MVPA)		

Less than the recommended level (ref)		
Recommended level	**0.83 (0.81-0.85)**	**<0.001**
Socio-demographic characteristics		
Age groups		
15-24 years (ref)		
25-34 years	**1.32 (1.24-1.41)**	**<0.001**
35-44 years	**1.77 (1.65-1.90)**	**<0.001**
45-54 years	**2.69 (2.50-2.89)**	**<0.001**
55-64 years	**3.99 (3.71-4.30)**	**<0.001**
65 and above years	**5.31 (4.92-5.73)**	**<0.001**
Gender		
Male (ref)		
Female	0.96 (0.93-1.01)	0.16
Highest educational qualification		
Year 11 or below (ref)		
Year 12	**0.91 (0.86-0.97)**	**<0.001**
Professional courses	0.98 (0.93-1.03)	0.42
Undergraduate	**0.81 (0.77-0.86)**	**<0.001**
Postgraduate	**0.75 (0.69-0.81)**	**<0.001**
Civil Status		
Single (ref)		
Married/living together	**0.90 (0.85-0.95)**	**<0.001**
Widow/seperated/divorced	**1.11 (1.04-1.19)**	**0.002**
Household income quintile		
Quintile 1 (0-20%)	**1.21 (1.16-1.26)**	**<0.001**
Quintile 2 (20-40%)	**1.13 (1.09-1.17)**	**<0.001**
Quintile 3 (40-60%)	1.03 (0.99-1.06)	0.16
Quintile 4 (60-80%)	**1.04 (1.01-1.08)**	**0.02**
Quintile 5 (80-100%) (ref)		
Labour force status		
Employed (ref)		
Unemployed	**1.36 (1.28-1.44)**	**<0.001**
Not in the labour force	**1.72 (1.66-1.78)**	**<0.001**
Indigenous status		
Not of indigenous origin (ref)		
Aboriginal/Torres Strait Islander	**1.28 (1.14-1.43)**	**<0.001**
Remoteness		
Major city (ref)		
Regional city	**1.13 (1.08-1.18)**	**<0.001**
Remote area	**0.85 (0.74-0.98)**	**0.03**
Lifestyle characteristics		
Smoking status		
Never smoked (ref)		
Ex-smoker	**1.24 (1.19-1.29)**	**<0.001**
Current smoker	**1.39 (1.33-1.46)**	**<0.001**
Alcohol consumption		
Never drank (ref)		
Ex-drinker	**1.20 (1.13-1.27)**	**<0.001**
Only rarely to 3 days/week	**0.94 (0.90-0.98)**	**0.01**
3+ days/week	**0.81 (0.76-0.85)**	**<0.001**

Abbreviations: OR, odds ratios; ref, reference.

Values in bold are statistically significant at $p<0.05$

Discussion

The results showed that the adult disability rate in Australia is approximately 28%. It is also revealed that the prevalence of disability among older adults (65 and above years) is more than 50% irrespective of gender. This finding corroborates previous survey findings that the rate of disability is higher among older adults (Australian Institute of Health and Welfare, 2019e).

The GEE population-averaged model identified obesity and physical activity as the risk and protective risk factors of adults with disability, respectively, after adjusting for confounders. The results reveal a positive association between obesity and disability; that is, obese people reported higher disability than their healthy-weight peers. This finding confirms existing evidence (Alley and Chang, 2007; Chen and Guo, 2008; Zoico et al., 2004). A longitudinal study also supports the present study's result, as it found that obesity was significantly positively associated with disability (Wong et al., 2015b). That study showed that obese adults experienced a 3% higher risk of having some form of disability for each additional year they lived (Wong et al., 2015b). A possible explanation is that obesity is closely associated with chronic diseases that result in health complexities (Al Snih et al., 2010). Further, metabolic irregularities due to obesity is another unanticipated explanation for developing a disability (Donini et al., 2016).

The study results also revealed a negative association between physical activity and disability. Adults undertaking the recommended level of moderate to vigorous physical activity were less prone to be disabled than peers performed less than the recommended level of physical activity per week. This finding corroborates previous study results (Boyle et al., 2007; Lee and Park, 2008). The mechanism through which physical activity negatively affects disability is complicated. Existing evidence shows that physical inactivity is responsible for the progression of chronic disease (Penedo and Dahn, 2005). Besides, physical inactivity may decrease learning power, increase ischemia, and cause neurotoxic damage (Kramer et al., 2005). The possible reason behind physical activity being a protective factor against disability acquisition is that regular physical activity has several beneficial effects on health. The benefits include improved aerobic capacity, bone and muscle strength, maintaining a healthy weight, and lower risk of having cardiovascular disease, type 2 diabetes and metabolic syndrome, and some cancers (Boyle et al., 2007; Centers for Disease Control and Prevention, 2020b).

This study found that excess body weight and cigarette/tobacco smoking are significant risk factors of adults disability. There is evidence that eliminating five modifiable risk factors (smoking, obesity, high blood pressure, high cholesterol, and diabetes) could reduce disability by 53% (Mehta et al., 2017). Therefore, the present study suggests that public health intervention should target weight management, reduce cigarette smoking to the lowest observed levels, and promote physical activity to prevent disability. These suggestions align with the existing evidence. Promotion of physical activity may reduce the level of obesity, and harsh tobacco control law discourages smoking, which in turn postpones the progression of disability (Lee and Park, 2008).

This study has several strengths that include the longitudinal nature of the data, the large sample size, and incorporation of a wide range of confounders. To the best of the authors' knowledge, this is the first Australian study that has used a nationally representative sample along with a longitudinal follow-up to check the association between obesity and physical activity with disability. The present study has used a nationally representative sample of 189,519 person-year observations from 26,208 respondents to find out precise estimates and draw a valid inference. Besides, this study adjusted the potential confounding effects of smoking, alcohol consumption, labour force status, and ethnicity.

Some limitations should be considered when interpreting the study results. Disability status, BMI, smoking, alcohol consumption, and physical activity were all assessed using self-report. Therefore, self-reported bias may arise since overweight and obese adults tend to overestimate height and underestimate weight (Gorber et al., 2007a; Maukonen et al., 2018). Also, justification bias may arise in case of self-reported disability, as respondents reported worse disability levels than probably exists in the general Australian population to obtain financial benefits through government transfer payments (Black et al., 2017). The present study is a retrospective longitudinal study that reveals the long-term association between obesity and physical activity with disability. However, causality cannot be drawn as the current research performed analyses on an unbalanced panel data set. Therefore, further investigation is required to draw causal inferences to explore the association between obesity and physical activity with disability using a prospective longitudinal cohort study design.

Conclusion

This study used de-identified data from the most recent 14 waves of the nationally-representative HILDA survey covering the period 2006 to 2019 to show the trend in the prevalence of adult disability and to check the relationship between obesity and physical activity with disability in Australia. The study results showed that the prevalence of adult disability is nearly 28% and that the rate is over 50% among older adults (65 and above years) irrespective of gender. Using the GEE technique, this study found that obesity is a significant risk, and physical activity a protective factor of adult disability in Australia. These findings have significant implications as Australia is currently experiencing sharp increases in adult disability and obesity. The population of adults with some form of disability should be a target group for public health interventions. Improved risk factor prevention and health promotion may assist in reducing the disability level. Therefore, health policymakers should target obesity for interventions to prevent adult disability. Another effective strategy to avoid disability should be encouraging physical activity in all Australians.

Abbreviations

ATSI	Aboriginal or Torres Strait Islander
BMI	Body Mass Index
GEE	Generalized Estimating Equation
HILDA	Household, Income and Labour Dynamics in Australia Survey
OR	Odds Ratios
WHO	World Health Organization

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Ethics approval

This study did not require ethical approval as the analysis used only de-identified existing unit record data from the HILDA survey. However, the authors completed and signed the Confidentiality Deed Poll and sent it to NCLD (ncldresearch@dss.gov.au) and ADA

(ada@anu.edu.au) before the data applications' approval. Therefore, datasets analysed and/or generated during the current study are subject to the signed confidentiality deed.

Author's contributions

SAK and NJS initiated the study, conducted the data analysis, and drafted the manuscript. KA, MKA, JG, and SB offered advice, critical comments, and edited the draft manuscript. All the authors read and approved the final manuscript.

Conflict of interest

The authors declare that they have no conflicts of interest.

Availability of data and materials

The data used for the study were collected from the Melbourne Institute of Applied Economic and Social Research. There are some restrictions on this data, and it is not available to the public. Those interested in accessing this data should contact the Melbourne Institute of Applied Economic and Social Research, The University of Melbourne, VIC 3010, Australia.

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CHAPTER 3: STUDY 3

Obesity, multimorbidity, and patterns of healthcare services utilisation in Australia: evidence from a longitudinal study of 20,000 adults

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Abstract

Objective

This study aimed to examine the longitudinal association between obesity and multimorbidity with healthcare utilisation in Australia.

Methods and analysis

Data were obtained from three waves (waves 9, 13, and 17) of the nationally-representative Household, Income and Labor Dynamics in Australia (HILDA) survey spanning the period 2009 to 2017. This study followed a retrospective cohort design, consisting of 41,073 person-year observations of 20,120 individuals aged 15 years or over. This study applies Generalized Estimating Equation models with logistic link function, together with count data regression models (negative binomial and Zero-Inflated Negative Binomial) to take into account the characteristics of the outcome variables and the longitudinal structure of the data set.

Results

The present research found that rates of doctor visits were 1.26 (Incidence Rate Ratios [IRR]: 1.26; 95% CI: 1.23-1.29) and 1.92 (IRR: 1.92; 95% CI: 1.86-1.98) times higher among obese and adults with multimorbidity compared to healthy weight and peers without multimorbidity, respectively. Obese adults were 1.24 (Odds Ratios [OR]: 1.24; 95% CI: 1.15-1.33), 1.13 (OR: 1.13; 95% CI: 1.06-1.20), 1.34 (OR: 1.34; 95% CI: 1.21-1.50), and 1.34 (OR: 1.34; 95% CI: 1.24-1.44) more likely to visit a hospital doctor, specialist doctor, mental health professionals, and have health check-ups, respectively, than healthy-weight counterparts. The results also showed that individuals with multimorbidity had 2.16 (OR: 2.16; 95% CI: 2.00-2.33); 2.58 (OR: 2.58; 95% CI: 2.41-2.76), 1.40 (OR: 1.40; 95% CI: 1.23-1.60), and 5.17 (OR: 5.17; 95% CI: 4.50-5.94) times greater utilisation of the above-mentioned healthcare services, respectively, compared to peers without multimorbidity. Moreover, hospital admission rates were 1.21 (IRR: 1.21; 95% CI: 1.07-1.37) and 2.33 (IRR: 2.33; 95% CI: 2.15-2.52) times greater among obese and adults with multimorbidity. Furthermore, night stay in hospital is 1.58 (IRR: 1.58; 95% CI: 1.39-1.80) times higher among adults with multimorbidity than their counterparts.

Conclusion

This study reveals that obese and adults with multimorbidity have an incremental use of healthcare services than healthy weight and peers without multimorbidity. Obesity and multimorbidity are significant public health concerns that require long-term management, with an emphasis on prevention. Failure to properly manage these chronic conditions may result in obesity-induced chronic diseases continuing to rise and increase pressure on the health system.

Keywords: Obesity, multimorbidity, healthcare services, HILDA, Australia

Introduction

Obesity and multimorbidity are two global health concerns of rapidly increasing importance. Obesity refers to the accumulation of excessive fat in the body (World Health Organization, 2020a). Approximately 650 million adults are obese, and each year at least 2.8 million people worldwide die due to obesity (World Health Organization, 2020a, 2020b). Recent studies indicate that these trajectories will continue for the next 10 to 15 years (Finkelstein et al., 2012; Wang et al., 2011). Rising obesity is associated with numerous chronic conditions, such as hypertension, heart disease, type II diabetes, and some cancers, with an elevated risk of mortality, disability, and reduced quality of life (Guh et al., 2009; M.A. Raebel et al., 2004; Withrow and Alter, 2011). The existence of two or more chronic diseases in a single individual is defined as multimorbidity (Australian Institute of Health and Welfare, 2020d). Multimorbidity has emerged as a serious public health challenge globally due to its high prevalence, the need for complex healthcare management, and its substantial health and economic burden (Fortin et al., 2007).

Both obesity and multimorbidity have emerged as key public health problems in Australia. In 2017-2018, approximately 31% of Australian adults were obese, and 20% had multimorbidity (Australian Bureau of Statistics, 2018a; Australian Institute of Health and Welfare, 2020d). Obesity prevalence has tripled among Australian adults over the past three decades (Hayes et al., 2017). The high prevalence of obesity and multimorbidity imposes a substantial health burden and increases healthcare resource utilization. In 2015, overweight and obesity were responsible for 8.4% of total burden of disease in Australia (Australian Institute of Health and Welfare, 2020e). Besides, one in every eight hospital admissions, one in every six days spent in hospital, and one in every six dollars spent on hospitalizations were attributed to individuals who were overweight or obese (Korda et al., 2015). Like obesity, chronic conditions have a significant impact on people's health and healthcare utilisation. In 2015, chronic diseases were responsible for approximately 66% of the disease burden (both fatal and non-fatal) in Australia (Australian Institute of Health and Welfare, 2020d). In 2017-18, five in ten hospitalizations and nine in ten deaths were attributed to ten selected chronic conditions in Australia (Australian Institute of Health and Welfare, 2020d).

Research to date shows that obese and adults with multimorbidity were more likely to consume a wide range of healthcare services (Marsha A. Raebel et al., 2004; Reidpath et al., 2002), including diagnostic services (Elrashidi et al., 2016; Peterson and Mahmoudi, 2015); prescribed drugs (Bell et al., 2011; Trasande and Chatterjee, 2009); emergency room visits (Elrashidi et al., 2016; Goetzel et al., 2010); and inpatient services (Payne et al., 2013; Peterson and Mahmoudi, 2015). Existing evidence also demonstrates that obese and adults with multimorbidity were more likely to utilize healthcare services, such as doctor consultations, hospital admissions, medical equipment applications, and medicines than others (Korda et al., 2015; R. Palladino et al., 2016). There is good evidence that obesity along with the presence of multimorbidity is associated with higher health service utilisation. However, these evidences are primarily based on cross-sectional data. To what extent obesity contributes to the rise of healthcare utilisation is unclear given that only few studies have examined this association in Australia using longitudinal data. Further, there is a shortage of research regarding the pattern of health service utilisation due to multimorbidity in Australia. Additionally, existing studies mainly considered a particular medical service or procedure as a proxy of healthcare service to check its association with obesity and multimorbidity. As a result, there is a lack of understanding as to whether obesity and multimorbidity prompt greater utilisation of a wide range of healthcare services. To address this gap in the literature, this study aims to examine the longitudinal association between obesity and multimorbidity with healthcare utilisation in Australia. The present study assesses the influence of obesity and multimorbidity on a wide range of healthcare services (such as number of doctor visits, specialized doctor visits, mental health professional visits, number of hospital admissions, number of nights stay in the hospital, and health check-ups or tests).

Methods

Participants

The present study utilized data from the Household, Income and Labor Dynamics in Australia (HILDA) survey. HILDA is a nationally representative longitudinal survey that collects information on Australian inhabitants' socio-economic and demographic characteristics, including family life, education, employment, income and labour market outcomes, annually since 2001. In the first survey, 7,000 private residential households were selected, wherein 13,000 adults aged 15 years and above were interviewed. To maintain national representativeness, additional individuals are added every year to the HILDA survey with the change of household composition. The HILDA survey collects information from all adult household members aged 15 years or over through face-to-face interviews by trained interviewers and self-completion questionnaire. The survey follows a multi-stage sampling technique to select households. In the sampling design each census collection district (CD) was divided into state and territory. Five populous states were further divided into metropolitan and non-metropolitan areas. The detailed description of the survey objectives, sampling design, and data collection procedure has been discussed elsewhere (Freidin et al., 2002).

This study utilized three waves of the HILDA survey that were conducted in 2009 (wave 9), 2013 (wave 13) and 2017 (wave 17). The main reason for selecting these waves is that the HILDA survey collected information on health services utilisation only in these three waves. The present study followed a complete case analysis. This study excluded missing information on the seven outcome variables and main exposure variables (i.e., body mass index [BMI] and multimorbidity). Following the exclusion criteria, this study constructed an unbalanced panel data set consisting of 41,073 person-year observations of 20,120 individuals.

Outcome measures

The primary outcome variable in this study is health service utilisation. The HILDA survey collects participants' health services utilisation through the health-specific questionnaire. This study considered seven different variables to evaluate health service utilization, namely: the number of doctor visits (family doctor/general practitioner visits); hospital doctor visits (outpatient or causality); specialized doctor visits (excluding outpatients or causality); mental health professional visits (during the last twelve months; yes or no); health check-ups or tests (yes or no); number of hospital admission (overnight stay); and number of nights stay in the hospital (total length of nights stay in hospital). The outcome variable, namely, hospital doctor visits, specialized doctor visits, mental health professional visits, and health check-ups or tests, were recorded in the binary form: yes or no, within the timeframe of the past 12 months. The other three outcome variables, namely number of doctor visits, number of hospital admissions and hospital stay, were measured in number, including zero.

Exposure variables

This study evaluates two health-related characteristics that served as the main variables of interest in the present study: obesity and multimorbidity. BMI was used to measure obesity. Self-reported height and weight were utilized to calculate an individual's BMI. BMI is measured through the formula of weight (in kilograms) divided by the square of height (in metres). This study further categorized BMI into four groups following the World Health

Organization (WHO) guidelines: underweight (BMI<18.50); healthy weight (BMI 18.50 to <25.00); overweight (BMI 25.00 to <30.00); and obesity (BMI ≥30) (World Health Organization (WHO), 2019).

Information on participants' chronic disease status was collected by asking: 'have you ever been told by a medical practitioner that you have been diagnosed with a serious illness or medical condition'? The HILDA survey considered 12 types of chronic diseases, such as: heart disease; circulatory disease; hypertension; type-1 diabetes; type-2 diabetes; asthma; bronchitis; arthritis; and cancer as the self-reported chronic conditions. Responses to the question were in binary form where 1 represents having the chronic disease and 0 for otherwise. This study measured multimorbidity by the presence of at least two of the nine studied chronic health conditions. The measurement scale was binary, where 1 stood for having multimorbidity and 0 stood for otherwise.

Assessment of other covariates

A wide range of covariates to adjust for factors that may be associated with health services utilization were considered following previous studies (Bertakis and Azari, 2005; Lehnert et al., 2016; Raffaele Palladino et al., 2016; Peytremann-Bridevaux and Santos-Eggimann, 2007; M.A. Raebel et al., 2004). Socio-demographic covariates include: age (15-25, 26-45, 46-60, and >60 years); gender (male and female); civil status (single, married/living together, and divorced/widow/separated); education (year 12 and below, professional qualifications, and university qualifications); household income quintile (quintile 1 [bottom] to 5 [top]); labour force status (employed, unemployed, and not in the labour force); indigenous status (non-indigenous and Aboriginal/Torres Strait Islander); and location (major city, regional city, and remote area). Health-related characteristics include: smoking status (no and yes); alcohol consumption (no and yes); physical activity (less than recommended level and recommended level); healthcare card (no and yes); and private health insurance (no and yes).

Statistical analysis

An unbalanced longitudinal data set consisting of 41,073 yearly observations from 20,120 de-identified individuals was constructed. To summarize the pooled characteristics of the study participants, descriptive statistics were represented through percentage (%) with 95% CI (in case of categorical variables) and mean with standard deviation (SD), median and range (in case of continuous variables). This study also presents the percentage of hospital doctor visits, specialized doctor visits, mental health professional visits, and health check-ups, or tests and mean doctor visits, hospital admission, and nights in hospital by BMI categories and multimorbidity.

This study deployed seven regression models to check the association between BMI and multimorbidity with health services utilization after adjusting for confounders. According to the nature of the outcome variables, this study employed negative binomial regression (model 1), generalized estimating equation (GEE) with logistic link function (models 2 to 5), and zero-inflated negative binomial regression model (models 6 to 7). This study employed the GEE technique with logistic link function to estimate the probability of hospital doctor visits, specialized doctor visits, mental health professional visits, and health check-ups or tests, if an individual has obesity and multimorbidity. The reason for employing the GEE technique is that data were correlated as an individual's observation may appear up to three times. GEE can potentially handle this issue better than the Generalized Linear Model (GLM) and estimate the parameters' population-averaged effects.

The study adopted the negative binomial regression technique to handle the count dependent variable (number of doctor visits). The negative binomial technique offers an accurate estimation between exposures and response if the outcome variable is of a count type and over-dispersed. For the other two outcome variables (the number of hospital admissions and the number of nights in hospital) this study fitted a Zero-Inflated Negative Binomial (ZINB) regression. ZINB is the extension of the standard negative binomial model designed for count response with excessive zeros. In the present study, the origin of zeros in the count responses (number of hospital admissions and number of nights in hospital) may be due to two mutually exclusive processes. Firstly, adults may be absent from hospital admission and night stays due to miscellaneous attitudes, conditions, or restrictions. Secondly, adults might be absent from hospital admission and night stay but could probably be admitted or stayed overnight in the hospital due to their poor health condition. The standard negative binomial model cannot distinguish between sources of these two distinct zeros because zeros may be inflated in the response (UCLA, 2019a). In the circumstances, the ZINB is the appropriate model for incorporating these two distinct data generation processes (UCLA, 2019a).

The study results (multivariate models) were presented in the form of incidence rate ratios (IRRs) and odds ratios (ORs) with 95% CIs. This study set the P-value at the <0.05 level for statistical significance. All analyses were performed using Stata version 16 (Stata Corp).

Results

Table 1 shows the pooled characteristics of 41,073 observations from 20,120 study participants regarding health services utilization, socio-demographic and health-related characteristics. Approximately 23% of the study participants were obese, and nearly 16% reported that they have multimorbidity. Regarding health services utilisation, the prevalence of hospital doctor, specialist doctor, and mental health professional visits were 18%, 31% and 8%, respectively. The prevalence of health check-ups or test in the past 12 months was around 73%. Further, the mean number of doctor visits, hospital admissions, and nights stay in hospital were 4.76 (SD, ±6.58), 0.20 (SD, ±0.77), and 0.90 (SD, ±5.79), including zero, respectively. A detailed description of the sample characteristics can be observed in Table 1.

Table 1: Background characteristics of study participants

Variables	n	% (95% CI)
Outcome Variable		
Number of doctor visits, Mean (SD)	41,073	4.76 (6.58), 5.57 (6.79) without 0; (median = 3, min = 0, max = 170)
Hospital doctor visits		
No	33,795	82.28 (81.91-82.65)
Yes	7,278	17.72 (17.35-18.09)
Specialist doctor visit		
No	28,380	69.1 (68.65-69.54)
Yes	12,693	30.9 (30.46-31.35)
Mental health professional visit		
No	37,932	92.35 (92.09-92.61)
Yes	3,141	7.65 (7.39-7.91)
Number of hospital admissions, Mean (SD)	41,073	0.20 (0.77), 1.54 (1.57) excluding 0; (median = 0, min = 0, max = 50)
Number of nights in hospital, Mean (SD)	41,073	0.90 (5.79), 6.92 (14.68) without 0; (median = 0, min = 0, max = 365)
Health check-ups or tests		
No	11,015	26.82 (26.39-27.25)
Yes	30,058	73.18 (72.75-73.61)
Explanatory Variables		
BMI		
Underweight	7,638	18.6 (18.22-18.98)
Healthy weight	13,602	33.12 (32.66-33.57)
Overweight	10,230	24.91 (24.49-25.33)
Obesity	9,603	23.38 (22.97-23.79)
Multimorbidity		
No	34,669	84.41 (84.05-84.76)
Yes	6,404	15.59 (15.24-15.95)
Socio-demographic characteristics		
Age		
15-25 years	7,638	18.6 (18.22-18.98)
26-45 years	13,602	33.12 (32.66-33.57)
46-60 years	10,230	24.91 (24.49-25.33)
>60 years	9,603	23.38 (22.97-23.79)

Gender		
Male	19,464	47.39 (46.91-47.87)
Female	21,609	52.61 (52.13-53.09)
Civil Status		
Single	9,325	22.7 (22.3-23.11)
Married/living together	24,696	60.13 (59.65-60.60)
Divorced/widow/separated	7,052	17.17 (16.81-17.54)
Education		
Year 12 and below	17,700	43.09 (42.62-43.57)
Professional qualifications	12,903	31.41 (30.97-31.87)
University qualifications	10,470	25.49 (25.07-25.91)
Household income quintile		
Quintile 1	8,215	20 (19.62-20.39)
Quintile 2	8,215	20 (19.62-20.39)
Quintile 3	8,214	20 (19.61-20.39)
Quintile 4	8,216	20 (19.62-20.39)
Quintile 5	8,213	20 (19.61-20.39)
Labour force status		
Employed	26,328	64.1 (63.64-64.56)
Unemployed	1,502	3.66 (3.48-3.84)
Not in the labour force	13,243	32.24 (31.79-32.7)
Indigenous status		
Non-indigenous	39,880	97.1 (96.93-97.25)
Aboriginal/Torres Strait Islander	1,193	2.9 (2.75-3.07)
Location		
Major city	27,239	66.32 (65.86-66.77)
Regional	13,227	32.2 (31.75-32.66)
Remote	607	1.48 (1.37-1.6)
Health-related behaviour		
Smoking status		
No	33,803	82.3 (81.93-82.67)
Yes	7,270	17.7 (17.33-18.07)
Alcohol consumption		
No	7,643	18.61 (18.23-18.99)
Yes	33,430	81.39 (81.01-81.77)
Physical activity		
Less than recommended level	26,872	65.42 (64.96-65.88)
Recommended level	14,201	34.58 (34.12-35.04)
Healthcare card		
No	36,883	89.8 (89.5-90.09)
Yes	4,190	10.2 (9.91-10.5)
Private health insurance		
No	17,587	89.8 (89.5-90.09)
Yes	23,486	10.2 (9.91-10.5)

Figure 1 displays the rate of health service utilisation in the form of hospital doctor visits, specialist doctor visits, mental health professional visits, and health check-ups or tests in the past 12 months by BMI categories and the presence of multimorbidity. As can be seen, health services utilisation increased with increasing BMI and having multimorbidity. The rates of hospital doctor visit (22%), specialist doctor visit (35%), and health check-ups or tests (80%) were highest among obese adults. Approximately 9% of obese adults consulted mental health professionals. Adults with multimorbidity also exhibited a higher rate of health services use in terms of hospital doctor visit (31%), specialist doctor visit (58%), mental health professional visit (8%), and health check-ups (97%).

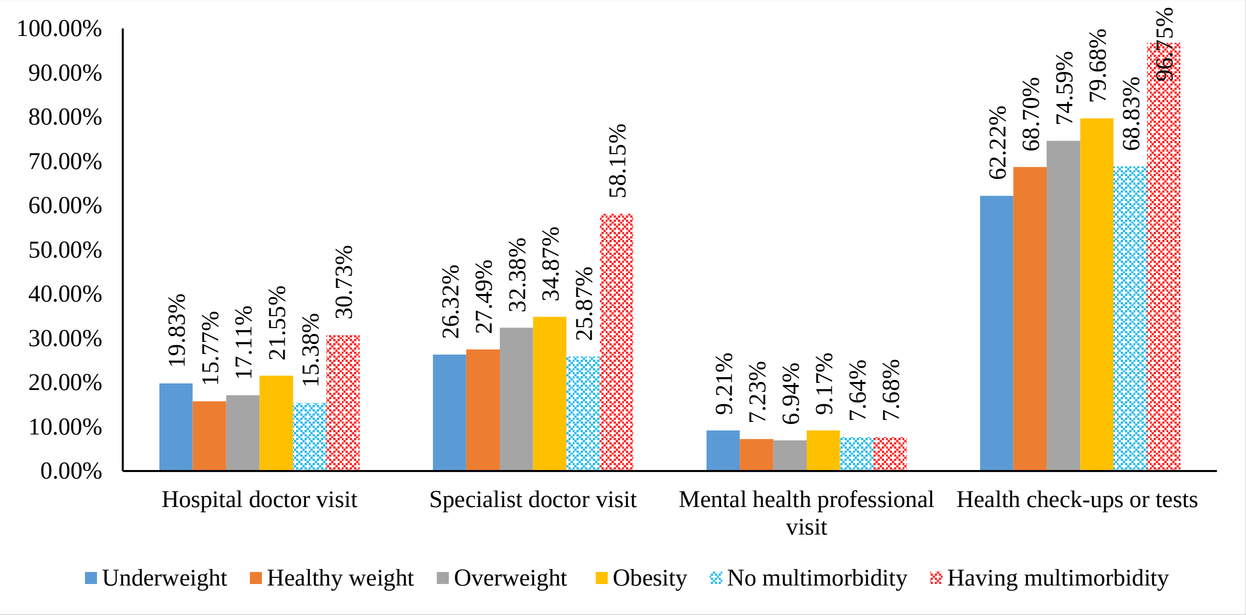

Figure 1: Rates of four types of selective healthcare utilization according to BMI and multimorbidity

Table 2: Rates of three types of health services utilization by weight status and multimorbidity

Health Status	Number of doctor visits, [mean (SD)]	Number of hospital admissions, [mean (SD)]	Number of nights in hospital, [mean (SD)]
Underweight	4.59 (6.93), 5.78 (7.32) excluding 0; (median = 3.0, min = 0, max = 90)	0.3 (1.92), 0.36 (2.15) excluding 0; (median = 0, min = 0, max = 50)	1.54 (10.8), 1.92 (12.08) excluding 0; (median = 0, min = 0, max = 250)
Healthy weight	4.07 (5.59); 4.86 (5.79) excluding 0; (median = 3.0, min = 0, max = 99)	0.17 (0.6), 0.19 (0.64) excluding 0; (median = 0, min = 0, max = 16)	0.82 (5.25), 0.93 (5.50) excluding 0; (median = 0, min = 0, max = 183)
Overweight	4.6 (6.38); 5.37 (6.59) excluding 0; (median = 3.0, min = 0, max = 170)	0.19 (0.72), 0.22 (0.77) excluding 0; (median = 0, min = 0, max = 33)	0.76 (4.81), 0.86 (5.16) excluding 0; (median = 0, min = 0, max = 279)
Obesity	6.15 (7.95); 6.93 (8.11) excluding 0; (median = 4.0, min = 0, max = 150)	0.26 (0.85), 0.29 (0.89) excluding 0; (median = 0, min = 0, max = 32)	1.18 (6.99), 1.30 (7.37) excluding 0; (median = 0, min = 0, max = 365)
No multimorbidity	3.91 (5.39), 4.70 (5.58) excluding 0; (median = 2.0, min = 0, max = 150)	0.15 (0.57), 0.17 (0.61) excluding 0; (median = 0, min = 0, max = 32)	0.57 (3.88), 0.65 (4.16) excluding 0; (median = 0, min = 0, max = 183)
Having multimorbidity	9.39 (9.75), 9.59 (9.76) excluding 0; (median = 6.0, min = 0, max = 170)	0.49 (1.39), 0.50 (1.39) excluding 0; (median = 0, min = 0, max = 50)	2.71 (11.39), 2.72 (11.35) excluding 0; (median = 0, min = 0, max = 365)

Table 3: Associated risk factors of health services utilisation

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	Number of doctor visits	Hospital doctor visits	Specialised doctor visits	Mental health professional	Health check-ups or tests	Hospital admissions	Nights stay in hospital
	IRR (95% CI)	OR (95% CI), No versus Yes	OR (95% CI), No versus Yes	OR (95% CI), No versus Yes	OR (95% CI), No versus Yes	IRR (95% CI)	IRR (95% CI)
BMI							
Underweight	0.99 (0.93-1.06), 0.79	1.13 (0.96-1.34), 0.13	1.06 (0.91-1.24), 0.46	0.93 (0.73-1.19), 0.58	0.89 (0.77-1.03), 0.13	2.08 (1.54-2.81), <0.001	1.37 (1.03-1.82), 0.03
Healthy weight (ref)							
Overweight	1.11 (1.08-1.13), <0.001	1.09 (1.02-1.16), 0.01	1.1 (1.04-1.16), 0.001	1.17 (1.06-1.29), 0.001	1.16 (1.09-1.23), <0.001	1.05 (0.93-1.17), 0.441	0.88 (0.79-0.97), 0.01
Obesity	1.26 (1.23-1.29), <0.001	1.24 (1.15-1.33), <0.001	1.13 (1.06-1.2), <0.001	1.34 (1.21-1.5), <0.001	1.34 (1.24-1.44), <0.001	1.21 (1.07-1.37), 0.002	1.04 (0.93-1.17), 0.50
Multimorbidity							
No (ref)							

Yes	1.92 (1.86-1.98), <0.001	2.16 (2.00-2.33), <0.001	2.58 (2.41-2.76), <0.001	1.40 (1.23-1.6), <0.001	5.17 (4.5-5.94), <0.001	2.33 (2.15-2.52), <0.001	1.58 (1.39-1.8), <0.001

Abbreviations: ref – reference category; Models (1 to 7) were adjusted for age, gender, civil status, education, household income quintile, labour force status, race, remoteness, smoking status, alcohol consumption, physical activity, healthcare card, and private health insurance.

Table 2 presents a comparison of the number of doctor visits, hospital admissions, and nights stay in the hospital (mean, SD, and median) by the four categories of BMI and the presence of multimorbidity. Results show that obese people and adults with multimorbidity had a higher mean number of health services usage. The average number of doctor visits, hospital admissions, and night stay in the hospital were 6.15, 0.26, and 1.18 for the obese adults, respectively. People with multimorbidity also utilized a higher mean number of healthcare services in the form of doctor visit (9.39), hospital admission (0.49) and night stay in the hospital (2.71).

Table 3 displays the adjusted association between BMI and multimorbidity with health services utilisation (hospital doctor visit, specialist doctor visit, mental health professional visit, health check-ups or test, number of doctor visit, hospital admission, and nights stay in the hospital) after adjusting for age, gender, civil status, education, household income quintile, labour force status, race, remoteness, smoking status, alcohol consumption, physical activity, healthcare card, and private health insurance. The results showed that obese and individuals with multimorbidity were more likely to utilize health services. As can be seen that rates of doctor visits were 1.26 (IRR: 1.26; 95% CI: 1.23-1.29) and 1.92 (IRR: 1.92; 95% CI: 1.86-1.98) times higher among obese and adults with multimorbidity compared to healthy weight and peers without multimorbidity, respectively (Model 1). The results also showed that obesity and multimorbidity were significantly associated with an increased odds of the hospital doctor visit, specialist doctor visit, mental health professionals visit and health check-ups (Models 2-5). Obese adults were 1.24 (OR: 1.24; 95% CI: 1.15-1.33), 1.13 (OR: 1.13; 95% CI: 1.06-1.20), 1.34 (OR: 1.34; 95% CI: 2.41-2.76), and 1.34 (OR: 1.34; 95% CI: 1.24-1.44) times highly likely visit hospital doctor, specialist doctor, mental health professionals and had health check-ups, respectively, than healthy-weight peers. Individuals with multimorbidity also had 2.16 (OR: 2.16; 95% CI: 2.00-2.33), 2.58 (OR: 2.58; 95% CI: 2.41-2.76), 1.40 (OR: 1.40; 95% CI: 2.41-2.76), and 5.17 (OR: 5.17; 95% CI: 4.5-5.94) greater rate of hospital doctor visit, specialized doctor visit, mental health professional visits, and health check-ups, respectively, compared with those reporting no multimorbidity.

The adjusted model (Model 6) found that the rates of hospital admissions were 1.21 (IRR: 1.21; 95% CI: 1.07-1.37) and 2.33 (IRR: 2.33; 95% CI: 2.15-2.52) times greater in obese and adults with multimorbidity, respectively, compared to their counterparts. The present study found that the rate of nights stay in hospital was 1.58 (IRR: 1.58; 95% CI: 1.39-1.8) times higher among adults with multimorbidity than peers without multimorbidity (Model 7). However, this study does not find evidence that an obese individual was more likely to spend nights in the hospital than non-obese peers (IRR: 1.04; 95% CI: 0.93-1.17).

Discussion

This population-based longitudinal study found that health services utilization is significantly higher among obese and adults with multimorbidity than their healthy weight peers and peers without multimorbidity. The present analyses found that the rate of doctor visits is higher among obese than healthy-weight peers. Our study corroborates previous findings that obese individuals have a higher frequency of doctor visits (Lynch et al., 2015; Maradit Kremers et al., 2014). Generally, obesity itself is a complex disorder, and if unchecked may increase visits to the doctor (Alley et al., 2012). The present study also shows that the likelihood of morbid conditions is associated with increased doctor visits and is in line with existing literature (Guh et al., 2009; Ng et al., 2020).

The results confirm that obese and individuals with multimorbidity have a higher frequency of specialized doctor visits, also substantiating previous findings (Lehnert et al., 2016; Marengoni et al., 2011). This study also reveals that obesity and multimorbidity were associated with elevated mental health professional visits compared with healthy weight and peers without multimorbidity. Previous studies also report that obesity and multimorbidity are associated with adverse health outcomes, worse psychological quality of life, increased mortality and higher mental health services utilization (Fortin et al., 2004; Perkins et al., 2004).

Further, the results showed that obesity and multimorbidity are significantly associated with higher number of health check-ups. This finding validates the results from the literature that obese and multimorbid patients have a higher likelihood of follow-up visits and diagnostic tests than the non-obese and peers without multimorbid conditions (Bertakis and Azari, 2005). One possible explanation is that physicians may request or more likely refer patients for laboratory and other health check-ups or tests if they have medical complications.

The results show that the mean number of hospital admissions are higher among obese and adults with multimorbidity. Previous studies conducted in Russia and India also found that number of hospitalizations increases among adults having multimorbidity (Lee et al., 2007;

Pati et al., 2014). The association between obesity and hospitalization are inconclusive. A past study infers that obesity is associated with higher hospital resource utilisation (M.A. Raebel et al., 2004). However, another study demonstrates no relationship between obesity and hospital service use (Bertakis and Azari, 2005).

The results showed that the likelihood of an overnight stay in hospital is positively associated with multimorbidity. The possible reason for this could be that patients with multimorbidity often have substantial complications and requires subsequent care that might impact the length of hospital stay substantially (R. Palladino et al., 2016). Unlike multimorbidity, no statistically significant relationship between obesity and night stays in hospital has been found. Previous studies also indicate that higher BMI does not necessitate intensive treatment modalities. Hence, patients with higher BMI have a shorter hospital stay than peers with healthy BMI (Hauck and Hollingsworth, 2010; Zizza et al., 2004). Contrary to this finding, two recent studies showed that obese individuals experienced longer hospital stay than healthy-weight persons (Lehnert et al., 2016; Marengoni et al., 2011).

The results of the present study augment the existing literature in numerous ways. Firstly, this research explores changes in the demand for a wide range of health services at different BMI levels and the presence of multimorbidity. Secondly, this study is based on a large population-based nationally representative sample of 41,073 Australian adults. This large sample size permits a greater generalization of results and leads to more precise and reliable conclusions being inferred. This study concludes that obesity and multimorbidity place a substantial burden on the utilisation of health services. This evidence might help to formulate new clinical guidelines to manage obese and multimorbid patients holistically.

This study acknowledges some potential limitations. First, the authors have examined the number of doctor visits, specialized and mental health professional visits, health check-ups or tests but not the visit costs. Second, the study results could be vulnerable due to self-reported bias because respondents are highly likely to underreport their weight and over report their height (Reidpath et al., 2002). Third, bias may also arise from self-reported multimorbidity and healthcare use measures, which may underestimate their prevalence, especially among older adults and persons from lower educational backgrounds. Fourth, analyses of this study are exclusively based on Australian data. Therefore, the results will be more relevant to those countries with a closer demographic and health profile to Australia and similar health service use patterns.

Conclusion

This study utilized three waves of the nationally representative HILDA survey data (2009-2017) to check the longitudinal association between obesity and multimorbidity with seven types of health services utilisation. The present study provides evidence that both obesity and multimorbidity were significantly associated with Australian adults' health services utilisation. The results showed that obese and adults with multimorbidity have more doctor visits, hospital doctor visits, specialized doctor visits, mental health professional visits, health check-ups or tests, and number of hospital admissions compared to their healthy weight peers and peers without multimorbidity. Obesity is a significant risk factor for disability and non-communicable diseases (type 2 diabetes, heart diseases, asthma, cancer, arthritis and depression) in Australian adults. Unless appropriate measures are framed and implemented to tackle the obesity epidemic, the prevalence of obesity and associated chronic conditions will rise, resulting in higher healthcare services utilisation and health expenditures. Therefore, this study recommends long-term health management with an emphasis on prevention to avoid this increasingly significant health burden of obesity on society.

Abbreviations

AOR	Adjusted Odds Ratio
BMI	Body Mass Index
HILDA	Household, Income and Labour Dynamics in Australia Survey
IRR	Incidence Rate Ratio
WHO	World Health Organization

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Contributors

SAK initiated the study, conducted the data analysis. SAK, SFBH, and NJS drafted the manuscript. KA, JG and SB offered advice, critical comments and edited the draft manuscript. All the authors read and approved the final manuscript.

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Competing interest

The authors declare that they have no conflicts of interest.

Ethics approval

This paper uses unit record data from Household, Income and Labour Dynamics in Australia Survey (HILDA) conducted by the Australian Government Department of Social Services (DSS). However, the findings and views reported in this paper are those of the authors and should not be attributed to the Australian Government, DSS, or any of DSS contractors or partners. DOI: 10.26193/OFRKRH, ADA Dataverse, V2."

This study did not require ethical approval as the analysis used only de-identified existing unit record data from the HILDA survey. However, the authors completed and signed the Confidentiality Deed Poll and sent it to NCLD (ncldresearch@dss.gov.au) and ADA (ada@anu.edu.au) before the data applications' approval. Therefore, the datasets analysed and/or generated during the current study are subject to the signed confidentiality deed.

Data availability statement

The data used for the study was collected from the Melbourne Institute of Applied Economic and Social Research. There are some restrictions on this data and it is not available to the public. Those interested in accessing this data should contact the Melbourne Institute of Applied Economic and Social Research, The University of Melbourne, VIC 3010, Australia.

CHAPTER 3: STUDY 4

Obesity, disability and self-perceived health outcomes in Australian adults: A longitudinal analysis using 14 annual waves of the HILDA cohort

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Abstract

Background

Both obesity and disability have been widely recognised as major public health challenges because they play significant roles in determining self-rated health and mental health. Longitudinal studies of the relationship between obesity and disability with self-reported health outcomes are scarce in Australia. Therefore, the objective of the present study was to examine the relationship between obesity and disability with self-reported overall health and mental health among Australian adults aged 15 years and above.

Methods

Data were extracted from the most recent 14 waves (waves 6 through 19) of the annual individual person dataset of the Household, Income and Labour Dynamics in Australia (HILDA) survey. Alongitudinal linear random-effects logistic regression model was adopted to investigate the relationships between obesity and disability with self-reported health outcomes.

Results

The results revealed that obese individuals and adults with some form of disability are more likely to report poor overall health and mental health. The odds of self-reporting overall poor or fair health were 2.40 and 6.07 times higher among obese (aOR: 2.40, 95% CI: 2.22-2.58) and adults with some form of disability (aOR: 6.07, 95% CI: 5.77-6.39), respectively, relative to the healthy weight and without disability counterparts. The results also showed that self-rated poor or fair mental health were 1.22 and 2.40 times higher among obese (aOR: 1.22, 95% CI: 1.15-1.30) and adults with disability (aOR: 2.40, 95% CI: 2.30-2.51), respectively, compared to their healthy weight peers and peers without disability.

Conclusion

As governmental and non-governmental organisations seek to improve the community's physical and mental well-being, these organisations need to pay particular attention to routine health care prevention, specific interventions, and treatment practices, especially for obese and/or people with disabilities.

Keywords: Obesity, disability, self-reported overall health, mental health, Australia

Introduction

Globally, the total number of obese women and men increased from 5 million in 1975 to 50 million in 2016, and from 6 million in 1975 to 74 million in 2016, respectively (World Health Organization, 2020a). This sharp rise in obesity is considered alarming as overweight and obesity were attributable to 4.7 million global deaths in 2017 (Lin et al., 2020). The Global Burden of Disease Study estimated that 147.7 million disability-adjusted life years (DALYs) of non-communicable diseases (NCDs) were accounted for by individuals with a high body mass index (BMI) in 2017. The study also projected that the DALYs of NCDs related to high BMI would be increased to 176.9 million by 2025 (Lin et al., 2020). Another recent global burden of disease study found that the burden of global deaths and DALYs related to high BMI has been doubled for both genders in the years between 1990-2017 (Dai et al., 2020).

The World Health Organization (WHO) estimated that up to 190 million people worldwide aged above 15-years experience some form of disability (World Health Organization, 2018). Likewise, the number of people affected by different NCDs has increased substantially. In 2016, it was estimated that about 72% of global deaths were due to NCDs, compared with 57% in 1990 (Naghavi et al., 2017). According to the latest National Health Surveys, 67% of Australian adults (aged more than 18 years) were either overweight or obese, and around 18% have some form of disability (Australian Institute of Health and Welfare, 2019e, 2018a). However, a recent study found that the overall prevalence of overweight and obesity among Australian adults (aged 15 years and over) climbed significantly from 55% to 60% between 2006 to 2019 (Keramat et al., 2021b). Besides, the prevalence of disability in Australian adults has risen from 26% (2006) to 29% (2019) (Keramat et al., 2021d). Furthermore, 47% of Australian adults have at least one of ten identified chronic diseases such as arthritis, asthma, cancer, cardiovascular disease, diabetes mellitus or mental health disorders, contributing to nearly 9 out of 10 national deaths in 2018 (Australian Institute of Health and Welfare, 2018a).

In the Global Action Plan for the Prevention and Control of NCDs 2013-2020, WHO has targeted reducing NCD induced premature mortality by 25% by 2025 (World Health Organization, 2013). To achieve this goal, reducing individual and community level exposure to NCDs' modifiable risk factors, such as overweight/obesity and disability, is essential (Lin et al., 2020).

Obesity has several adverse health consequences, including reduced life expectancy (Finkelstein et al., 2010; Vidra et al., 2019). One study found that higher BMI is associated with lower expected survival and is responsible for approximately 95 million years-of-life-lost(Finkelstein et al., 2010). Other studies have shown that obesity is a significant risk factor for increased morbidity and mortality linked to chronic diseases, including cardiovascular diseases (CVDs), diabetes, cancer, osteoarthritis, liver and kidney disease, sleep apnea, and depression (Hruby and Hu, 2015; Pi-Sunyer, 2009). Like obesity, people with disabilities experience health-related problems such as compromised functional ability, pain or fatigue, and inactivity. Moreover, persons with a disability often have restrictions in participating in work and intimate relationships and may perceive poor health-related quality of life (Roebroeck et al., 2009). Apart from these, there is evidence that obesity is associated higher likelihood of disability in Australian adults (Keramat et al., 2021d). Due to the extent of obesity and disability among Australians, it is warranted to understand the role of obesity and disability in determining their self-perceived overall health and mental health status.

Previous studies have not incorporated both self-reported overall health and mental health status while determining its relationships with obesity and disability. Further, earlier studies have been mainly cross-sectional, had a small sample size, and focused primarily on older people, lacking generalizability. This situation constitutes a significant literature gap. Therefore, this study investigates the relationship between obesity and disability with self-reported physical and mental health status following a retrospective longitudinal study design.

Methods

Data source

The data for the present analyses were extracted from the individual person datasets of the Household, Income and Labour Dynamics in Australia (HILDA) survey. The HILDA survey is a nationally representative large-scale panel study that collects detailed information on individual characteristics, social, economic and personal well-being, labour market activities, family life, and health status. The survey commenced in 2001, and since then, has collected data every year from household members aged 15 years and over through face-to-face interviews, telephone interviews by trained interviewers and self-completed questionnaires (SCQ), following the University of Melbourne's ethical guidelines. The sampling unit in the HILDA survey is the household, wherein adult household members are tracked each year. The study samples are generated following the multi-stage sampling design. The methodology utilised in the HILDA survey to select the sample and collect data has been outlined elsewhere (Freidin et al., 2002).

Analytic sample and missing data

This present study followed a retrospective longitudinal research design and analysed the data utilising the most recent 14 waves (waves 6 through 19) of the HILDA survey spanning from 2006 to 2019. The principal reason for selecting these waves is that data on the key variable of interest (body mass index) is available only in these waves. Figure 1 displays the process of obtaining the analytic sample. The final analytic sample is restricted to those respondents with no missing information on the key outcome (self-assessed health and mental health) and primary exposure (BMI and disability) variables. Within the eligible participants, it is noted that 1.91% of persons had missing information on mental health or BMI or disability and were therefore excluded (figure 1). The final sample comprises 186,723 yearly observations from 26,104 unique participants.

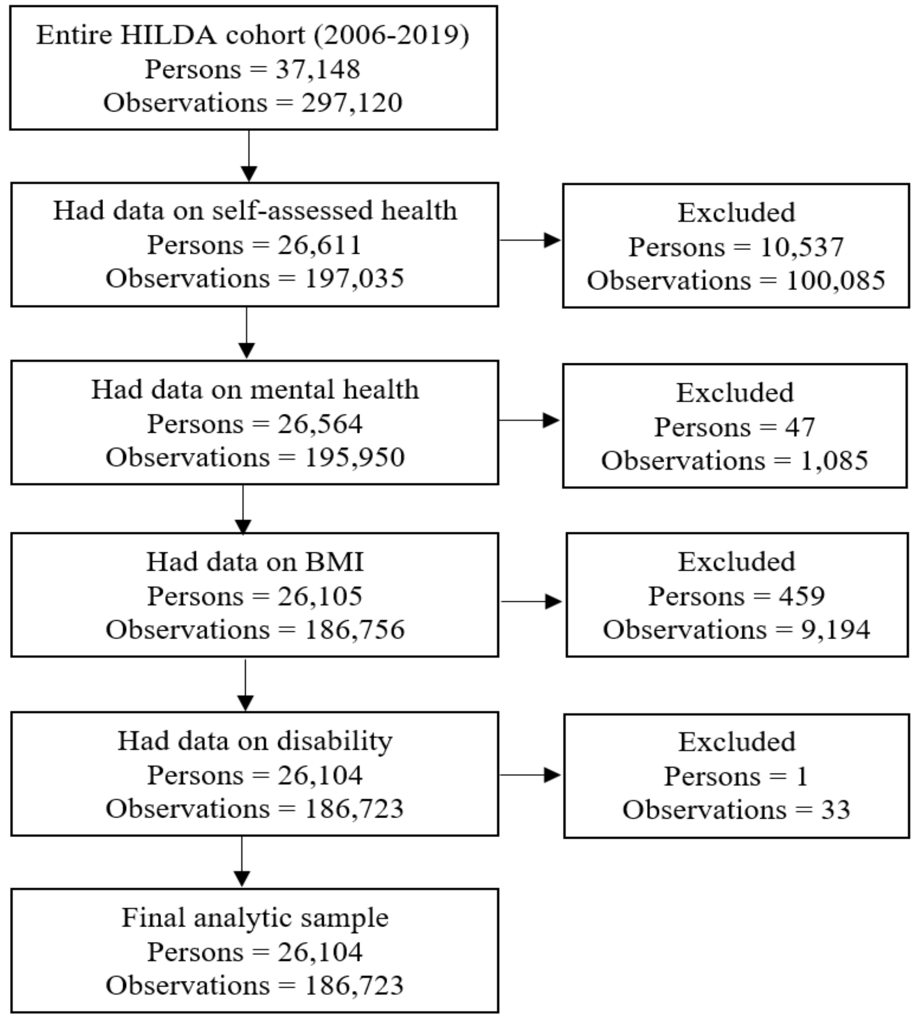

Figure 1: Flow chart of sample selection and missing data

Outcome Variables

This study's primary outcome variable is health outcome, operationally defined as self-assessed health and mental health. These variables were derived from the HILDA survey, which accumulates a wide range of individual-level health-related data, including their self-reported health status and mental condition. The HILDA survey captures the respondents' self-reported health status by asking, 'in general, would you say your health is?' The responses were coded on 1 to 5 scale: excellent (1), very good (2), good (3), fair (4), and poor (5). This study further dichotomised this measure into good or better health (excellent, very good and good) and poor or fair health (poor and fair) following a previous study (Brucker, 2017).

Mental health in the HILDA survey was assessed in every wave through the five-item mental health inventory (MHI-5) scale, one of the eight dimensions of the short form 36 (SF-36) health survey. The MHI-5 scale includes five items asking the respondents how often they have been nervous, felt downhearted, felt calm and peaceful, felt so down in the dumps that nothing could cheer them up, and been happy, in the past four weeks (Hashmi et al., 2020). The responses to each item were on a 1 to 6 scale, wherein 1, 2, 3, 4, 5 and 6 represent 'all of the time', 'most of the time', 'a good bit of the time', 'some of the time', 'a little of the time', and 'none of the time', respectively. The sum of all responses across each item lies between scores of 5 to 30. This score was further rescaled into a 0 to 100 mental health score by subtracting five and multiplying by four. The lowest score 0 represents 'worst possible mental health', and 100 represents 'best possible mental health'. To define a person mental health state, this study collapsed the MHI-5 score into two levels: good or better mental health (equal or above 60 MHI-5 scores) and poor or fair mental health (below 60 MHI-5 scores) following an established cut-off point (Kelly et al., 2008).

Exposure Variables

The key explanatory variables of interest in this study were obesity (measured through BMI) and disability. The HILDA survey calculates the respondent's BMI by utilising their self-reported weight and height following the formula weight (in kilograms) divided by height (in metres) square. This study collapsed BMI into four levels following World Health Organization (WHO) guidelines: underweight (BMI <18.50), healthy weight (BMI 18.50 to 24.99), overweight (BMI 25 to <30), and obese (BMI ≥30.00) (World Health Organization, 2020a).

The HILDA survey collects information on the disability status of the participants in every wave through personal interviews following the International Classification of Functioning, Disability and Health (ICF) under the WHO framework guidelines (LaMontagne et al., 2016). Disability status was assessed using the question, 'do you have any long-term health conditions, impairment or disability that restricts your everyday activities, and has lasted or are likely to last for six months or more'. To define a person's disability status, the survey provided 17 categories of disabilities, such as hearing problems, speech problems, difficulty in learning or understanding things, limited use of arms or fingers and limited use of feet or legs to check if they have any of these conditions. The responses were coded as yes or no. Participants who replied 'yes' to the question mentioned above were defined as an individual with long-term health problems or disability.

Other Covariates

This study included a range of covariates based on the previous literature and information available in the HILDA dataset to account for potential confounders in the multivariable regression models (Brucker, 2017; Imai et al., 2008; Lee et al., 2015). The covariates included age, gender, civil status, education, equivalized household income, labour force status, indigenous status, location, smoking status, alcohol consumption, and physical activity.

The variable age was initially collected as a continuous variable, and this study categorised age into four groups: <30, 30 to 44, 45 to 59, and 60 and over years. Gender is a dichotomous variable (male and female). Respondents' civil status was reported in six categories; however, this was collapsed into two categories: cohabitating (married, and never married but living with someone in a relationship) and non-cohabitating (separated but not divorced, divorced, widowed, and never married and not living with someone in a relationship). The respondents' education status comprises seven categories: postgraduate- masters or doctorate, graduate diploma or certificate, bachelor or honours, advance diploma or diploma, certificate III or IV, year 12, and Year 11 and below. For the present statistical analysis, this was collapsed into three categories: year 12 and below (year 12, and Year 11 and below), professional qualifications (advance diploma or diploma, and certificate III or IV) and university qualifications (postgraduate- masters or doctorate, graduate diploma or certificate, bachelor or honours). The construction of most of the studied variables is straightforward except household yearly disposable income. The income variable was converted into equivalised household disposable income through the 'modified OECD' equivalence scale. The formula for measuring equivalised household income is following.

$$\text{Equivalised household income} = \frac{\text{Household yearly disposable income}}{(1 \times \text{first adult}) + (0.5 \times \text{every other adult}) + (0.3 \times \text{every child})}$$

This study further categorised equivalised household income into quintiles (quintiles 1 and 5, indicating the lowest and highest family income quintiles, respectively).

Respondents current labour force status was categorised into three levels (employed, unemployed and not in the labour force). Indigenous status was classified as non-indigenous, and Aboriginal/Torres Strait Islander (ATSI) or both. The location included in the HILDA survey was categorised into five groups, but this study coded it into three levels: major city, regional (inner and outer regional) and remote (remote and very remote). For the present study, a summary measure with smoking status (never smoke, a former smoker and current smoker), alcohol consumption (non-drinker, ex-drinker, only rarely to 3 days/week and 3+ days/week), physical activity (not at all to <1/week, 1-3 times/week and ≥ 4 times/week) were coded.

Analytic strategy

The characteristics of the study sample were outlined by the descriptive statistics in the form of frequency (n) and percentages (%) with 95% confidence intervals (CIs). A 2-step modelling approach (bivariate and multivariable regression) was followed to identify the relationships between obesity and disability with health outcomes. A confounder was included in the fully adjusted model only when it was found significant at 5% or less risk level in the bivariate analyses. Four separate regression models were fitted to test the relationships between obesity and disability with self-perceived health outcomes. Model 1 and 3 display the results obtained from bivariate regression. In models 2 and 4, self-reported health (model 2) and mental health status (model 4) were regressed by obesity and disability adjusting for cofounders.

This study fitted the random-effects longitudinal regression model to check the association between self-perceived health outcomes (self-assessed health and mental health condition) and obesity and disability. The random-effects regression model is often applied to longitudinal data to measure the effects of variables that change over time (e.g., obesity and disability) and the fixed characteristics of an individual (e.g., gender). This model provides an estimate of between-person effects. The key assumption of the random-effects model is that the variation between individuals is supposed to be random and not associated with the covariates included in the model.

The current analyses reported the multivariable regression results through adjusted odds ratios (aORs) with 95% CIs. This study evaluated all multivariable models at a 95% significance level ($P < 0.05$). All statistical analyses were carried out using Stata v16.

Results

Table 1 displays the pooled characteristics of the study participants, as well as their first and last, contributed waves. It reports self-assessed overall health, self-rated mental health, obesity, and disability status of Australian adults, along with socio-economic and lifestyle characteristics of the 186,723 person-year observations. The proportion of reporting poor or fair overall health (ranged from nearly 17% to 18%) and mental health (ranged from approximately 22% to 25%) was similar at baseline, final, pooled in all waves. Table 1 also demonstrates that almost 21% to 27% of participants were obese and about 26% to 29% have some form of disability at baseline, final, pooled in all waves. Of the total, there was an equal distribution in all age groups, more than half were female (53%), almost 40% were non-cohabitating, approximately one-fourth have university qualifications (25%), nearly two-thirds were employed (64%), most were not of indigenous origin (97%), lived in major cities (66%), 18% were current smoker, 27% drunk alcohol over three days a week, and 27% do not perform physical activity (pooled in all waves).

Table 1: Distribution of the analytic sample: Baseline, final and pooled across all waves (person = 26,104, observation = 186,723)

Characteristics	Baseline wave (2006)		Final wave (2019)		Pooled in all waves (2006 to 2019)	
	n	%	n	%	n	%
Outcome variables						
Self-reported health						
Good or better health	8,902	83.04	12,526	81.77	155,226	83.13
Poor or fair	1,818	16.96	2,792	18.23	31,497	16.87
Mental health						
Good or better health	8,383	78.20	11,413	74.51	144,790	77.54
Poor or fair	2,337	21.80	3,905	25.49	41,933	22.46
Exposures and covariates						
BMI						
Underweight	339	3.16	352	2.30	4,875	2.61
Healthy weight	4,569	42.62	5,627	36.73	73,753	39.50
Overweight	3,597	33.55	5,199	33.94	63,698	34.11
Obesity	2,215	20.66	4,140	27.03	44,397	23.78
Disability						
No	7,896	73.66	10,843	70.79	134,633	72.10
Yes	2,824	26.34	4,475	29.21	52,090	27.90
Age						
< 30 years	2,655	24.77	3,717	24.27	47,503	25.44
30-44 years	3,017	28.14	3,760	24.55	46,093	24.69
45-59 years	2,745	25.61	3,616	23.61	47,019	25.18
≥ 60 years	2,303	21.48	4,225	27.58	46,108	24.69
Gender						
Male	5,076	47.35	7,273	47.48	88,336	47.31
Female	5,644	52.65	8,045	52.52	98,387	52.69
Civil Status						
Cohabitating	6,382	59.53	9,239	60.31	112,302	60.14
Non-Cohabitating	4,338	40.47	6,079	39.69	74,421	39.86
Education						
Year 12 and below	5,409	50.46	5,841	38.13	81,235	43.51
Professional qualifications	3,011	28.09	5,091	33.24	58,131	31.13
University qualifications	2,300	21.46	4,386	28.63	47,357	25.36
Household yearly disposable income quintile						
Quintile 1 (lowest)	2,144	20.00	3,064	20.00	37,347	20.00
Quintile 2	2,145	20.01	3,067	20.02	37,343	20.00

Quintile 3	2,143	19.99	3,060	19.98	37,346	20.00
Quintile 4	2,145	20.01	3,064	20.00	37,343	20.00
Quintile 5 (highest)	2,143	19.99	3,063	20.00	37,344	20.00
Labour force status						
Employed	7,014	65.43	9,826	64.15	120,224	64.39
Unemployed	337	3.14	574	3.75	6,709	3.59
Not in the labour force	3,369	31.43	4,918	32.11	59,790	32.02
Indigenous status						
Non-indigenous	10,476	97.72	14,753	96.31	181,283	97.09
Aboriginal or Torres Strait Islander	244	2.28	565	3.69	5,440	2.91
Location						
Major city	6,885	64.23	10,154	66.29	123,698	66.25
Regional	3,664	34.18	4,970	32.45	60,369	32.33
Remote	171	1.60	194	1.27	2,656	1.42
Smoking status						
Never smoked	5,559	51.86	8,681	56.67	101,588	54.41
Ex-smoker	2,926	27.29	4,194	27.38	51,472	27.57
Current smoker	2,235	20.85	2,443	15.95	33,663	18.03
Alcohol consumption						
Never drank	1,112	10.37	1,703	11.12	20,151	10.79
Ex-drinker	690	6.44	1,390	9.07	14,686	7.87
Only rarely to 3 days/week	5,704	53.21	8,439	55.09	101,720	54.48
3+ days/week	3,214	29.98	3,786	24.72	50,166	26.87
Physical activity (≥ 30 minutes)						
Not at all to <1/week	2,717	25.35	4,299	28.07	50,076	26.82
1-3 times/week	4,305	40.16	5,841	38.13	73,597	39.42
≥4 times/week	3,698	34.50	5,178	33.80	63,050	33.77

Table 2 shows the prevalence of self-reported poor or fair health and mental health status by age and gender at four different time points (2006, 2011, 2015 and 2019). The results show that self-reported poor or fair health prevalence increased with ageing and was higher among females. For example, in 2019, the prevalence of poor or fair health among females aged < 30 and over 60 years were nearly 11% and 31%, respectively. However, poor or fair mental health prevalence was found highest amongst young females than their older counterparts. For example, in 2019, the highest and lowest prevalence of poor or fair mental health among females aged < 30 and over 60 years were 37% and 22%, respectively.

Table 2: Self-perceived poor or fair health outcomes by age and gender at four different periods

Year	**Age**	**< 30 years**		**30-44 years**		**45-59 years**		**60 and over years**	
	Gender	**Poor Health**	**Poor mental health**	**Poor health**	**Poor mental health**	**Poor health**	**Poor mental health**	**Poor health**	**Poor mental health**
2006	Male	6.48	20.08	12.46	20.54	18.25	20.14	31.43	17.83
	Female	9.54	26.69	11.96	24.05	18.82	23.54	31.60	19.75
2011	Male	6.09	19.50	9.82	21.14	17.35	21.17	30.73	16.68
	Female	8.73	22.69	11.60	23.89	19.81	24.61	27.60	19.34
2015	Male	7.93	23.21	12.04	22.17	18.41	20.32	30.05	17.30
	Female	9.05	30.20	11.70	24.73	19.59	24.29	29.76	19.42
2019	Male	8.27	26.34	11.65	25.32	19.68	22.85	29.65	17.78
	Female	11.11	36.81	13.01	28.29	18.28	25.51	30.90	21.71

The study participants' distribution of self-reported fair or poor health and mental health by weight status is displayed in Figure 2. The highest prevalence of self-reported poor or fair health was recorded in obese individuals (27.71%). The figure also shows that over one-fourth of the obese adults (27.18%) had poor or fair mental health.

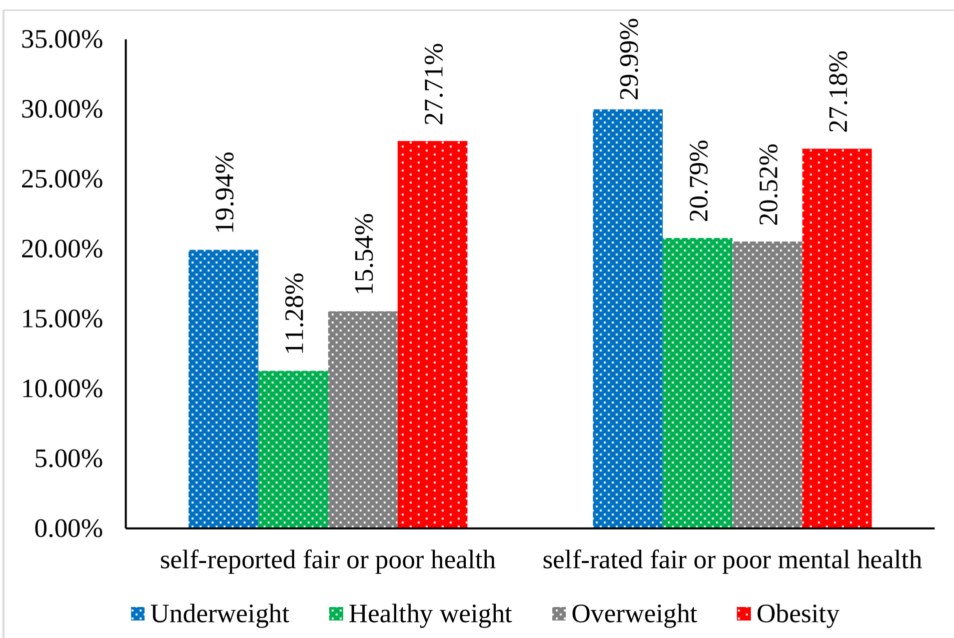

Figure 2: Distribution of the self-assessed fair or poor health outcomes by weight status, 26,104 persons, 186,723 observations, 2006 to 2019

Figure 3 presents the distribution of self-assessed poor or fair health and mental health status among the study participants according to their disability status. The prevalence of both self-reported poor or fair health and mental health were found highest among the participants with some forms of disability. Over one-third of the adults with a disability (43%) reported poor or fair health (figure 3). The figure also depicts that self-reported poor or fair mental health among adults with a disability was 36%.

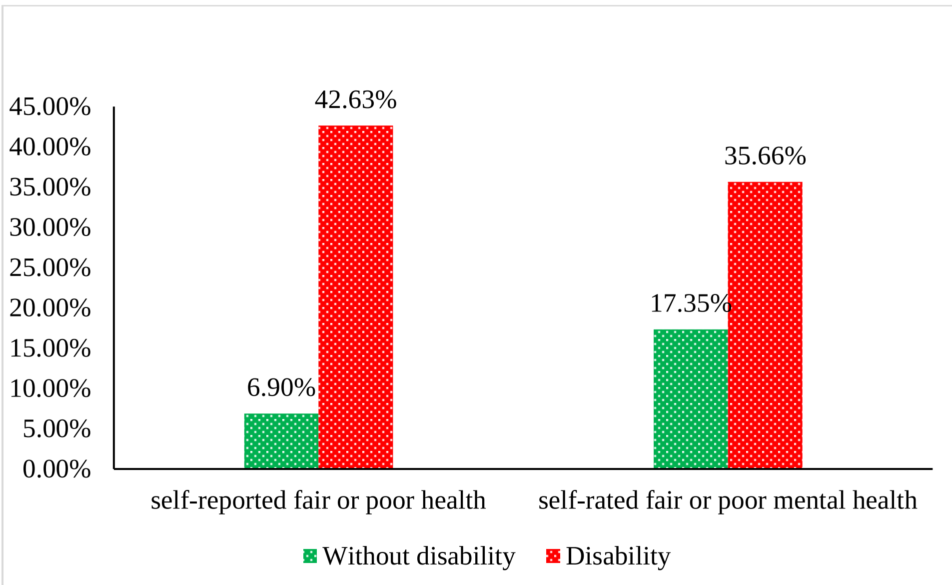

Figure 3: Distribution of the self-assessed fair or poor health outcomes by disability status, 26,104 persons, 186,723 observations, 2006 to 2019

Table 3 reports the statistical association between obesity and disability with health outcomes derived from bivariate and multivariable random-effects regression models. The bivariate regression results showed that being obese (OR: 3.36, 95% CI: 3.11-3.63) and having a disability (OR: 8.79, 95% CI: 8.35-9.25) were associated with higher odds of reporting poor or fair health (model 1). The bivariate association also indicates that the odds of self-reported fair or poor mental health were 1.32 and 2.47 times higher among obese (OR: 1.32, 95% CI: 1.24-1.41) and participants with disability (OR: 2.47, 95% CI: 2.36-2.58) (model 3).

The multivariable models explore the association between health outcomes with obesity and disability after adjusting for confounders (models 2 and 4). The odds of self-reporting poor or fair health were 2.40 and 6.07 times higher among obese (aOR: 2.40, 95% CI: 2.22-2.58) and adults with disability (aOR: 6.07, 95% CI: 5.77-6.39) relative to a healthy weight and without disability counterparts, respectively (model 2). Similar results were also observed for self-rated poor mental health status revealed from the multivariable model 4. The probability of self-reporting poor or fair mental health were 1.22 and 2.40 times higher among obese (aOR: 1.22, 95% CI: 1.15-1.30) and individuals with a disability (aOR: 2.40, 95% CI: 2.30-2.51) compared to a healthy weight and non-disabled counterparts, respectively.

Table 3: Unadjusted and adjusted random-effect regression results for the between-person difference in self-perceived health outcomes due to obesity and disability, 26,104 persons, 186,723 observations, 2006 to 2019

Exposures and other covariates	Model 1[a]	Model 2[b]	Model 3[c]	Model 4[d]
	Poor or fair versus good or better health	Poor or fair versus good or better health	Poor or fair versus good or better mental health	Poor or fair versus good or better mental health
	OR (95% CI), P value	aOR (95% CI), P value	OR (95% CI), P value	aOR (95% CI), P value
BMI				
Underweight	**1.64 (1.41-1.89), <0.001**	**1.62 (1.40-1.87), <0.001**	**1.39 (1.24-1.55), <0.001**	**1.20 (1.08-1.34), 0.001**
Healthy weight (ref)				
Overweight	**1.46 (1.37-1.56), <0.001**	**1.24 (1.16-1.32), <0.001**	0.98 (0.93-1.03), 0.45	1.00 (0.95-1.05), 0.91
Obesity	**3.36 (3.11-3.63), <0.001**	**2.40 (2.22-2.58), <0.001**	**1.32 (1.24-1.41), <0.001**	**1.22 (1.15-1.30), <0.001**
Disability				
No (ref)				
Yes	**8.79 (8.35-9.25), <0.001**	**6.07 (5.77-6.39), <0.001**	**2.47 (2.36-2.58), <0.001**	**2.40 (2.30-2.51), <0.001**

[a and c] Model 1 and 3: Unadjusted

[b and d] Model 2 and 4: Adjusted for age, gender, civil status, education, household yearly disposable income, labour force status, indigenous status, location, smoking status, alcohol consumption, and physical activity

Abbreviations: AOR, Adjusted Odds Ratio; ref, reference.

Values in bold are statistically significant.

Discussion

This study investigated the association between obesity and disability with self-reported health outcomes among Australian adults over 14 years from 2006 to 2019. Among Australian adults, around 24% were obese, and almost 28% suffered from some form of disability. The study also found that 17% of Australian adults reported poor or fair overall health and 23% had poor or fair mental health. This study revealed two significant findings. Firstly, the present analysis showed that obesity is significantly associated with self-rated poor health and mental health status. This finding is supported by the literature claiming that a statistically significant association exists between obesity and poor health outcomes (Hellgren et al., 2019; Herman et al., 2013; Imai et al., 2008; Lee et al., 2015; Lim et al., 2007; Micciolo et al., 2013). However, few studies revealed a weak association between obesity and self-reported poor health (Kepka et al., 2007; Macmillan et al., 2011). The possible reason might be that obese adults were more susceptible to comorbid chronic diseases that made themselves rate their health less positively. Besides, obese adults may have higher exposure to the healthcare system that rationally enables them to assess their health (Cullinan and Gillespie, 2016). Additionally, the growing stigma associated with obesity worldwide may cause ill-feeling towards obese respondents resulting in self-reported poor mental health (Noh et al., 2017).

Secondly, the present study found that adults with a disability were more likely to report elevated poor self-rated physical and mental health than adults without a disability. This finding is consistent with previous studies that show disability is consistently associated with increased poorer physical and mental health status (Alonso et al., 2013; Brucker, 2017; Hoeymans et al., 1999). There were several dimensions found in the literature that compelled disabled adults to report poor health status. For example, the social function dimension of disabilities was found to be a significant determinant of poor self-rated health conditions among heart failure patients (Carlson et al., 2013). Besides, evidence shows that the physical ability dimension is associated with elevated poor physical health among people with spinal cord injury (Machacova et al., 2011). Further, depression and embarrassment were the crucial dimensions of disabilities that caused self-reporting of elevated poor mental health (Buist-Bouwman et al., 2008). Furthermore, the mobility dimension contributed to the lower self-rated health and mental health conditions (Alonso et al., 2011; Garin et al., 2010). Moreover, family burden and stigma dimensions have been significantly associated with poor self-rated health status (Alonso et al., 2013).

This study's findings provide several policy insights for improving Australian adults' perceptions toward achieving better health status. For instance, employment in old age and promoting healthy behaviours might be suitable interventions to reduce self-reported poor health among obese people (Khalaila, 2017). Interventions for reducing the dimension specific burden might be helpful to improve health status. For example, there is evidence that physical exercise-related therapeutic interventions in breast cancer survivors increased physical mobility dimension and resulted in better self-rated health (Schootman et al., 2012). Moreover, therapeutic interventions for combating disability induced stigma and family burden dimensions were found to be effective for improving self-rated physical and mental health (Alonso et al., 2013; Buist-Bouwman et al., 2008).

This study features several important innovations. First, to the best of the authors' knowledge, this is the first study that examined the longitudinal association between obesity and disability with self-rated health and mental health in the Australian context by pooling a nationally representative 14-year longitudinal data of adults. Second, the study included many confounding variables, such as health risk behaviour (i.e. smoking status, alcohol consumption, and physical activity) to avoid spurious association. Third, this study used longitudinal random-effects regression model to capture the differences in self-perceived health outcomes between individuals associated with obesity and disability.

Despite having these strengths, this study also has some limitations. First, this study used self-reported data, which might result in self-reported bias and consequentially over/underestimate the study's findings. Further, the study used existing measures from the HILDA study and could not include variables that might be more relevant to estimate self-reported poor health and mental health in adults. Lastly, the unbalanced longitudinal study design restricts interpreting direct causal associations between outcomes and main variables of interest.

Conclusion

The present study revealed that almost 17% of Australian adults self-reported poor physical health, and nearly 23% self-reported poor mental health. The study also revealed that both obesity and disability were strongly associated with self-reported poor health outcomes. Unsurprisingly, the current study indicated that obese adults with a disability were more likely to report poor health and mental health outcomes compared to a healthy weight and non-disabled counterparts, respectively. Exploring the longitudinal association between obesity and disability with health outcomes might help policymakers improve the community's physical and mental well-being. This study suggested that routine health care prevention, specific intervention and treatment practices need to pay particular attention to the obese and adults with some form of disability.

Abbreviations

AOR	Adjusted Odds Ratio
BMI	Body Mass Index
HILDA	Household, Income and Labour Dynamics in Australia Survey
MHI-5	Mental Health Inventory-5
SF-36	36-Item Short-Form Health Survey
WHO	World Health Organization

Authors' contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Ethics approval

This paper uses unit record data from the Household, Income and Labour Dynamics in Australia Survey (HILDA) conducted by the Australian Government Department of Social Services (DSS). However, the findings and views reported in this paper are those of the authors and should not be attributed to the Australian Government, DSS, or any of DSS contractors or partners. DOI: 10.26193/OFRKRH, ADA Dataverse, V2."

This study did not require ethical approval as the analysis used only de-identified existing unit record data from the HILDA survey. However, the authors completed and signed the Confidentiality Deed Poll and sent it to NCLD (ncldresearch@dss.gov.au) and ADA (ada@anu.edu.au) before the data applications' approval. Therefore, the datasets analysed and/or generated during the current study are subject to the signed confidentiality deed.

Conflict of interest

The authors declare that they have no conflicts of interest.

Availability of data and materials

The data used for the study was collected from the Melbourne Institute of Applied Economic and Social Research. There are some restrictions on this data, and it is not available to the public. Those interested in accessing this data should contact the Melbourne Institute of Applied Economic and Social Research, The University of Melbourne, VIC 3010, Australia.

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CHAPTER 3: STUDY 5

Comorbid chronic diseases and health-related quality of life in the obese population: New insights from Australian longitudinal data

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Abstract

Objective

This study aims to examine the relationship between nine comorbid chronic conditions and HRQoL separately, along with the number of chronic diseases among the Australian obese population.

Methods

Data for this study were sourced from three waves (waves 9, 13 and 17) of the Household, Income and Labour Dynamics in Australia (HILDA) survey. The paper studies 9,444 person-year observations from 5,524 individuals over the years 2009, 2013, and 2017. The outcome variable of HRQoL was measured through the 36-Item Short Form Health Survey (SF-36), and the main variables of interest were nine chronic conditions and the number of chronic diseases. Generalized estimating equations (GEE) were used to test the association between comorbid chronic diseases and HRQoL.

Results

This study found a negative relationship between the number of comorbid chronic conditions and sub-scale, summary measures, and health utility index of the SF-36. Obese adults with 1, 2, 3, and 3+ comorbid chronic diseases scored lower points on the SF-36 physical component summary (b = -2.83, b = -7.37, b = -11.15, b = -14.29, respectively), mental component summary (b = -1.46, b = -2.34, b = -3.66, and b = -6.34, respectively), and in the short-form six-dimension utility index (SF-6D) scale (b = -0.030, b = -0.063, b = -0.099, and b = -0.138, respectively) compared to obese peers without comorbid chronic diseases. The number of chronic conditions was associated with reductions in the score of all eight dimensions of the SF-36. Obese people with any of the nine studied comorbid chronic diseases (heart disease, circulatory disease, hypertension, type 1 diabetes, type 2 diabetes, asthma, bronchitis, arthritis, and cancer) were associated with lower HRQoL compared to peers without that particular comorbid chronic disease.

Conclusion

Comorbid chronic diseases in obese individuals are associated with lower HRQoL. Increasing the number of comorbid chronic conditions is associated with a further reduction in all dimensions and summary measures of the SF-36. The findings, therefore, call for improved

holistic management of obesity and interventions to reduce obesity-related comorbidities to improve HRQoL of obese Australian.

Keywords: Comorbid chronic diseases, HRQoL, PCS, MCS, SF-6D, Australia, HILDA

Introduction

Overweight and obesity are rapidly growing public health problems affecting many countries worldwide. Among the adult population, in 2016, more than 1.9 billion adults were overweight globally, of which 650 million were obese (World Health Organization, 2020a). In Australia, obesity has increased from 18.5% to 27.9% between 1995 and 2015 (Hayes et al., 2017). Two-thirds (67%, 12.5 million) of Australian adults were either overweight or obese in 2017-18 (Australian Bureau of Statistics, 2018a), and adult obesity prevalence was projected to increase from 19% in 1995 to 35% by 2025 (Hayes et al., 2017).

Quality of life broadly refers to the extent to which an individual can function successfully in daily life and their perceived well-being across physical, emotional, and social structures (Klassen et al., 2017; Perales et al., 2014). Obesity is associated with increased comorbidity, mortality and reduced health-related quality of life (HRQoL) (Busutil et al., 2017; Kortt and Dollery, 2011; Schelbert, 2009; Ul-Haq et al., 2012; Zhu et al., 2015). The health burden among individuals with raised body mass index (BMI) is becoming concerning, especially in those with co-occurring chronic conditions (Guh et al., 2009; Schienkiewitz et al., 2012). The relationship between BMI and HRQoL has been investigated in several population-based studies and have confirmed a negative association between BMI and self-perceived quality of life, with a higher risk of poorer HRQoL in overweight and obese persons (Audureau et al., 2016; Busutil et al., 2017; Jia and Lubetkin, 2005; Kolotkin et al., 2001; Renzaho et al., 2010; Song et al., 2015). Further, obese persons report pain which has been considered the most significant impairment to HRQoL (Audureau et al., 2016; Kolotkin et al., 2001; Kortt and Clarke, 2005). Moreover, overweight and obese people experience higher psychological distress, which is another considerable impairment in their HRQoL (Kolotkin et al., 2001; Kolotkin and Andersen, 2017). Several studies across diverse geographical locations have reported that comorbid chronic diseases are associated with poor quality of life. For instance, earlier studies found that overweight or obese individuals often report physical, mental, and social relationship problems (Banegas et al., 2007; Choo et al., 2014; Pimenta et al., 2015; Rozjabek et al., 2020; Slagter et al., 2015). Of those reporting poor HRQoL, the highest burden was found among those with multiple comorbid chronic conditions (Lima et al., 2009). Other empirical studies have reported poor HRQoL among persons with comorbid or multimorbid diseases (Busetto et al., 2012; Tyack et al., 2018; Zhang et al., 2018).

HRQoL among obese individuals is understudied, with only a few empirical studies focused on establishing the association between comorbidities and quality of life. Two studies have reported that overweight and obesity were associated with low or poor HRQoL (Hoare et al., 2019; Renzaho et al., 2010). However, a recent study has not found a statistically significant association between HRQoL (measured by SF-6D) and comorbid chronic diseases in the Australian general population (Kortt and Dollery, 2011). The discrepancy in the relationship between comorbid conditions and HRQoL in the existing literature warrants further investigation to draw robust conclusions on the longitudinal relationship between comorbidity and HRQoL in the obese population. Therefore, this paper aims to examine the associations between comorbid chronic diseases and HRQoL among the Australian obese population. This is a novel study that provides a significant opportunity to advance the understanding of the relationship between nine comorbid chronic diseases and HRQoL in the obese population separately, along with the number of comorbidities. The study will provide insights into the need for measures to prevent overweight and obesity, manage those with comorbid conditions, and prevent further development of comorbidities among overweight and obesity with a view to improving HRQoL.

Methodology

Data Source and Sample selection

This study's data were sourced from the Household, Income and Labour Dynamics in Australia (HILDA) survey, a nationally representative longitudinal study of the Australian population. The survey collects information annually on many aspects of life, such as wealth, labour market outcomes, household and family relationships, fertility, health and education. The survey was started in 2001, and a multistage sampling approach was used to select an initial sample of households. At first, 488 Census Collection Districts (CD) were sampled with a probability proportional to size sampling technique; each consists of 200-250 households approximately across Australia. Secondly, from each of the CDs, a sample of 22-34 dwellings was selected randomly. Finally, up to three households from each dwelling were selected that results in the selection of a total of 12,252 households. Individuals aged 15 years or older residing in each household were included in the sample. The sample was expanded over time by including any child born or adopted by groups of respondents or by any new household member resulting from adjustments of the originating households' composition. Therefore, the survey follows the lives of more than 17,000 Australian adults annually.

This study utilized three waves of data: wave 9 (2009), 13 (2013) and 17 (2017) from the HILDA survey, spanning a period of nine years. The main reason for selecting these three waves is that data on comorbid chronic conditions were available only in these waves. This study restricted the sample to only obese adults aged 15 years or over. Missing observations on the outcome (dimensions of HRQoL) and main variables of interest (chronic diseases) were excluded from subsample analyses. After adjusting the inclusion and exclusion criteria, the final analytic sample consists of 9,444 person-year observations from 5,524 unique respondents.

Outcome variable

The outcome of interest in the present analysis is the health-related quality of life (HRQoL). HRQoL was measured through the RAND 36-Item Short Form Survey Instrument (SF-36). The SF-36 health survey is made up of 36 questions that cover eight dimensions: physical functioning (PF), role physical (RP); bodily pain (BP), general health (GH), vitality (VT), social functioning (SF); role emotional (RE); and mental health (MH). For example, the physical functioning dimension was assessed by ten questions, and each question has three levels (Yes, limited a lot; Yes, limited a little; and No, not limited at all). These levels were scaled as 1, 2, and 3 and thus, summed values lie between 10 to 30. This computed value was further transformed into a 0-100 scale. Similarly, each of the eight dimensions' score scale ranged from 0 to 100, wherein 0 represents the worst and 100 represents the best health status. It is important to note that SF-36 does not consider the trade-offs among the eight dimensions. It means each dimension is equally important in describing the health states. Two summary measures of quality of life (QoL): physical component summary (PCS), and mental component summary (MCS) that reflect the physical and mental health-related quality of life, respectively, were derived from the SF-36 score. The summary scores, PCS and MCS, were calculated using the recommended scoring algorithms for Australians (Australian Bureau of Statistics, 1997) and standardized by linear Z-score transformation with a mean of 50 and standard deviation (SD) of 10. The values of PCS and MCS ranged from 4.54 to 76.09 and from -1.21 to 76.19, respectively, with higher scores indicating better QoL (Perales et al., 2014).

Another instrument that is widely used in the economic evaluation as a measure of HRQoL is SF-6D. The SF-6D utility index can be derived from the SF-36 score and places health states in a scale that ranges from 0 to 1. The value 1 indicates full health (all the eight dimensions at the best level), and 0 shows the worst health (equivalent to death).

Exposure variables

In the present analyses, comorbid chronic diseases are considered as the main exposure variables. This study assessed nine self-reported chronic diseases: heart disease, circulatory disease, hypertension, type 1 diabetes, type 2 diabetes, asthma, bronchitis, arthritis, and cancer. The HILDA survey collects information on an individual's chronic disease status by asking the question: 'have you ever been told by a medical practitioner that you have been diagnosed with a serious illness or medical conditions'. The responses were taken in binary form: an answer of zero means no, and one means yes. The variable number of comorbid chronic disease is constructed by summing up the nine studied chronic diseases. The variable was categorized into five: 0 (having no chronic condition), 1 (having only one chronic condition), 2 (having two of the studied chronic diseases), 3 (having three of the studied chronic diseases) and 3+ (having more than three of the studied chronic diseases).

Other Covariates

A set of socio-demographic and behavioural characteristics were included in the study as potential confounders. All the explanatory variables were categorized using dummies. Socio-demographic factors include age (15-25, 26-45, 46-60, and over 60 years); gender (male, and female); civil status (single [separated, divorced, widowed or never married], married [legally married], de-facto [in a de-facto relationship]); education (year 12 or below, certificate courses [certificate III or IV], university qualifications [undergraduate degree, degree with honours, advanced diploma or diploma, masters, doctorate, graduate diploma or graduate certificate]; household income (measured through OECD equivalence scale and categorized into quintiles of 1 to 5); indigenous status (non-indigenous, and Aboriginal or Torres Strait Islander); and location (major city, regional city [inner and outer regional], remote areas [remote or very remote areas]). Behavioural characteristics include smoking status (never smoked, ex-smoker, current smoker); alcohol consumption (never drink, ex-drinker, only rarely to 3 days per week, 3+ days per week); and physical activity that lasts at least 30 minutes (not at all to <1 per week, 1-3 times per week, ≥4 times per week).

Statistical analysis

The authors constructed an unbalanced longitudinal data set consisting of 9,444 person-year observations of 5,524 unique participants by linking de-identified individuals' records wherein respondent information appeared more than once (up to three times). The current analyses report the pooled descriptive statistics as mean (SD) for continuous variables and percentages with 95% confidence intervals (CIs) for categorical variables.

This study fitted multivariate regression models to explore the relationship between comorbid chronic diseases and HRQoL. The regression models take the following form:

$$\mathrm{HRQoL}_{it} = \beta_0 + \beta_1 \mathrm{CD}_{it} + \beta_2 \mathrm{X}_{it} + \varepsilon_{it} \qquad (1)$$

In equation 1, HRQoL_{it} represents the summary measures, health utility index, and a particular dimension of SF-36 representing respondents' QoL. CD is the key variables of interests that capture the presence of comorbid chronic diseases in the respondents, X is a vector of control variables, ε_{it} is the error term, and subscripts i refer to individual and t indicates periods.

This study constructed ten different models, defined by the primary variables of interest: number of comorbid chronic diseases, solely heart disease, circulatory disease exclusively, solely hypertension, solely type 1 diabetes, solely type 2 diabetes, solely asthma, solely bronchitis, solely arthritis, and solely cancer. The reference category was always the absence of the comorbid chronic diseases. All models were adjusted for age, gender, civil status, education, equivalized household income, labour force status, race, place of living, smoking status, alcohol consumption, and physical activity.

This study deployed the Generalized Estimating Equation (GEE) to estimate the effects of comorbid chronic diseases on HRQoL. A significant advantage of using the GEE technique is that it provides unbiased estimates of population-averaged regression coefficients when the data's correlation structure is misspecified. A p-value of less than 0.05 was considered statistically significant, and the regression results were reported for three levels of P <0.001, <0.01, and <0.05. All analyses were conducted using STATA version 16.

Results

Table 1 shows the pooled summary statistics for the 9,444 Australian adults. The mean score for the eight domains of the SF-36 were 76.35 (SD = 25.60) for PF, 71.16 (SD = 40.06) for RP, 78.92 (SD = 36.43) for RE , 78.33 (SD = 25.53) for SF , 72.30 (SD = 18.36) for MH, 54.94 (SD = 20.71) for VT, 65.87 (SD = 25.47) for BP, and 60.57 (SD = 21.48) for GH. The mean component summary measures (PCS and MCS) and health utility index (SF-6D) derived from the SF-36 were 45.78 ± 11.38, 47.72 ± 11.26, and 0.73 ± 0.13 (mean ± SD), respectively. Among the study sample, over one quarter (27%) have at least one chronic condition, followed by two (15%), three (7%), and more than three (4%) comorbid chronic diseases. The most common comorbid chronic disease among the obese adults was hypertension (29%), followed by arthritis (24%), asthma (14%), type 2 diabetes (10%), and heart disease (6%).

The results also reveal that almost one-fourth of the participants were over sixty years (25%), over half were female (55%), and married (53%). Of the total, 18% had university qualifications, 61% were employed, 96% were non-indigenous, 61% lived in major cities, 19% were current smoker, 22% drunk over three days a week, and over one third (36%) do not perform physical activities.

Table 1: Pooled characteristics of study participants and subjective health scores

Variables	n	Mean (SD) / % (95% CI)
SF-36 domain scores [Mean (SD)]		
Physical functioning (PF)	9,444	76.35 (25.60)
Role physical (RP)	9,444	71.16 (40.06)
Role emotional (RE)	9,444	78.92 (36.43)
Social functioning (SF)	9,444	78.33 (25.53)
Mental health (MH)	9,444	72.30 (18.36)
Vitality (VT)	9,444	54.94 (20.71)
Bodily pain (BP)	9,444	65.87 (25.47)
General health (GH)	9,444	60.57 (21.48)
SF-36 component summary scores [Mean (SD)]		
PCS	9,444	45.78 (11.38)
MCS	9,444	47.72 (11.26)
SF-6D	9,444	0.73 (0.13)
Number of comorbid chronic diseases (from the study checklist)		
0	4,452	47.14 (46.14-48.15)
1	2,556	27.06 (26.18-27.97)
2	1,400	14.82 (14.12-15.56)
3	673	7.13 (6.62-7.66)
3+	363	3.84 (3.47-4.25)
Heart disease		
No	8,869	93.91 (93.41-94.38)
Yes	575	6.09 (5.62-6.59)
Circulatory disease		
No	9,112	96.48 (96.09-96.84)
Yes	332	3.52 (3.16-3.91)
Hypertension		
No	6,677	70.7 (69.77-71.61)
Yes	2,767	29.3 (28.39-30.23)
Type 1 diabetes		

No	9,311	98.59 (98.33-98.81)
Yes	133	1.41 (1.19-1.67)
Type 2 diabetes		
No	8,472	89.71 (89.08-90.3)
Yes	972	10.29 (9.7-10.92)
Asthma		
No	8,088	85.64 (84.92-86.33)
Yes	1,356	14.36 (13.67-15.08)
Bronchitis		
No	9,206	97.48 (97.14-97.78)
Yes	238	2.52 (2.22-2.86)
Arthritis		
No	7,176	75.98 (75.11-76.84)
Yes	2,268	24.02 (23.16-24.89)
Cancer		
No	9,103	96.39 (95.99-96.75)
Yes	341	3.61 (3.25-4.01)
Age		
15-25 years	1,001	10.6 (9.99-11.24)
26-45 years	3,175	33.62 (32.67-34.58)
46-60 years	2,903	30.74 (29.82-31.68)
>60 years	2,365	25.04 (24.18-25.93)
Gender		
Male	4,270	45.21 (44.21-46.22)
Female	5,174	54.79 (53.78-55.79)
Civil Status		
Single	3,487	36.92 (35.95-37.9)
Married	4,998	52.92 (51.91-53.93)
De-facto	959	10.15 (9.56-10.78)
Education		
Year 12 and below	4,281	45.33 (44.33-46.34)
Certificate courses	3,428	36.3 (35.33-37.27)
University qualifications	1,735	18.37 (17.6-19.17)
Household income quintile		
Quintile 1	1,889	20 (19.21-20.82)
Quintile 2	1,889	20 (19.21-20.82)
Quintile 3	1,889	20 (19.21-20.82)
Quintile 4	1,889	20 (19.21-20.82)
Quintile 5	1,888	19.99 (19.2-20.81)
Labour force status		
Employed	5,803	61.45 (60.46-62.42)
Unemployed	341	3.61 (3.25-4.01)
Not in the labour force	3,300	34.94 (33.99-35.91)
Indigenous status		
Non-indigenous	9,076	96.1 (95.69-96.48)
Aboriginal/Torres Strait Islander	368	3.9 (3.52-4.31)
Location		
Major city	5,741	60.79 (59.8-61.77)
Regional	3,544	37.53 (36.55-38.51)
Remote	159	1.68 (1.44-1.96)
Smoking status		

Never smoked	4,500	47.65 (46.64-48.66)
Ex-smoker	3,184	33.71 (32.77-34.67)
Current smoker	1,760	18.64 (17.86-19.43)
Alcohol consumption		
Never drink	898	9.51 (8.93-10.12)
Ex-drinker	913	9.67 (9.09-10.28)
Only rarely to 3 days/week	5,538	58.64 (57.64-59.63)
3+ days/week	2,095	22.18 (21.36-23.03)
Physical activity that lasts at least 30 min		
Not at all to <1/week	3,392	35.92 (34.96-36.89)
1-3 times/week	3,701	39.19 (38.21-40.18)
≥4 times/week	2,351	24.89 (24.03-25.78)

Table 2 presents the mean values of each of the eight dimensions of SF-36, the summary measures and the health utility index by the number of comorbid chronic diseases. As can be seen, the mean score for all SF-36 dimensions/subscales, composite measures, and health utility index decline with a higher number of chronic diseases. For example, obese people with more than three comorbid chronic diseases had the lowest scores than their counterparts with zero, one, two and three chronic conditions. The respective mean PCS, MCS, and SF-6D scores among the study sample with over three chronic diseases (29.48 ± 9.78, 43.86 ± 11.76, and 0.59 ± 0.11, respectively) were much lower than peers without the comorbid chronic disease (50.77 ± 8.14, 48.02 ± 10.76, and 0.76 ± 0.11, respectively).

Table 2: The SF-36 subscale scores and the summary measures by number of chronic conditions

The SF-36 subscale and summary measures	**Number of comorbid chronic diseases**				
	0 (Mean ± SD)	1 (Mean ± SD)	2 (Mean ± SD)	3 (Mean ± SD)	3+ (Mean ± SD)
Physical functioning	86.18 (19.64)	77.36 (22.83)	64.08 (25.89)	51.21 (26.98)	42.57 (25.29)
Role physical	84.61 (30.84)	72.45 (38.93)	54.00 (43.37)	38.41 (42.25)	24.06 (35.83)
Role emotional	84.72 (31.63)	79.75 (35.39)	72.95 (40.29)	64.14 (43.25)	52.34 (45.31)
Social functioning	83.82 (22.15)	79.34 (24.46)	72.38 (27.26)	63.84 (29.29)	53.62 (27.57)
Mental health	73.56 (17.50)	72.22 (18.74)	71.82 (18.86)	68.74 (19.77)	65.89 (18.91)
Vitality	58.51 (19.66)	55.24 (20.70)	51.31 (20.96)	46.50 (20.28)	38.76 (18.60)
Bodily pain	75.40 (21.12)	65.36 (24.09)	54.04 (24.77)	45.00 (25.08)	36.79 (21.97)
General health	67.47 (18.30)	60.99 (19.73)	53.06 (21.65)	43.60 (21.88)	33.50 (19.79)
PCS	50.77 (8.14)	46.06 (10.12)	39.38 (11.44)	33.83 (11.40)	29.48 (9.78)
MCS	48.02 (10.76)	47.83 (11.40)	48.05 (11.81)	46.67 (12.14)	43.86 (11.76)
SF-6D	0.76 (0.11)	0.73 (0.12)	0.69 (0.13)	0.64 (0.12)	0.59 (0.11)

Figure 1 depicts the composite summary scores (PCS and MCS) of the SF-36 by age and gender. It is observed that the PCS score declines with age. Mean PCS score ranged from 52.19

(15-25 years) to 39.48 (60+ years) in males and from 51.26 (15-25 years) to 36.82 (60+ years) in females. However, the MCS score of the study participants went up with age. The mean MCS score ranged from 47.80 (15-25 years) to 50.59 (60+ years) in males and from 42.89 (15-25 years) to 50.83 (60+ years) in females.

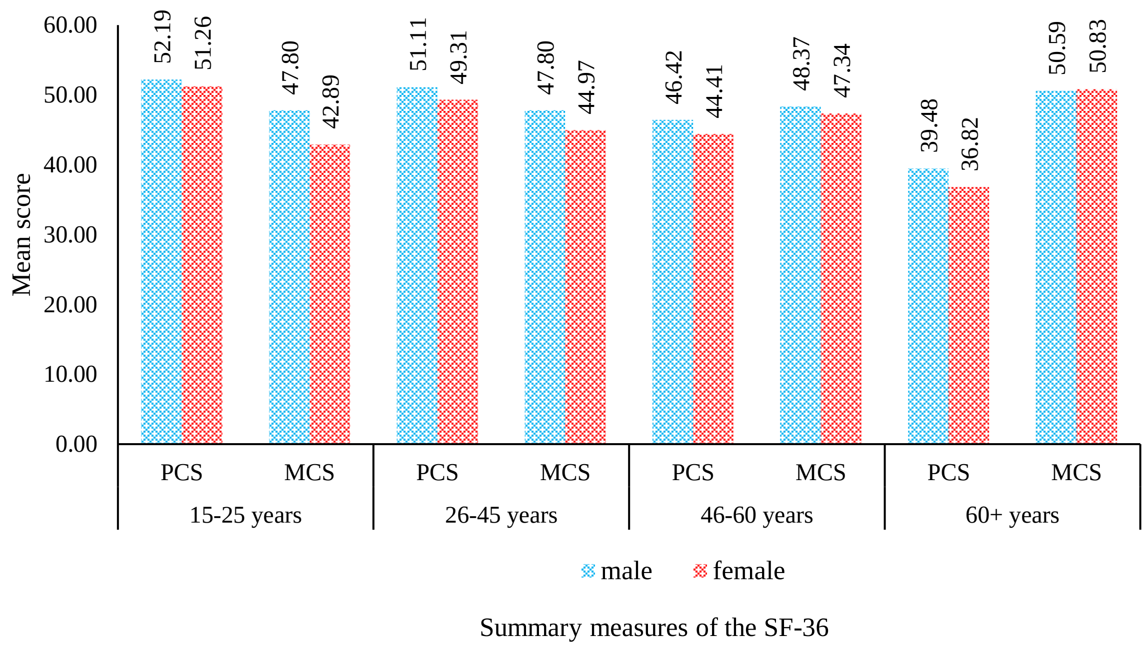

Figure 1: Mean summary measures of the SF-36 (PCS and MCS) by age and gender

Figure 2 offered the visual representation of the health utility index (SF-6D) by age and gender. The figure shows that the study participant's overall health state slightly declines with age and is generally lower in females. The mean SF-6D score ranged from 0.77 (26-45 years) to 0.70 (60+ years) in males and from 0.72 (15-25 years) to 0.69 (60+ years) in females.

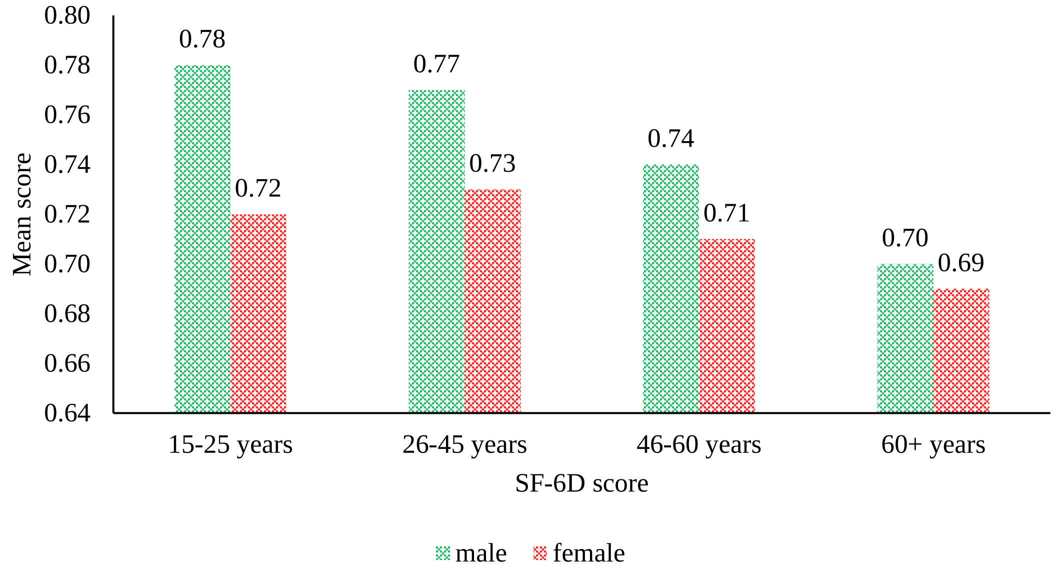

Figure 2: Mean SF-6D score by age and gender

Table 3 displays the association between comorbid chronic diseases and the three summary measures (PCS, MCS and SF-6D) of the SF-36. The estimated coefficients of the number of comorbid chronic diseases and individual chronic diseases concerning the summary measures and health utility index were reported in models 1 to 3. Models 1 and 2 indicate that obese people with a higher number of comorbid chronic diseases scored significantly worse on both PCS and MCS scores than obese people with zero comorbid chronic diseases. Obese people with 1, 2, 3, and 3+ comorbid chronic diseases scored 3 (b = -2.83), 7 (b = -7.37), 11 (b = -11.15), and 14 (b = -14.29) points/units lower on the PCS indicator, and 1 (b = -1.46), 2 (b = -2.34), 4 (b = -3.66), and 6 (b = -6.34) units lower on the MCS indicator, respectively, compared with obese people without comorbid chronic diseases. Models 1 and 2 also report the effects of individual chronic diseases on both PCS and MCS indicators. The result showed that obese people with any of the nine chronic diseases had significantly lower scores on both PCS and MCS indicators. For example, the effect of having cancer in obese people on both PCS (b = -4.08) and MCS (b = -2.27) were lower than counterparts without cancer.

On the SF-6D scale, obese adults with 1, 2, 3 and more than 3 comorbid chronic diseases scored 3 (b = -0.03), 6 (b = -0.063), 10 (b = -0.099), and 14 (b = -0.138) percentage points lower, respectively, compared with obese peers who do not have any chronic disease (model 3). Similarly, the results also showed that obese people having any type of the studied chronic diseases (heart disease, circulatory disease, hypertension, type 1 diabetes, type 2 diabetes, asthma, bronchitis, arthritis, and cancer) scored lower on the SF-6D scale compared with obese people without that particular chronic disease. For example, obese adults with heart disease scored 6 (b = -0.058) percentage points lower on the SF-6D scale than their counterparts without heart disease.

Table 3: GEE estimates of the relationship between chronic conditions and HRQoL

Variables	Model 1 PCS, β (95% CI)	Model 2 MCS, β (95% CI)	Model 3 SF-6D, β (95% CI)
Number of comorbid chronic diseases[a]			
0 (ref)			
1	-2.83*** (-3.28, -2.38)	-1.46*** (-1.99, -0.92)	-0.030*** (-0.036, -0.024)
2	-7.37*** (-7.96, -6.77)	-2.34*** (-3.04, -1.63)	-0.063*** (-0.070, -0.055)
3	-11.15*** (-11.95, -10.36)	-3.66*** (-4.60, -2.71)	-0.099*** (-0.109, -0.089)
3+	-14.29*** (-15.32, -13.26)	-6.34*** (-7.56, -5.11)	-0.138*** (-0.151, -0.125)
Heart disease[a]			
No (ref)			
Yes	-5.09*** (-5.92, -4.25)	-3.39*** (-4.33, -2.46)	-0.058*** (-0.068, -0.048)
Circulatory disease[a]			
No (ref)			
Yes	-6.35*** (-7.4, -5.29)	-4.33*** (-5.51, -3.15)	-0.070*** (-0.083, -0.057)
Hypertension[a]			
No (ref)			
Yes	-3.02*** (-3.49, -2.54)	-0.83** (-1.36, -0.29)	-0.025*** (-0.031, -0.019)
Type 1 diabetes[a]			
No (ref)			
Yes	-4.00*** (-5.64, -2.37)	-1.20 (-3.04, 0.63)	-0.027** (-0.047, -0.007)
Type 2 diabetes[a]			
No (ref)			
Yes	-3.02*** (-3.68, -2.37)	-1.61*** (-2.34, -0.87)	-0.029*** (-0.037, -0.021)
Asthma[a]			
No (ref)			
Yes	-3.77*** (-4.32, -3.22)	-2.47*** (-3.09, -1.85)	-0.041*** (-0.047, -0.034)
Bronchitis[a]			
No (ref)			
Yes	-7.69*** (-8.93, -6.45)	-4.87*** (-6.26, -3.48)	-0.078*** (-0.093, -0.063)
Arthritis[a]			
No (ref)			
Yes	-8.5*** (-8.98, -8.02)	-1.26*** (-1.83, -0.69)	-0.068*** (-0.074, -0.061)
Cancer[a]			
No (ref)			
Yes	-4.08*** (-5.12, -3.04)	-2.27*** (-3.43, -1.10)	-0.042*** (-0.055, -0.030)

*** p<0.001, ** p<0.01, * p<0.05; ref reference category.

[a] Model adjusted for age, gender, civil status, education, household income quintile, labour force status, race, place of living, smoking status, alcohol consumption, and physical activity

Table 4 summarizes the multiple regression analysis results for the number of comorbid chronic diseases which affect the SF-36 subscales. The results show that a negative correlation persists between comorbid chronic conditions and all the dimensions of SF-36. It indicates that a greater number of chronic diseases were associated with lower scores in all domains of the SF-36. For example, having more than three comorbid chronic conditions were associated with substantial reductions in PF (-26.76 units), RP (-41.67 units), RE (-25.36 units), SF (-25.02 units), MH (-9.87 units), VT (-19.92 units), BP (-29.33 units), and GH (-32.49 units).

Table 4: GEE estimates of the relationship between the status of chronic conditions and the dimensions of the SF-36

Variable	**Physical functioning, β (95% CI)**	**Role physical, β (95% CI)**	**Role emotional, β (95% CI)**	**Social functioning, β (95% CI)**	**Mental health, β (95% CI)**	**Vitality, β (95% CI)**	**Bodily pain, β (95% CI)**	**General health, β (95% CI)**
Number of chronic diseases								
0 (ref)								
1	-4.56***	-7.87***	-4.55***	-4.22***	-2.94***	-4.23***	-7.6***	-7.12***
	(-5.59, -3.52)	(-9.61, -6.12)	(-6.28, -2.81)	(-5.39, -3.06)	(-3.82, -2.06)	(-5.19, -3.26)	(-8.71, -6.48)	(-8.06, -6.18)
2	-12.7***	-20.84***	-9.94***	-10.29***	-4.69***	-8.86***	-16.41***	-15.27***
	(-14.06, -11.34)	(-23.13, -18.55)	(-12.21, -7.67)	(-11.81, -8.76)	(-5.84, -3.55)	(-10.12, -7.59)	(-17.87, -14.95)	(-16.5, -14.05)
3	-21.16***	-30.96***	-15.57***	-16.37***	-7.44***	-13.05***	-22.96***	-23.49***
	(-22.99, -19.33)	(-34.04, -27.88)	(-18.63, -12.52)	(-18.42, -14.32)	(-8.98, -5.89)	(-14.75, -11.35)	(-24.92, -20.99)	(-25.14, -21.84)
3+	-26.76***	-41.67***	-25.36***	-25.02***	-9.87***	-19.92***	-29.33***	-32.49***
	(-29.13, -24.4)	(-45.66, -37.68)	(-29.32, -21.41)	(-27.68, -22.36)	(-11.87, -7.87)	(-22.12, -17.71)	(-31.88, -26.78)	(-34.62, -30.35)

Model adjusted for age, gender, civil status, education, household income quintile, labour force status, race, place of living, smoking status, alcohol consumption, and physical activity

*** $p<0.001$, ** $p<0.01$, * $p<0.05$; ref reference category.

Discussion

This study is the first to assess the relationships between comorbid chronic diseases and HRQoL among the obese population in Australia. The current study further highlighted the interplay of nine chronic diseases in the previously found association between obesity and HRQoL (Busutil et al., 2017; Jia and Lubetkin, 2005).

The study results showed that the PCS, MCS, and SF-6D scores in obese people reduced sharply with an increasing number of chronic diseases. The negative association between the rising number of comorbid chronic conditions and overall HRQoL is similar to previous studies that reported a significant reduction in HRQoL among persons having multimorbidities (Brettschneider et al., 2013; Hunger et al., 2011; Sendi et al., 2005; Serrano-Aguilar et al., 2009; Sundh et al., 2015; Tyack et al., 2018; Ul-Haq et al., 2012; Wang et al., 2016). The results showed that obese individuals having any of the nine studied chronic diseases were associated with reduced PCS, MCS, and SF-6D scores. Results from previous empirical studies showed that an increase of the number of comorbidities in an individual or patient was associated with lower HRQoL (Banegas et al., 2007; Busetto et al., 2012; Lima et al., 2009; Zhang et al., 2018), which is consistent with the current study findings. Also, earlier studies have reported a statistically significant negative association between a higher number of comorbid chronic conditions and worse scores on PCS and MCS in obese people (Marrie et al., 2012; Sundh et al., 2015). Further, this current study revealed that a higher number of chronic diseases was associated with a reduction in scores in all eight dimensions of the SF-36. Similar findings have been highlighted elsewhere that studied the association between comorbid diseases and HRQoL (Adriaanse et al., 2016; Mond and Baune, 2009; Pati et al., 2020).

Although consistent findings were revealed, some of the earlier studies used a different survey instrument other than the SF-36 to measure HRQoL (Brettschneider et al., 2013; Hunger et al., 2011; Sendi et al., 2005; Wang et al., 2016). Therefore, there is a need for careful interpretation of the current study findings compared with the previous literature. The current results indicate that the burden posed by comorbid chronic diseases in an individual irrespective of the underlying condition, and the association could be attributed to several plausible factors. First, the observed lower HRQoL could be due to the synergistic effects that coexist among chronic diseases, resulting from one condition hampering a patient's ability to adhere to treatment for another (Mujica-Mota et al., 2015). An additional reason could be that obese individuals are at a greater risk of developing several chronic cardiovascular, muscular-skeletal, and metabolic comorbid conditions

(Cercato and Fonseca, 2019; Choi et al., 2018). As a result, these conditions in the obese population could have negated their quality of life due to the increasing deteriorating effects of multiple chronic diseases (Ul-Haq et al., 2012). Besides, comorbidities may profoundly impact patients' ability to manage their self-care and may pose significant barriers to lifestyle changes and regimen adherence (Adriaanse et al., 2016). Further, the present study results could have been influenced by comorbid mental health disorders that are most prevalent among persons suffering from chronic diseases.

The present study has several strengths. Firstly, this is the first longitudinal study that reports the relationships between comorbid chronic diseases and HRQoL in obese populations by analyzing eight dimensions, summary measures (PCS and MCS), and the health utility index (SF-6D) of the SF-36. Secondly, this study considered nine chronic diseases to check their associations separately with HRQoL. The current study was not without limitations, however. The unbalanced longitudinal nature of the study prevents the establishment of causal associations. Secondly, the study is limited in generalizability because the study's sample was limited to only the Australian obese population, which might portray features different from those in other countries and settings. Data on the severity of the comorbid conditions were not available, and this could have played a role in determining the association with HRQoL.

The study's findings provide first-hand evidence on the impact of increasing comorbid chronic diseases on the HRQoL of obese adults. The significant association found in the current study has implications for strengthening public health measures. Preventive measures are needed to reduce the burden of obesity and the subsequent development of obesity-related comorbidities. More comprehensive and holistic care should be given to individuals with chronic diseases due to the burden associated with its complications. Clinically, the types of comorbid chronic conditions found in the study related to HRQoL should inform treatment and care strategies to be deployed for persons with obesity.

Conclusion

The present study provides a better understanding of the relationship between comorbid chronic diseases and HRQoL in obese people in Australia. The study demonstrates that comorbid chronic disease in obese individuals is associated with poorer HRQoL. More specifically, increasing the number of comorbid chronic conditions was associated with a further reduction in scores for all eight dimensions, summary measures (PCS and MCS), and health utility index (SF-6D) of the SF-36. The findings, therefore, call for improved holistic management of obesity and all obesity-related comorbidities.

Abbreviations

BMI	Body Mass Index
HILDA	Household, Income and Labour Dynamics in Australia Survey
HRQoL	Health-related Quality of Life
PCS	Physical Component Summary
MCS	Mental Component Summary
SF-6D	Short-Form Six-Dimension
SF-36	36-Item Short-Form Health Survey

Authors' contributions

SAK initiated the study, conducted the data analysis. SAK, BOA, MS, RGA, and AAS drafted the manuscript. KA, JG and SB offered advice, critical comments and edited the draft manuscript. All the authors read and approved the final manuscript.

Ethics approval

This paper uses unit record data from Household, Income and Labour Dynamics in Australia Survey (HILDA) conducted by the Australian Government Department of Social Services (DSS). However, the findings and views reported in this paper are those of the authors and should not be attributed to the Australian Government, DSS, or any of DSS contractors or partners. DOI: 10.26193/OFRKRH, ADA Dataverse, V2."

This study did not require ethical approval as the analysis used only de-identified existing unit record data from the HILDA survey. However, the authors completed and signed the Confidentiality Deed Poll and sent it to NCLD (ncldresearch@dss.gov.au) and ADA (ada@anu.edu.au) before the data applications' approval. Therefore, the datasets analysed and/or generated during the current study are subject to the signed confidentiality deed.

Conflict of interest

The authors declare that they have no conflicts of interest.

Availability of data and materials

The data used for the study was collected from the Melbourne Institute of Applied Economic and Social Research. There are some restrictions on this data and it is not available to the public. Those interested in accessing this data should contact the Melbourne Institute of Applied Economic and Social Research, The University of Melbourne, VIC 3010, Australia.

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CHAPTER 4: THE IMPACT OF OBESITY ON ADVERSE LABOUR MARKET OUTCOMES

CHAPTER 4: STUDY 1

Gender differences in the longitudinal association between obesity, and disability with workplace absenteeism in the Australian working population

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Abstract

Background: Excess weight can increase absenteeism of workers and can have a negative influence on their productivity. Current evidence on this association is mostly based on cross-sectional data and there is little evidence concerning the longitudinal relationship between obesity, and disability with workplace absenteeism. Further, gender differences in this association have often ignored in the existing literature.

Objectives: This study aims to examine gender differences in the longitudinal association between obesity, and disability with absenteeism in the workplace.

Methods: Data from thirteen waves (2006 to 2018) of the Household, Income and Labour Dynamics in Australia (HILDA) survey were pooled, resulting in 117,769 observations for 19,851 adult employees. The Zero-Inflated Negative Binomial (ZINB) regression model was deployed to investigate the links between obesity, and disability with workplace absenteeism for the total sample and stratified by gender.

Results: The findings showed that overweight (Incidence Rate Ratio [IRR]: 1.23, 95% confidence interval [CI]: 1.02-1.47), obesity (IRR: 1.35, 95% CI: 1.12-1.64) and disability (IRR: 2.83, 95% CI: 2.36-3.38) were associated with prolonged workplace absenteeism irrespective of gender. This study found that the multiplicative interaction between weight status and gender is significantly associated with absenteeism. The results reveal that the rate of absenteeism was 2.79 times (IRR: 2.79, 95% CI: 1.96-3.97) and 1.73 times (IRR: 1.73, 95% CI: 1.20-2.48) higher among overweight and obese women than male counterparts, respectively. Moreover, this study found that the weight status of male workers is not associated with absenteeism. However, disability (IRR: 3.14, 95% CI: 2.43-4.05) is positively associated with longer days of absence among male workers. Finally, the study results showed that the rate of absenteeism is 1.82 (IRR: 1.82, 95% CI: 1.36-2.44), 1.61 (IRR: 1.61, 95% CI: 1.21-2.13), and 2.63 (IRR: 2.63, 95% CI: 1.99-3.48) times higher among overweight, obese, and female workers with a disability, respectively, compared with their lower weight counterparts.

Conclusion: Workplace absenteeism is significantly associated with overweight and obesity among Australian workers. An active workplace health promotion program is very important for weight management of overweight and obese workers and thus to reduce workplace absenteeism. For example, employers may provide incentives for maintaining recommended body weights, encourage exercise, and promote healthy diets amongst their workers.

Keywords: Obesity, disability, absenteeism, ZINB regression, Australia

Introduction

Globally, the prevalence of obesity has almost tripled since 1975 (World Health Organization, 2020a). Worldwide more than 650 million adults aged 18 years or over were obese in 2016 (World Health Organization, 2020a). Studies conducted on US workers provide evidence that obese employees were more likely to be absent from the workplace compared to their healthy weight counterparts (Frone, 2007; Poston et al., 2011; Tucker and Friedman, 1998). Moreover, a study in Ireland concludes that obese employees were 72% more prone to be absent (Fitzgerald et al., 2016). Further, a recent study in the Netherlands revealed that obese workers took 14 days of extra leave per annum compared to their lower weight counterparts (Jans et al., 2007). Similar results have been found in a British study where the authors claimed that obese workers were absent for four extra days per year (Harvey et al., 2010). However, a study in Germany did not find evidence that overweight men took more sick leave days (Lehnert et al., 2014). A few studies have also examined the longitudinal association between obesity and workplace absenteeism (Howard and Potter, 2014; Reber et al., 2018; Roos et al., 2015; Vanwormer et al., 2012). A prospective study among middle-aged employees in Finland revealed that stable obesity and weight gain in the follow-up period increased the risk of prolonged sickness absence (Roos et al., 2015). Two US-based longitudinal studies also provided evidence that obesity is positively associated with absenteeism (Howard and Potter, 2014; Vanwormer et al., 2012).

The prevalence of overweight and obesity among Australian adults is 63% and its rising prevalence has become a serious public health concern (Australian Institute of Health and Welfare, 2017a). The high health and financial burden of overweight and obesity in Australia has been well documented (Australian Institute of Health and Welfare, 2017b). Excess weight in individuals is responsible for 7% of the total health burden in the country (Australian Institute of Health and Welfare, 2017b). The direct financial cost of obesity to the Australian economy was estimated to be AUD 3.8 billion in 2011-12 (PwC Australia, 2015). In addition to the direct costs, overweight and obesity have indirect costs in the form of lost productivity (i.e. increased absenteeism and presenteeism). In 2011-12, the indirect cost of obesity was estimated to be AUD 4.8 billion to the Australian economy (PwC Australia, 2015).

Absenteeism in the Australian workplace has risen by 7% since 2010 (DHS, 2016). Approximately ninety-two million workdays are lost annually with the annual cost in the form of lost productivity is estimated to be AUD 33 billion (DHS, 2016). This is up to 8%

of the total payroll costs to Australian companies (DHS, 2016). The main reasons for employees' absence are poor health and fitness (Wee et al., 2019), illness (flu, headache, and gastro), family responsibilities, mental issues, and alcohol/drug-related issues (DHS, 2016). Employees who are absent from the workplace due to personal illness or injury include obese individuals who take longer leave periods compared with non-obese individuals (Australian Institute of Health and Welfare, 2005). According to the National Health Survey (NHS), over 4 million workdays were lost from Australian workplaces in 2001 due to obesity (Australian Institute of Health and Welfare, 2005). This evidence suggests that there might be an association between weight status and absenteeism for the Australian working population.

A few studies that have attempted to identify the longitudinal relationship between obesity and workplace absenteeism have mostly been based in the US or European countries. Evidence on the relationship between obesity and disability with workplace absenteeism from the Australian perspective is still lacking. Additionally, very few studies have investigated gender differences in the longitudinal association between obesity, disability, and workplace absenteeism. The present study fills this void in the literature by addressing the research question: does gender difference exist in the longitudinal association between obesity and disability with absenteeism in the workplace?

Excessive bodyweight of workers should be a major concern to businesses as there might be a positive association between workplace absenteeism and obesity and thus the extra cost to companies. The present study will offer evidence on the longitudinal links between obesity, disability, and workplace absenteeism. The results of the study might be used by policymakers and organizations for the development and implementation of workplace health promotion programs to tackle excessive weight problems of the workers.

Materials and methods

Data source and sample selection

The present study used the individual person dataset from the Household, Income and Labour Dynamics in Australia (HILDA) survey. This is a large-scale nationally representative panel survey of Australian households that collects data on family, wealth, health, education, and labor market dynamics (Freidin et al., 2002). This household panel survey is similar to the Panel Study of Income Dynamics (PSID) in the US, the British Household Panel Survey (BHPS), and the German Socio-Economic Panel (SOEP). The HILDA survey commenced in 2001 and since then has been conducted annually following the University of Melbourne's ethical guidelines. It collects detailed information from household members aged 15 years and over using a combination of face-to-face interviews and telephone interviews by trained interviewers, and self-completed questionnaires. There is a concern that responses collected through different modes have a significant impact on data quality. However, preliminary findings suggest that there is little systematic variation in responses by data collection modes (Watson and Wooden, n.d.).

This study utilized twelve recent waves (waves 6 to 18) from the HILDA dataset. The main reason for choosing the most recent 13 waves of the survey (2006-2018) is that data on Body Mass Index (BMI) are available only in these waves. The inclusion criteria of the present study are participants aged 15-64 years and who are employed at each wave. Missing information on the outcome variable of days absent from the workplace in the last 12 months were excluded (n = 2368 observations). Further, pregnant female employees were excluded (n = 6364 observations) from the subsample analyses to avoid potential bias and ensuring the validity of the study findings. After employing inclusion criteria and excluding missing data, the unbalanced panel consists of 117,769 observations from 19,851 adult employees. Study participants were generated from the dataset following the HILDA survey protocol. HILDA uses a multi-stage sampling approach including sampling within households within a particular administrative area. Detailed information about the sampling procedure and design have been described elsewhere (Freidin et al., 2002).

The percentage of participants who were lost due to missing information on the outcome variable and to pregnancy was 2.01% and 5.40%, respectively. The total percentage of loss to follow-up in the present study is less than 10%. That is in the acceptable range for longitudinal studies and thus leads to little bias.

Measures

Outcome variable

The main outcome variable of the study is days absent from work on paid workers' compensation in the last twelve months**.** It is a derived variable and was constructed using the variable work schedule to determine the number of days absent from the workplace.

Gender differences

Work and health-related behaviors often differ by gender (Gustafsson Sendén et al., 2016). The existing evidence reported mixed results when explaining the association between obesity and absenteeism (Harvey et al., 2010). The inconsistent findings may be due to variables that moderate the relationship. Previous studies identified the variable, gender, which moderates the association between job-related factors and workplace absenteeism (Scott and Mabes, 1984). Attendance rate is an avenue by which women differ from men at the workplace (Scott and McClellan, 1990). Keeping this in mind, the present study conducts gender-specific analyses while examining the longitudinal association between obesity, disability, and absenteeism. Moreover, this study will include a multiplicative interaction term, BMI × gender, in the regression model to test whether the joint effect of BMI and gender is significant in explaining workplace absenteeism.

Exposure variables

The main variables of interest in the present study are BMI and disability. BMI is calculated using self-reported height and weight following the formula weight (in kilograms) divided by height (in meters squared). This study categorized BMI into four groups following the World Health Organization (WHO) guidelines: <18.50 (underweight), 18.50-24.99 (normal/healthy weight), 25.00-29.99 (overweight), and ≥30.00 (obesity) (World Health Organization, 2020a). The obesity often further categorized into three groups: 30.00-34.99 (obese class I), 35.00-39.99 (obese class II), and ≥40.00 (obese class III). Underweight is not a topic of interest in the current study. As a result, this study merged two BMI categories (underweight with healthy weight) and form a new category, <25 BMI, following relevant studies conducted in Australia and The Netherlands (Au and Hollingsworth, 2011; Nigatu et al., 2015) to conduct the regression analysis.

The disability of an adult used in the HILDA survey was based on the guidelines of the International Classification of Functioning, Disability, and Health (ICF) under the WHO framework (LaMontagne et al., 2016). Participants were asked if they have any 'disability, impairment, or disability that restricts them in everyday activities, and has lasted or are likely to last, for 6 months or more' (Melbourne Institute of Applied Economic and Social Research, 2018). Responses were coded in binary form (yes or no). Participants who answered 'yes' were counted as an adult with a disability.

Other covariates

This study selected potential confounders following relevant published studies on the risk factors of workplace absenteeism (Ferrie et al., 2007; Fitzgerald et al., 2016; Frone, 2007; Harvey et al., 2010; Howard and Potter, 2014; Jans et al., 2007; Janssens et al., 2012; Lehnert et al., 2014; Nigatu et al., 2015; Reber et al., 2018; Roos et al., 2015; Tucker and Friedman, 1998; Vanwormer et al., 2012) and information available in the HILDA datasets. Confounders were included in the fully adjusted model only if a confounder was found significant at 5% or less risk level at any level in the bivariate analyses.

This study includes age (15-25, 26-45, 46-60, and over 60 years) (Frone, 2007; Harvey et al., 2010; Poston et al., 2011; Reber et al., 2018), gender (male and female) (Frone, 2007;

Harvey et al., 2010; Vanwormer et al., 2012), civil status (non-cohabitating and married/cohabitating) (Reber et al., 2018), and education (year 12 or below, professional qualification, and university qualification) (Frone, 2007; Poston et al., 2011) as socio-demographic characteristics.

The present study also included eleven measures of job-related characteristics that include firm size (small, medium, and large) (Bubonya et al., 2017), employment contract (permanent, fixed-term and casual) (Asay et al., 2016; Bubonya et al., 2017), tenure with the current employer (1-5 years, and 6 or more years) (Bubonya et al., 2017), hours worked per week (<35, 35-40, and >40 hours a week) (Magee et al., 2016), work schedule (day and shift work) (Bubonya et al., 2017; Magee et al., 2016), job type (non-manual and manual) (Frone, 2007; Magee et al., 2016), supervisory responsibility (yes and no), paid holiday leave (yes and no), paid sick leave (yes and no) (Howard and Potter, 2014; Magee et al., 2016), union membership (yes and no) (Asay et al., 2016; Bubonya et al., 2017), and overall job satisfaction (dissatisfied, neutral, and satisfied)(Magee et al., 2016).

Confounding role of other comorbidities such as cancer, diabetes, heart disease, depression, asthma, bronchitis, and arthritis in explaining workplace absenteeism could not be explored in the present study. The principal reason for not exploring such roles is that these data were available only in waves 9, 13, and 17 of the HILDA survey.

Estimation strategy

The authors constructed an unbalanced longitudinal data set consisting of 117,769 observations by linking 19,851 individuals' records who participated in either any of the waves from 6 to 18 of the HILDA survey. Descriptive statistics in the form of frequency (n) and percentages (%) with 95% confidence intervals (CI) or mean (SD) or median (range) were used to describe absenteeism, weight status, disability, socio-demographic and job-related characteristics of the study participants.

To explore the factors associated with workplace absenteeism, the present study followed the conceptual framework of Hafner et al. (Hafner, Marco, Christian Van Stolk, Catherine Saunders, Joachim Krapels, 2015). Accordingly, factors of workplace productivity (absenteeism and presenteeism) are broadly categorized into three groups and can be expressed as follows.

$Y_i = f(j, p, h)$

In the function, Y_i refers to workplace productivity (i.e. absenteeism), j refers to job-related factors (i.e. work demands), p refers to personal factors (i.e. lifestyle factors), and h refers to health and physical factors (i.e. long-term health conditions).

To find out the longitudinal association between exposure and outcome variables, the present study followed the forward addition approach for building models. In this approach, the multivariate model starts with the basic model where BMI is the exposure, and absenteeism is the outcome variable. Confounders and interaction terms were added one at a time based on their level of significance. The process continued until all significant confounders and interaction term was included in the model.

The outcome variable, workplace absenteeism, is a count variable where all the values are non-negative integer numbers including zero. The negative binomial model is appropriate to estimate the association between exposures and the outcome variable when the outcome variable is a count variable and overdispersed (Trindade et al., 2015). In the present study, the number of zeros in the outcome variable is excessive. Among these zeros, there are two kinds of zero values. First, there are some certain zeros because employees may not be absent in the workplace due to work restrictions. Second, there might exist zeros for employees who were not absent in the workplace but could be absent due to sickness or other conditions. Hence, the number of zeros might be inflated in the outcome variable due to certain zeroes. The standard negative binomial regression model cannot differentiate between these two processes when they arrive at a zero value in the outcome variable (UCLA, 2019a). However, the Zero-Inflated Negative Binomial (ZINB) model can handle these two distinct data generation processes (UCLA, 2019a). The ZINB model fits a logistic regression model to predict the excess zeros in the dependent variable (absenteeism) and then fits the negative binomial regression model to get a count of the number of days absent for non-excess zeros (UCLA, 2019b). Given this, the current study followed standard practice and employed the ZINB regression model to estimate the longitudinal association between obesity, disability, and workplace absenteeism. The study results are demonstrated in the form of the incidence rate ratio (IRR) for each variable. Stata 14 windows version was used for all statistical analyses. This study set a p-value at <0.05 level for statistical significance.

Ethics approval

This study requires no ethics approval for the authors as the analysis used only de-identified existing unit record data from the Household, Income and Labour Dynamics in Australia (HILDA) Survey. However, the authors had completed and signed the Confidentiality Deed Poll and sent it to NCLD (ncldresearch@dss.gov.au) and ADA (ada@anu.edu.au) before the data applications' approval. Therefore, datasets analyzed and/or generated during the current study are subject to the signed confidentiality deed.

Results

Descriptive characteristics of the study sample

Table 1 shows the pooled characteristics of the employees in terms of overweight, obesity, disability, absenteeism, socio-demographic characteristics, and job-related characteristics. Among the study participants, around 52% were either normal weight or underweight (<25 BMI), 29% were overweight, and 19% were obese. An estimated 16% of Australian workers have a disability. The average number of absent days per annum of workers is 0.7, although the standard deviation (8.8) is very high. A higher value of the standard deviation over mean indicates the absent days variable is overdispersed with excessive zeros. Additionally, Table 1 reports that median absent days of the employees is 0.00 and ranges from 0 to 352 days.

Table 1: Background characteristics of the study participants

Variables	N	% (95% CI)
Outcome Variable: Days absent in the past 12 months (mean [SD])	117,769	0.7 (8.8) 32.9 (50.9) without counting 0 days (median=0.0; min=0, max=352)
Explanatory variables		
Health-related characteristics		
BMI		
BMI (<25)	61,102	51.9 (51.6-52.2)
Overweight (25.00-29.99)	34,532	29.3 (29.1-29.6)
Obesity (≥30.00)	22,135	18.8 (18.6-19.1)
Obese class I (30.00-34.99)	14,749	12.5 (12.3-12.7)
Obese class II (35.00-39.99)	5,052	4.3 (4.2-4.4)
Obese class III (≥40.00)	2,334	2.0 (1.9-2.1)
Disability		
No	98,477	83.6 (83.4-83.8)
Yes	19,292	16.4 (16.2-16.6)
Socio-demographic characteristics		
Age		
15-25 years	25,960	22.1 (21.8-22.3)
26-45 years	49,867	42.3 (42.1-42.6)
46-60 years	37,011	31.4 (31.2-31.7)
>60 years	4,931	4.2 (4.1-4.3)
Gender		
Male	60,204	51.1 (50.8-51.4)
Female	57,565	48.9 (48.6-49.2)
Civil status		
Non-Cohabitating	46,884	39.8 (39.5-40.0)
Married/Cohabitating	70,885	60.2 (59.9-60.5)
Education		

Year 12 or below	44,421	37.7 (37.4-38.0)
Professional qualification	39,369	33.4 (33.2-33.7)
University qualification	33,979	28.9 (28.6-29.1)
Job-related characteristics		
Farm size		
Small (1-19 employees)	51,704	43.9 (43.6-44.2)
Medium (20-99 employees)	32,314	27.4 (27.2-27.7)
Large (≥100 employees)	33,751	28.7 (28.4-28.9)
Employment contract		
Permanent	78,442	66.6 (66.3-66.9)
Fixed-term	11,600	9.9 (9.7-10.0)
Casual	27,727	23.5 (23.3-23.8)
Tenure-current employer		
1-5 years	65,326	55.5 (55.2-55.8)
6 or more years	52,443	44.5 (44.2-44.8)
Hours worked per week		
<35 hours/week	37,836	32.1 (31.9-32.4)
35-40 hours/week	42,432	36.1 (35.8-36.3)
>40 hours/week	37,501	31.8 (31.6-32.1)
Work schedule		
Day work	88,769	75.4 (75.1-75.6)
Shift work	29,000	24.6 (24.4-24.9)
Job type		
Non-manual	59,582	50.6 (50.3-50.9)
Manual	58,187	49.4 (49.1-49.7)
Supervisory responsibilities		
Yes	53,490	45.4 (45.1-45.7)
No	64,279	54.6 (54.3-54.9)
Paid holiday leave		
Yes	85,447	72.5 (72.3-72.8)
No	32,322	27.5 (27.2-27.7)
Paid sick leave		
Yes	85,709	72.8 (72.5-73.0)
No	32,060	27.2 (27.0-27.5)
Union membership		
Yes	26,967	22.9 (22.7-23.1)
No	90,802	77.1 (76.9-77.3)
Overall job satisfaction		
Dissatisfied	3,006	2.6 (2.5-2.7)
Neutral	17,649	15.0 (14.8-15.2)
Satisfied	97,114	82.4 (82.2-82.7)

Abbreviations: SD Standard Deviation; CI Confidence Interval

Figure 1 demonstrates that average absenteeism is significantly higher among overweight and obese employees compared with lower weight employees. Figure 1 illustrates that the average number of missed days is highest among the morbidly obese (obese class III) workers (1.79), followed by workers belong to obese class II (1.23 days).

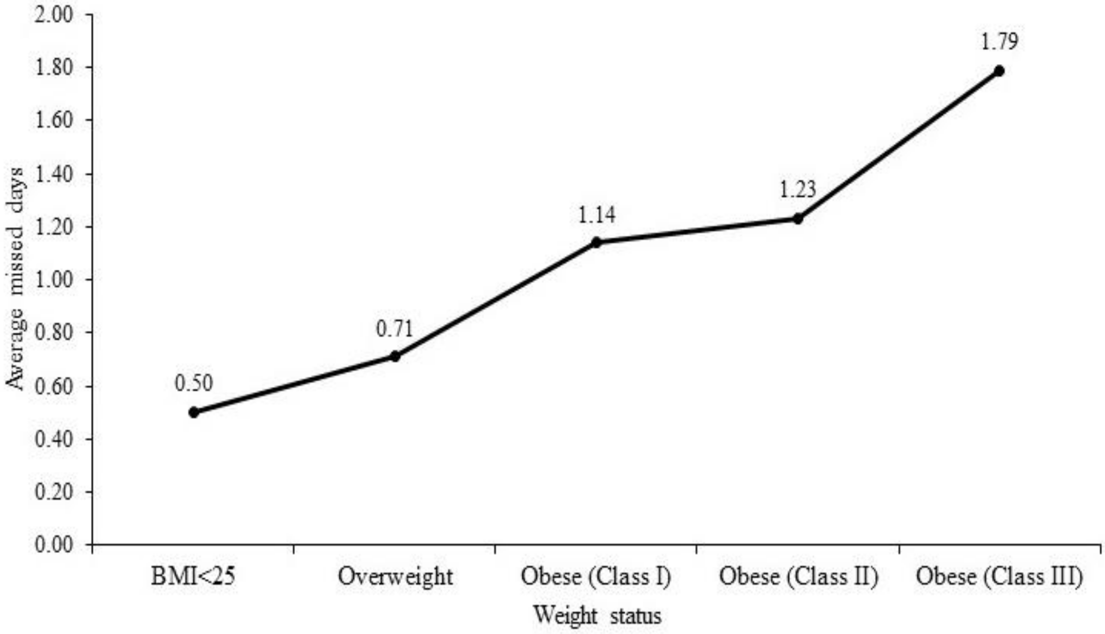

Figure 1: Average number of missed days according to weight status

Factors associated with workplace absenteeism

Estimates of the longitudinal association between obesity, and disability with absenteeism after controlling for socio-demographic and job-related characteristics are presented in Table 2.

The results showed a set of significant links between overweight, obesity, and disability with absenteeism in the adjusted model (model 1). The results showed that overweight, obesity, and disability have a longitudinal association with absenteeism. The findings indicate that the rate of workplace absenteeism in overweight and obese workers were 1.23 (IRR: 1.23, 95% CI: 1.02-1.47) and 1.35 (IRR: 1.35, 95% CI: 1.12-1.64) times higher compared with their lower weight counterparts, respectively. Model 1 also reveals that the rate of days absent from the workplace among workers with a disability was 2.83 times (IRR: 2.83, 95% CI: 2.36-3.38) higher compared with workers without a disability. Model 2 reports a significant association between the interaction of BMI and gender with prolonged absenteeism. The results showed that the rate of absenteeism was 2.79 times (IRR: 2.79, 95% CI: 1.96-3.97) and 1.73 times (IRR: 1.73, 95% CI: 1.20-2.48) higher among overweight and obese women employees than their male counterparts, respectively.

The present study also explored the relationship between obesity, disability, with absenteeism by gender. Model 3 and Model 4 report the results obtained from multivariate models for male and female workers, respectively. The adjusted model (model 3) showed that male workers' weight status is not associated with workplace absenteeism. However, the study findings suggest that the rate of absenteeism in male workers with a disability is 3.14 times (IRR: 3.14, 95% CI: 2.43-4.05) higher compared with lower weight counterparts. Model 4 shows that there is a longitudinal association between female workers' weight status, disability with absenteeism. After adjusting confounders, model 4 also reveals that the rate of absenteeism among overweight and obese women workers were 1.82 (IRR: 1.82, 95% CI: 1.36-2.44) and 1.61 (IRR: 1.61, 95% CI: 1.21-2.13) times higher compared with lower weight peers, respectively. The present study also showed that the rate of absenteeism among women with disabilities is 2.63 times (IRR: 2.63, 95% CI: 1.99-3.48) higher than women without a disability.

Table 2: ZINB regression results for factors associated with workplace absenteeism.[a]

Variables	**Model 1 (total sample) IRR (95% CI)[b]**	**Model 2 (total sample) IRR (95% CI)[c]**	**Model 3 (only male) IRR (95% CI)[d]**	**Model 4 (only female) IRR (95% CI)[e]**
BMI				
BMI (<25) (ref)				
Overweight (25.00-29.99)	**1.23 (1.02-1.47)**		0.96 (0.76-1.22)	**1.82 (1.36-2.44)**
Obesity (≥30.00)	**1.35 (1.12-1.64)**		1.26 (0.96-1.65)	**1.61 (1.21-2.13)**
Disability				
No (ref)				
Yes	**2.83 (2.36-3.38)**	**2.89 (2.42-3.46)**	**3.14 (2.43-4.05)**	**2.63 (1.99-3.48)**
Gender				
Male (ref)				
Female	0.97 (0.81-1.16)			
Interaction terms (BMI × Gender) Male × BMI (<25) (ref)				
Overweight × female		**2.79 (1.96-3.97)**		
Obesity × female		**1.73 (1.20-2.48)**		
Socio-demographic characteristics				
Age				
15-25 years (ref)				
26-45 years	**1.47 (1.19-1.83)**	**1.52 (1.23-1.88)**	1.11 (0.82-1.49)	**2.06 (1.47-2.88)**
46-60 years	**1.81 (1.43-2.29)**	**1.93 (1.53-2.44)**	**1.47 (1.06-2.04)**	**2.56 (1.77-3.69)**
>60 years	**1.67 (1.09-2.56)**	**1.70 (1.11-2.61)**	0.78 (0.42-1.44)	**2.79 (1.43-5.42)**
Civil status				
Non-Cohabitating (ref)				
Married/Cohabitating	0.90 (0.77-1.05)	0.94 (0.80-1.09)	1.03 (0.83-1.29)	1.00 (0.79-1.26)
Education				
Year 12 or below	**1.75 (1.38-2.22)**	**1.76 (1.39-2.22)**	**3.64 (2.60-5.11)**	0.96 (0.71-1.31)
Professional qualification	**1.92 (1.51-2.43)**	**1.93 (1.52-2.44)**	**3.50 (2.50-4.91)**	0.89 (0.67-1.19)
University qualification (ref)				
Job-related characteristics				
Farm size				
Small (1-19 employees)	1.09 (0.90-1.31)	1.07 (0.89-1.30)	1.10 (0.85-1.43)	0.96 (0.71-1.31)

Medium (20-99 employees)	1.00 (0.83-1.21)	0.97 (0.81-1.18)	1.00 (0.77-1.30)	0.89 (0.66-1.19)
Large (≥100 employees) (ref)				
Employment contract				
Permanent (ref)				
Fixed-term	0.88 (0.68-1.14)	0.85 (0.66-1.10)	0.93 (0.65-1.33)	0.77 (0.52-1.15)
Casual	0.84 (0.58-1.22)	0.78 (0.54-1.12)	0.73 (0.46-1.17)	1.38 (0.70-2.75)
Tenure-current employer				
1-5 years (ref)				
6 or more years	0.86 (0.73-1.01)	**0.82 (0.69-0.96)**	**0.76 (0.61-0.96)**	0.91 (0.71-1.18)
Hours worked per week				
<35 hours/week	**0.80 (0.66-0.99)**	**0.79 (0.65-0.97)**	**0.72 (0.52-0.99)**	0.81 (0.61-1.07)
35-40 hours/week (ref)				
>40 hours/week	0.99 (0.83-1.18)	0.98 (0.82-1.16)	0.95 (0.77-1.17)	0.85 (0.60-1.19)
Work schedule				
Day work (ref)				
Shift work	1.18 (0.99-1.40)	**1.21 (1.02-1.43)**	**1.51 (1.19-1.91)**	1.20 (0.91-1.57)
Job type				
Non-manual (ref)				
Manual	**2.00 (1.63-2.48)**	**2.03 (1.66-2.50)**	**2.55 (1.94-3.35)**	**1.61 (1.17-2.21)**
Supervisory responsibilities				
Yes (ref)				
No	0.93 (0.80-1.08)	0.93 (0.81-1.08)	0.97 (0.79-1.19)	0.85 (0.68-1.08)
Paid holiday leave				
Yes (ref)				
No	0.96 (0.43-2.15)	1.10 (0.49-2.45)	1.21 (0.46-3.17)	0.59 (0.18-1.98)
Paid sick leave				
Yes (ref)				
No	0.87 (0.38-1.99)	0.79 (0.34-1.81)	0.66 (0.24-1.83)	1.01 (0.29-3.58)
Union membership				
Yes (ref)				
No	**0.53 (0.43-0.66)**	**0.55 (0.43-0.66)**	**0.60 (0.46-0.78)**	**0.51 (0.36-0.72)**
Overall job satisfaction				
Dissatisfied	**1.57 (1.07-2.31)**	**1.54 (1.06-2.25)**	1.60 (0.93-2.75)	1.46 (0.83-2.54)
Neutral	1.15 (0.95-1.41)	1.21 (0.99-1.48)	0.78 (0.60-1.02)	**1.70 (1.25-2.33)**

Satisfied (ref)				

Abbreviations: BMI Body Mass Index; CI Confidence Interval; IRR Incidence Rate Ratio; Ref Reference

[a]Values in bold are statistically significant at $p<0.05$

[b]Estimates of obesity and disability after adjusting socio-demographic and job-related characteristics using the total sample (model 1)

[c]Estimates of the interaction of BMI and gender using the total sample (model 2).

[d]Estimtes of obesity and disability after adjusting socio-demographic and job-related characteristics using male samples only (model 3).

[e]Estimtes of obesity and disability after adjusting socio-demographic and job-related characteristics using female samples only (model 4).

Discussion

The purpose of the present study is to assess the longitudinal association between obesity, and disability with workplace absenteeism in Australian workers, and to test for gender differences in such associations. This study pooled 13 waves of data from the nationally representative sample of the HILDA survey. Controlling for socio-demographic and job-related characteristics, ZINB regression analysis showed that overweight and obesity are associated with prolonged absenteeism for the entire sample. Some observational studies also confirm that obese workers tend to have a higher number of work absences (Ferrie et al., 2007; Fitzgerald et al., 2016; Frone, 2007; Harvey et al., 2010; Jans et al., 2007; Janssens et al., 2012; Poston et al., 2011). In addition to cross-sectional study findings in the literature, a recent study has also confirmed a longitudinal association between obesity and workplace absenteeism (Howard and Potter, 2014). It was already well documented that obesity is a major risk factor for many chronic diseases (World Health Organization, 2020a). Obese workers missed more days of work due to personal illness or injury compared with non-obese workers (Australian Institute of Health and Welfare, 2005). Further, the present study revealed that having a disability is significantly associated with prolonged absenteeism irrespective of gender. This finding is in line with a study from the Netherlands where the authors found that long-term health condition like distress is positively associated with long-term sickness absence (Nigatu et al., 2015). The association between disability and higher absenteeism might be explained by the fact that comorbidities lead to a higher number of absent days (Jans et al., 2007; Nigatu et al., 2015).

The present study also found a significant multiplicative interaction of BMI and gender in explaining workplace absenteeism. The study results revealed that the rate of absenteeism is higher among overweight and obese women than male counterparts. Additionally, the present study checks the longitudinal association between BMI and prolonged absenteeism separately for male and female workers. The current study results showed that there is no longitudinal association between overweight, obesity, and a high rate of absenteeism among male workers. However, the results found that overweight, obesity, and absenteeism are positively associated in the long-run among female workers. An existing longitudinal study supports the present study findings as it found obesity was associated with extra sick leave days and long-term workplace absenteeism in female but not in male workers (Reber et al., 2018). An important cause of this gender difference in workplace absenteeism may be the menstrual cycle (Ichino and Moretti, 2009). Further, the gender difference in absenteeism could be attributed to women's double burden of wage work and unpaid household chores (Karlsson, 2016). Another possible explanation is that women typically perform more monotonous and stressful jobs (Karlsson, 2016).

Knowledge of the longitudinal association between obesity and absenteeism is important to companies and policymakers to take measures to reduce the rate of absenteeism in the workplace (Reber et al., 2018). From the viewpoint of public policy, the results of this longitudinal study will help policymakers to have a more comprehensive understanding of absenteeism in the workplace due to excessive weight. The results suggest that organizations should focus on an integrated lifestyle approach for weight management of their workers by using multiple intervention strategies. Organizations should create a supportive environment by enabling physical infrastructure and workplace culture to encourage a healthy lifestyle. For example, companies may offer healthy catering services, establish gym and activity centers for physical activity, establish on-site bicycle storage, and provide walking maps and routes. The effectiveness of workplace-targeted interventions is currently unclear. However, there is evidence that the absenteeism rate is low among workers who perform physical activities regularly (van Amelsvoort et al., 2006; van den Heuvel et al., 2005).

The study contributes to the existing literature in several ways. First, to the best of the author's knowledge, this is the first study on the longitudinal association between obesity, disability, and absenteeism from the Australian context. Second, the present study pooled a nationally representative longitudinal sample of 117,769 observations for 19,851 workers where participants were observed for 13 years to offer precise estimates on the association. Third, the study incorporated a large number of job-related characteristics as confounders including less investigated factors (work schedule, job type, paid, and sick leave arrangement) which are associated with absenteeism. Fourth, this is the first study that examines the effect of the interactions between BMI and gender on absenteeism.

Conclusion

This study aimed to examine the gender differences in the longitudinal association between obesity, and disability with absenteeism. Using the ZINB regression technique, the present study found evidence of significant association and compared the results with existing evidence. The study found that workplace absenteeism is higher among overweight, obese, and workers with a disability compared with their counterparts. The results also revealed that interactions of BMI and gender are associated with prolonged absenteeism. This study found evidence that the rate of absenteeism is higher among overweight and obese women than male counterparts. However, the study results did not find evidence of a longitudinal association between overweight, and obesity with a high rate of absenteeism among male workers. The findings are important evidence in the consideration of workplace health promotion policies. Implementation of workplace health promotion programs to treat workers excess weight might be an effective tool to lower the rate of absenteeism.

The present study has some limitations. First, the unbalanced longitudinal design of the study draws longitudinal associations but it is not possible to discern the causal effect of obesity, and disability on workplace absenteeism. Second, the study findings might be vulnerable to bias, as data on BMI, disability, and absenteeism are self-reported. Self-reported bias is high among overweight and obese adults, as they tend to overestimate their height and underestimate their weight (Gorber et al., 2007a; Maukonen et al., 2018). Similarly, there might be justification bias in case of self-reported disability as individuals tended to over-report their disability level as a result of the financial benefits attached to that classification (Black et al., 2017). The authors call for a well-designed cohort study that can draw causal inferences on the association between obesity, disability, and absenteeism.

Abbreviation

AUD	Australian Dollar
BMI	Body Mass Index
HILDA	Household, Income and Labour Dynamics in Australia survey
IRR	Incidence Rate Ratio
WHO	World Health Organization
ZINB	Zero-Inflated Negative Binomial

Author's contributions: SAK initiated the study, conducted the data analysis, and drafted the manuscript. KA, JG, and SB offered advice, critical comments, and edited the draft manuscript. All the authors read and approved the final manuscript.

Conflict of Interest

The authors declare that they have no conflicts of interest.

Availability of data and materials

The data used for the study were collected from the Melbourne Institute of Applied Economic and Social Research. There are some restrictions on this data and it is not available to the public. Those interested in accessing this data should contact the Melbourne Institute of Applied Economic and Social Research, The University of Melbourne, VIC 3010, Australia.

CHAPTER 4: STUDY 2

A longitudinal exploration of the relationship between obesity, and long term health condition with presenteeism in Australian workplaces, 2006-2018

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Abstract

Background

Obesity and long term health condition (LTHC) are major public health concerns that have an impact on productivity losses at work. Little is known about the longitudinal association between obesity and LTHC with impaired productivity.

Objective

This study aims to explore the longitudinal association between obesity and LTHC with presenteeism or working while sick.

Design

Longitudinal research design

Setting

Australian workplaces

Methods

This study pooled individual-level data of 111,086 employees collected in wave 6 through wave 18 from the Household, Income and Labour Dynamics in Australia (HILDA) survey. The study used a Generalized Estimating Equation (GEE) model with logistic link function to estimate the association.

Results

The findings suggest that overweight (Odds Ratios [OR]: 1.09, 95% Confidence Interval [CI]: 1.05-1.14), obesity (OR: 1.38, 95% CI: 1.31-1.45), and LTHC (OR: 3.03, 95% CI: 2.90-3.16) are significantly positively associated with presenteeism.

Conclusion

The longitudinal association between obesity and LTHC with presenteeism among Australian employees implies that interventions to improve workers' health and well-being will reduce the risk of presenteeism at work.

Keywords: Obesity, long term health condition, presenteeism, Australia

Introduction

The global obesity prevalence has nearly tripled since 1975. In 2016, 13% (over 650 million) of adults aged 18 years and over were obese, worldwide (World Health Organization, 2020a). In 2017-18, nearly 2 in 3 (67%, 12.5 million) Australian adults were either overweight or obese, and 1 in 3 adults was obese (Australian Institute of Health and Welfare, 2019a). The rising prevalence of overweight and obesity is a serious public health concern in Australia as this trend has high health and financial costs to the economy (Australian Institute of Health and Welfare, 2017a). In 2015, 8.4% of the disease burden was attributable to overweight and obesity in Australia (Australian Institute of Health and Welfare, 2019a). Overweight and obesity cost AUD 8.6 billion to the Australian economy in 2011-12 (PwC Australia, 2015).

Excessive weight in workers caused direct (e.g. patient care and medical supplies) and indirect (e.g. lost productivity) cost burdens to employers. The indirect costs of obesity can be grouped into six categories (Trogdon et al., 2008) and both absenteeism and presenteeism have contributed highly to indirect costs. Presenteeism is the second main component of measuring workplace productivity and is defined as impaired functioning while being present at work due to the presence of mental or physical health complications (Johns, 2010). Presenteeism is difficult to identify and measure compared with absenteeism (Econtech, 2011). However, there is evidence that the annual cost of presenteeism is higher than that of absenteeism in the US economy (Hitt et al., 2007). Like the US, productivity loss through presenteeism is a persistent and ongoing problem in the Australian economy. A landmark study revealed that the estimated cost of presenteeism was AUD 34.1 billion in 2010 and will cost AUD 35.8 billion in 2050 to the Australian economy (Econtech, 2011).

It is assumed that obesity negatively impacts workers’ performance as obese people often suffer from comorbidities, including diabetes, cardiovascular diseases, and musculoskeletal disorders. The existing empirical evidence shows that obesity is positively associated with presenteeism (Gates et al., 2008; Goetzel et al., 2010; Janssens et al., 2012; Kudel et al., 2018; Sanchez Bustillos et al., 2015). Findings from two recent studies conducted in Canada and Belgium suggests that obesity is positively and significantly associated with impaired productivity (Janssens et al., 2012; Sanchez Bustillos et al., 2015). Moreover, three studies conducted in the US reported similar findings (Gates et al., 2008; Goetzel et al., 2010; Kudel et al., 2018). One study utilized data of 59,772 adult workers in different US occupations and found that work productivity impairment is significantly higher among obese workers than normal-weight peers (Kudel et al., 2018). Another study in the US precisely concluded that the rate of presenteeism is 12% higher among obese workers compared with healthy weight counterparts (Goetzel et al., 2010). Similarly, another study of 341 manufacturing employees in the US found that obese workers are less productive than their healthy weight counterparts (Gates et al., 2008). The study design of all of these research studies was cross-sectional and based in the US, Canada, or European countries. As a result, a systematic review study suggested conducting a longitudinal study to reconfirm the association between obesity and productivity loss at workplace (Trogdon et al., 2008).

No studies have quantified the longitudinal association between workers' health and impaired productivity. Longitudinal studies can track individual changes over time, and thus can estimate the association more precisely than cross-sectional studies. Additionally, much research has measured presenteeism through a single question and not incorporated important job-related characteristics. To overcome these limitations, the present study aimed to quantify the association between Body Mass Index (BMI) and LTHC with presenteeism using longitudinal data. Three questions will be used to validate the measure of presenteeism. Further, this study will incorporate several health-related, socio-economic, lifestyle, and job-related characteristics as confounders to precisely measure the association. This study may help health policymakers and employers to identify the characteristics of employees associated with a higher rate of presenteeism and make policy interventions to improve workers' health, thereby improving productivity in the workplace.

Conceptual framework

To explore the association between obesity and LTHC with presenteeism, this study followed the conceptual framework of Hafner et al. (Hafner et al., 2015). Figure 1 highlights that factors of workplace productivity are broadly categorized into three groups: job-related factors, individual and lifestyle factors, and health and physical factors. Job-related factors refer to aspects of the work environment, such as work hours, employment contracts, and overall job satisfaction of the workers. Individual and lifestyle factors are related to personal characteristics and behavior, such as age, education, family commitments, alcohol consumption, and physical activity. Health and physical factors include aspects of the health and well-being of the workers, such as weight status, long term health condition, and mental health. The conceptual model posits that job-related characteristics, individual and lifestyle factors, and health and physical factors may have a direct association with workers' productivity. However, these factors are interrelated dynamically. For example, a worker may develop mental-health problems due to bullying in the workplace. To capture this dynamic effect, Hafner et al. (Hafner et al., 2015) suggested using longitudinal data that can track the same individual over a long period.

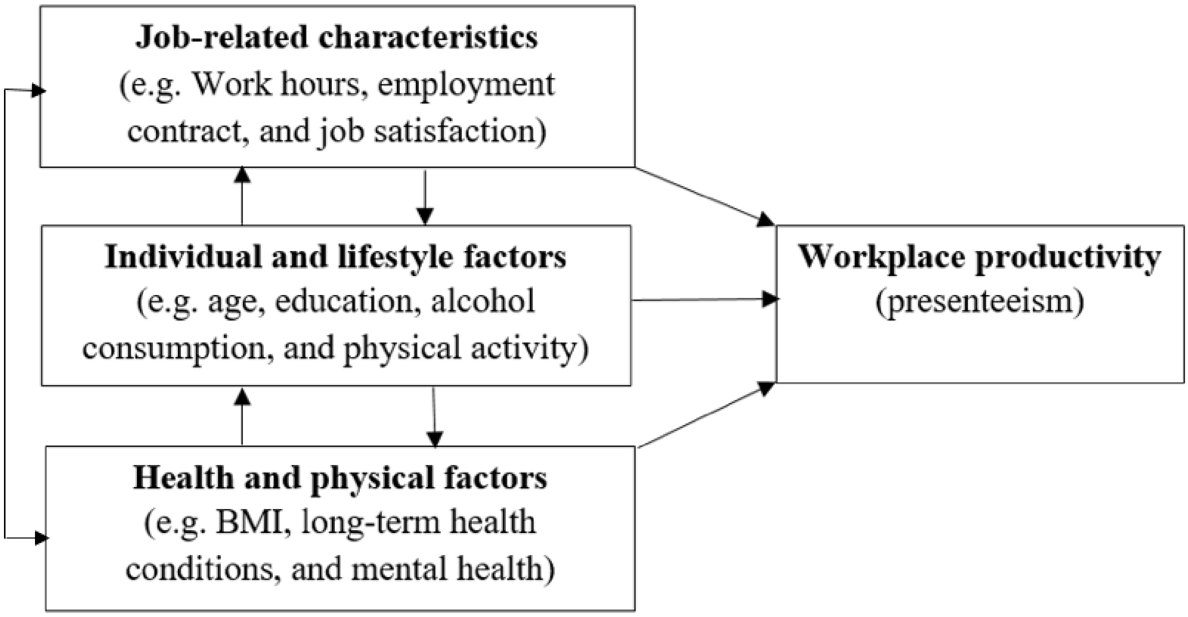

Figure 1: Factors potentially associated with presenteeism. Source: Hafner et al. [14]

Materials and methods

Data source and sample selection

The data of the present study were taken from the Household, Income, and Labour Dynamics in Australia (HILDA) survey in Australia. HILDA is a nationally representative household-based panel survey that collects data on three main areas: economic and subjective well-being, labour market dynamics, and family life. More specifically, the survey collects data on a wide range of topics covering family relationships, wealth, income, employment, health, and education (Freidin et al., 2002). The HILDA survey was commenced in 2001 and since then has been conducted every year. Each year HILDA survey collects data on the lives of over 13,000 Australian adults from more than 7,000 households following a multi-stage sampling approach (Wilkins, 2013). The survey collects information from individuals aged 15 years or over in the household through a personal interview by trained interviewers as well as self-completed questionnaires. The details of the survey design have been described previously (Freidin et al., 2002). The survey is funded by the Australian Government through the Department of Social Services and designed and managed by the Melbourne Institute of Applied Economic and Social Research.

Questions on BMI were included in the HILDA survey from wave 6, and questions on LTHC and presenteeism have been incorporated since wave 1 (see later for details). As a result, the study utilized the most recent thirteen waves (6 to 18) from the HILDA dataset. Given the study's focus on workplace presenteeism, the analysis was restricted to individuals who are currently employed and aged 15 to 64 years. Further, the study excluded pregnant employees from the subsample analyses to avoid potential bias. Additionally, this study restricted the sample to those with no missing information on the outcome variable (presenteeism) and main exposure variables (obesity and LTHC). After exercising the exclusion criteria, the unbalanced panel consists of 19,087 participants and 111,086 observations for the subsample analysis.

Outcome variable

The main outcome variable of the present study is presenteeism at work. The variable presenteeism was derived from the Short Form Health Survey (SF-36) questionnaire. The details of the survey can be found elsewhere (Ware et al., 2000). Participants were asked three questions through the self-completed questionnaire. More specifically, participants were asked whether they have experienced any of the following three events in the past four weeks due to any physical problems: "cut down the amount of time spent on work or other activities"; "accomplished less than would like"; and "were limited in the kind of work". The responses were recorded in binary form: yes or no. Using these responses the present study formed a presenteeism variable which is a binary indicator. Presenteeism variable takes the value of 1 if a participant answered "yes" to any of the above three questions, and 0 otherwise.

Exposure variable

Two health-related characteristics served as the main variables of interest in the present study: obesity and LTHC. The present study used BMI to measure obesity. BMI of the respondents has been derived using the formula weight (in kilograms) divided by square of the height (in meters). BMI has been categorized into four groups following the World Health Organization (WHO) guidelines; underweight (BMI <18.50), normal/healthy weight (BMI 18.50 to <25.00), overweight/pre-obesity (BMI 25.00 to <30.00), and obesity (BMI ≥30) (World Health Organization, 2020a). Underweight is not a concern of the present study. As a result, this study forms a new category, BMI <25, by merging underweight and healthy weight categories following previous studies (Au and Hollingsworth, 2011; Nigatu et al., 2015).

The HILDA survey collects data on an individual's LTHC following the guidelines of the International Classification of Functioning, Disability, and Health (ICF) under the WHO framework (LaMontagne et al., 2016). Participants were presented a show-card that listed examples of long term health condition, impairments, or disabilities and asked if they have any of these conditions which restrict them in their daily activities that had lasted or were likely to last six months or more. Responses were taken in binary form, either yes or no. Respondents who answered 'yes' were considered as a worker with LTHC, and 0 otherwise.

Other covariates

This study selected covariates following previous studies on presenteeism at work (Arnold, 2016; Bockerman and Laukkanen, 2010; Bubonya et al., 2017; Callen et al., 2013; Janssens et al., 2012; Sanchez Bustillos et al., 2015). Socio-demographic covariates included are age (15-35, 36-55, and 56-64 years), gender (male and female), civil status (partnered and non-cohabitating), education (year 12 or below, professional qualification, and university qualification), ethnicity (not of indigenous origin, and Aboriginal and Torres Strait Islander [ATSI]), remoteness (major cities, regional, and remote or very remote), and equivalized household income. Household income variable was categorized into quintiles: quintile 1 (bottom quintile) though 5 (top quintile). In addition to the socio-demographic controls, this study included lifestyle factors and job-related characteristics. Lifestyle factors included smoking status (non-smoker and current smoker), alcohol consumption (non-drinker and current drinker), and physical activity (inactive, some activity, and regular activity). The HILDA survey collects data on an individual's physical activity by asking how often they participate in physical activity. Responses were taken in 6 forms: not at all, less than once a week, 1 to 2 times a week, 3 times a week, more than 3 times a week, and every day. Respondents who answered 'not at all' were classified as inactive, less than once a week, 1 to 2 times a week, and 3 times a week were classified as some activity; and more than 3 times a week and every day were classified as a regular activity.

The present study included the following employment controls: hours worked per week (<35, 35-40, and >40 hours/week), employment contract (permanent, casual, and fixed-term), occupation (8 categories), industry (13 categories), supervisory responsibilities (yes or no), member of employee association (yes or no), provision of paid sick leave (yes or no), and overall job satisfaction (from 0 = worst to 10 = best).

Estimation strategy

The authors constructed an unbalanced longitudinal data set by linking individual's records who participated in wave 6 through wave 18 of the HILDA survey. To summarise the characteristics of the cohort, the present study used descriptive statistics in the form of frequency (n) and percentage (%) along with 95% confidence intervals (CI) or mean with standard deviation (SD). Further, this study calculated the frequencies of presenteeism among the study participants by BMI categories, LTHC, and other covariates. Chi-square tests or t-test have been employed to assess the bivariate relationship between presenteeism, obesity, LTHC, and other covariates. This study included covariates in the multivariate analysis if a covariate is significant at p-value equals to 0.05 in the bivariate analysis.

Given the discrete nature of the dependent variable, presenteeism, the present study explores the association between obesity and LTHC with presenteeism using Generalized Estimating Equation (GEE) with a logistic link function. The econometric model developed to capture the association is as follows.

$$\mathrm{Y_{it}} = \propto_0 + \beta_1 \mathrm{BMI_{it}} + \beta_2 \mathrm{LTHC_{it}} + \beta_3 \mathrm{SD_{it}} + \beta_4 \mathrm{LS_{it}} + \beta_5 \mathrm{JR_{it}} + \varepsilon_{it} \qquad (1)$$

In equation 1, $\mathrm{Y_{it}}$ represents presenteeism that a worker i may experience in period t; $\mathrm{BMI_{it}}$ is the indicator of obesity, and $\mathrm{LTHC_{it}}$ is the indicator of long term health condition. Finally, $\mathrm{SD_{it}}$, $\mathrm{LS_{it}}$, and $\mathrm{JR_{it}}$ represent the vector of socio-demographic, lifestyle and job-related characteristics, respectively and ε_{it} is the error term.

In the case of longitudinal data, repeated measurements on the same adult have been collected over time. For example, data on presenteeism, weight status, and LTHC of the same adult were taken repeatedly over the study period. As a result, observations from an individual are correlated and failure to take into account this correlation may lead to bias estimates. GEE can take into account the correlation of within-individual data. GEE estimate is a quasi-likelihood method where first mean and covariance are important. In the case of longitudinal data, observations on each individual are correlated. As a result, the Generalized Linear Model (GLM) cannot estimate parameters and make inferences as it assumes errors are independent and distributed individually. GEE can handle this issue by relaxing the assumption that observations were generated from a certain distribution. GEE estimates the population-averaged effects of the parameters. The main advantage of using GEE is that it is computationally simpler compared with Maximum Likelihood Estimates (MLE) in the case of categorical data. Besides, GEE offers a better prediction of the within-subject covariance structure. The main limitation of the GEE estimate is that likelihood-based methods cannot be applied to estimate the statistical inference.

This study revealed the adjusted association between obesity and LTHC with presenteeism by incorporating socio-demographic (age, gender, civil status, education, ethnicity, remoteness, and equivalized household income), lifestyle (smoking status, alcohol consumption, and physical activity) and job-related characteristics (hours worked per week, employment contract, occupation, industry, supervisory responsibilities, member of an employee association, paid sick leave and overall job satisfaction). The study results are presented in the form of Odds Ratio (OR) for each explanatory variable. This study set a P-value at <0.05 level for statistical significance. All statistical analyses were conducted using Stata version 16, Windows version.

Ethics approval

This study requires no ethics approval for the authors as the analysis used only de-identified existing unit record data from the HILDA survey. However, the authors completed and signed the Confidentiality Deed Poll and sent it to NCLD (ncldresearch@dss.gov.au) and ADA (ada@anu.edu.au) before the data applications' approval. Therefore, datasets analyzed and/or generated during the current study are subject to the signed confidentiality deed.

Results

Table 1 provides a summary of the prevalence of presenteeism, BMI class, presence of LTHC, socio-demographic, lifestyle and employment characteristics of the study participants. A total of 111,086 workers were included in the final analysis. Among the participants, approximately 19% of workers reported presenteeism. Table 1 showed that approximately 35% of workers were overweight, 22% were obese and 16% had LTHC.

Table 1: Background characteristics of the study participants

Variables	**n**	**% (95% CI)**
Outcome variable: Presenteeism		
No	90,172	81.17 (80.94-81.40)
Yes	20,914	18.83 (18.60-19.06)
Health-related characteristics		
BMI categories		
BMI (<25)	47,723	42.96 (42.67-43.25)
Overweight (25.00-29.99)	38,564	34.72 (34.44-35.10)
Obesity (≥30)	24,799	22.32 (22.08-22.57)
Long term health condition		
No	92,955	83.68 (83.46-83.89)
Yes	18,131	16.32 (16.11-16.54)
Socio-demographic characteristics		

Age		
15-35 years	46,943	42.26 (41.97-42.55)
36-55 years	50,047	45.05 (44.76-45.34)
56-64 years	14,096	12.69 (12.49-12.89)
Gender		
Male	56,126	50.52 (50.23-50.82)
Female	54,960	49.48 (49.18-49.77)
Civil status		
Married / partnered)	69,914	62.94 (62.65-63.22)
Non-cohabitating	41,172	37.06 (36.78-37.35)
Education		
Year 12 or below	40,270	36.25 (35.97-36.53)
Professional qualification	37,150	33.44 (33.17-33.72)
University qualification	33,666	30.31 (30.04-30.58)
Ethnicity		
Not of indigenous origin	108,323	97.51 (97.42-97.60)
ATSI	2,763	2.49 (2.40-2.58)
Remoteness		
Major Cities	76,583	68.94 (68.67-69.21)
Regional	32,862	29.58 (29.31-29.85)
Remote or very remote	1,641	1.48 (1.41-1.55)
Household income quintile		
Quintile 1 (bottom quintile)	16,592	14.94 (14.73-15.15)
Quintile 2	20,722	18.65 (18.43-18.88)
Quintile 3	22,763	20.49 (20.25-20.73)
Quintile 4	25,289	22.77 (22.52-23.01)
Quintile 5 (top quintile)	25,720	23.15 (22.91-23.40)
Lifestyle factors		
Smoking status		
Non-smoker	89,749	80.79 (80.56-81.02)
Current Smoker	21,337	19.21 (18.98-19.44)
Alcohol consumption		
Former/non-drinker	14,279	12.85 (12.66-13.05)
Current drinker	96,807	87.15 (86.95-87.34)
Physical activity		
Inactive	29,499	26.56 (26.30-26.82)
Some activity	35,845	32.27 (31.99-32.54)
Regular activity	45,742	41.18 (40.89-41.47)
Job-related characteristics		
Farm Size		
Small	47,902	43.12 (42.83-43.41)
Medium	30,658	27.60 (27.34-27.86)
Large	32,526	29.28 (29.01-29.55)
Hours worked/week		
<35 hours a week	36,153	32.55 (32.27-32.82)
35-40 hours a week	40,110	36.11 (35.83-36.39)
>40 hours a week	34,823	31.35 (31.08-31.62)
Employment contract		
Permanent	74,694	67.24 (66.96-67.52)
Casual	10,836	9.75 (9.58-9.93)
Fixed-term	25,556	23.01 (22.76-23.25)
Occupation		

Professional	27,209	24.49 (24.24-24.75)
Managerial	14,550	13.10 (12.90-13.30)
Technical trade	14,596	13.14 (12.94-13.34)
Personal services	12,809	11.53 (11.34-11.72)
Clerical	15,878	14.29 (14.09-14.50)
Sales	10,007	9.01 (8.84-9.18)
Machinery	6,373	5.74 (5.60-5.88)
Labour work	9,664	8.70 (8.54-8.87)
Industry		
Public services	7,444	6.70 (6.56-6.85)
Agriculture	2,681	2.41 (2.32-2.51)
Mining	1,972	1.78 (1.70-1.85)
Manufacturing	8,911	8.02 (7.86-8.18)
Electricity	1,104	0.99 (0.93-1.05)
Construction	8,938	8.05 (7.89-8.21)
Trade	14,621	13.16 (12.96-13.36)
Hospitality	7,153	6.44 (6.30-6.59)
Transport	6,943	6.25 (6.11-6.39)
Finance	4,006	3.61 (3.50-3.72)
Education	11,417	10.28 (10.10-10.42)
Health	15,819	14.24 (14.04-14.45)
Other services	20,077	18.07 (17.85-18.30)
Supervisory responsibilities		
Yes	50,524	45.48 (45.19-45.77)
No	60,562	54.52 (54.23-54.81)
Employee association		
Yes	26,021	23.42 (23.18-23.67)
No	85,065	76.58 (76.33-76.82)
Paid sick leave		
Yes	81,543	73.41 (73.14-73.66)
No	29,543	26.59 (26.34-26.86)
Overall job satisfaction (Mean [SD])	111,086	7.65 (1.62)

Figure 2 demonstrates the reported presenteeism by weight status and presence of LTHC. There was a substantial difference in the prevalence of presenteeism by BMI categories and LTHC variables. The prevalence of presenteeism was found highest among obese workers (22%), following overweight (16%), and workers with BMI<25 (13%). Approximately, 39% of workers having LTHC reported presenteeism.

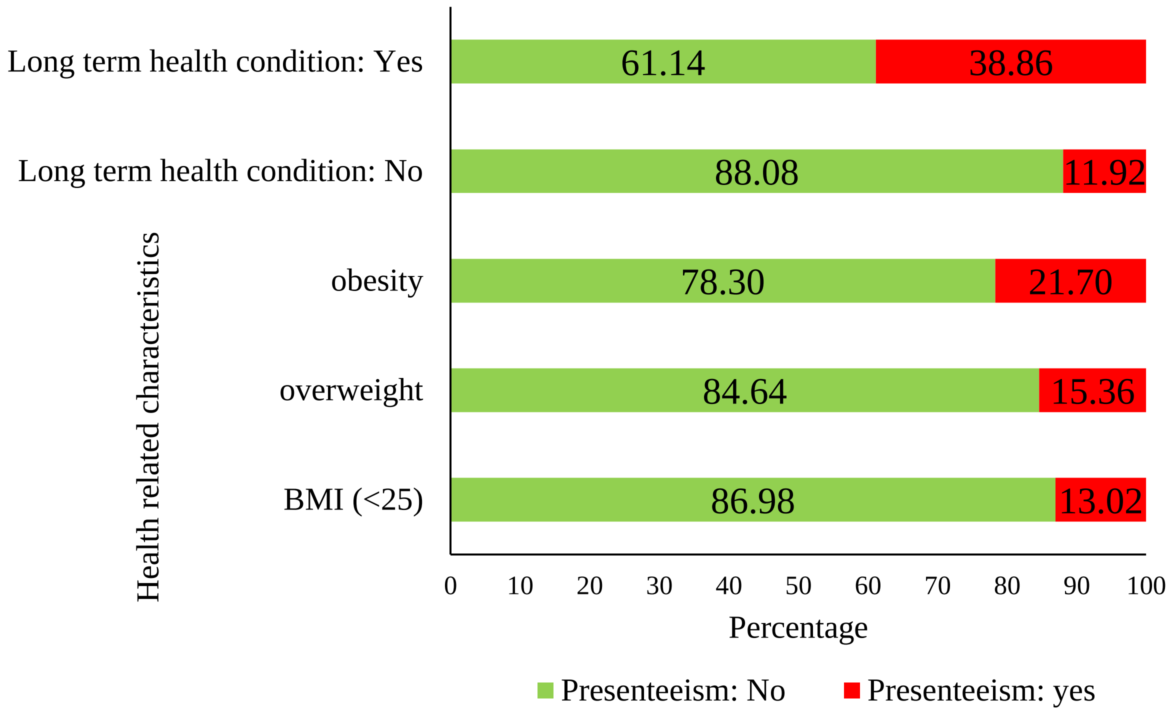

Figure 2: Prevalence of presenteeism by weight status and long term health condition

Table 2 presents the distribution of reported presenteeism by BMI categories, health, socio-demographic, lifestyle, and job-related characteristics. Table 2 also reports the bivariate relationship between presenteeism, obesity, LTHC along with other covariates achieved through the Chi-square tests or t-tests. The results showed that BMI, LTHC, and all the confounders were significantly associated with presenteeism in the bivariate analyses.

Table 2: Bivariate analysis between health, socio-demographic, lifestyle, and job-related characteristics with presenteeism in Australian workers.

Variables	**No presenteeism**		**Presenteeism**		**P-value**
	n	**% (95% CI)**	**n**	**% (95% CI)**	
Health-related characteristics					
BMI categories					<0.001
BMI (<25)	39,904	83.62 (83.28-83.95)	7,819	16.38 (16.05-16.72)	
Overweight (25.00-29.99)	31,708	82.22 (81.84-82.60)	6,856	17.78 (17.40-18.16)	
Obesity (≥30)	18,560	74.84 (74.3-75.38)	6,239	25.16 (24.62-25.70)	
Long term health condition					<0.001
No	80,047	86.11 (85.89-86.33)	12,908	13.89 (13.67-14.11)	
Yes	10,125	55.84 (55.12-56.57)	8,006	44.16 (43.43-44.88)	
Socio-demographic characteristics					
Age					<0.001
15-35 years	39,739	84.65 (84.32-84.98)	7,204	15.35 (15.02-15.68)	
36-55 years	39,952	79.83 (79.48-80.18)	10,095	20.17 (19.82-20.52)	
56-64 years	10,481	74.35 (73.63-75.07)	3,615	25.65 (24.93-26.37)	
Gender					<0.001

Male	46,766	83.32 (83.01-83.63)	9,360	16.68 (16.37-16.99)	
Female	43,406	78.98 (78.63-79.32)	11,554	21.02 (20.68-21.37)	
Civil status					<0.01
Married / partnered)	57,065	81.62 (81.33-81.91)	12,849	18.38 (18.09-18.67)	
Non-cohabitating	33,107	80.41 (80.03-80.79)	8,065	19.59 (19.21-19.97)	
Education					<0.01
Year 12 or below	32,986	81.91 (81.53-82.29)	7,284	18.09 (17.71-18.47)	
Professional qualification	29,814	80.25 (79.85-80.65)	7,336	19.75 (19.35-20.15)	
University qualification	27,372	81.30 (80.88-81.72)	6,294	18.70 (18.28-19.12)	
Ethnicity					<0.01
Not of indigenous origin	88,000	81.24 (81.00-81.47)	20,323	18.76 (18.53-19.00)	
ATSI	2,172	78.61 (77.04-80.10)	591	21.39 (19.90-22.96)	
Remoteness					<0.01
Major Cities	62,455	81.55 (81.28-81.83)	14,128	18.45 (18.17-18.72)	
Regional	26,349	80.18 (79.75-80.61)	6,513	19.82 (19.39-20.25)	
Remote or very remote	1,368	83.36 (81.48-85.09)	273	16.64 (14.91-18.52)	
Household income quintile					<0.001
Quintile 1 (bottom quintile)	13,017	78.45 (77.82-79.07)	3,575	21.55 (20.93-22.18)	
Quintile 2	16,620	80.20 (79.66-80.74)	4,102	19.80 (19.26-20.34)	
Quintile 3	18,304	80.41 (79.89-80.92)	4,459	19.59 (19.08-20.11)	
Quintile 4	20,799	82.25 (81.77-82.71)	4,490	17.75 (17.29-18.23)	
Quintile 5 (top quintile)	21,432	83.33 (82.87-83.78)	4,288	16.67 (16.22-17.13)	
Lifestyle factors					
Smoking status	73,379	81.76 (81.51-82.01)	16370	18.24 (17.99-18.49)	<0.001
Non-smoker	16,793	78.70 (78.15-79.25)	4,544	21.30 (20.75-21.85)	
Current Smoker					
Alcohol consumption					<0.001
Former/non-drinker	10,948	76.67 (75.97-77.36)	3,331	23.33 (22.64-24.03)	
Current drinker	79,224	81.84 (81.59-82.08)	17,583	18.16 (17.92-18.41)	
Physical activity					<0.001
Inactive	23,282	78.92 (78.46-79.39)	6,217	21.08 (20.61-21.54)	
Some activity	29,095	81.17 (80.76-81.57)	6,750	18.83 (18.43-19.24)	
Regular activity	37,795	82.63 (82.28-82.97)	7,947	17.37 (17.03-17.72)	
Job-related characteristics					
Farm Size					<0.001
Small	38,510	80.39 (80.04-80.75)	9,392	19.61 (19.25-19.96)	
Medium	25,148	82.03 (81.59-82.45)	5,510	17.97 (17.55-18.41)	
Large	26,514	81.52 (81.09-81.93)	6,012	18.48 (18.07-18.91)	
Hours worked/week					<0.001
<35 hours a week	28,288	78.25 (77.82-78.67)	7,865	21.75 (21.33-22.18)	
35-40 hours a week	33,049	82.40 (82.02-82.77)	7,061	17.60 (17.23-17.98)	
>40 hours a week	28,835	82.80 (82.40-83.20)	5,988	17.20 (16.80-17.60)	
Employment contract					<0.001
Permanent	61,060	81.75 (81.47-82.02)	13,634	18.25 (17.98-18.53)	
Casual	8,865	81.81 (81.07-82.53)	1,971	18.19 (17.47-18.93)	
Fixed-term	20,247	79.23 (78.72-79.72)	5,309	20.77 (20.28-21.28)	
Occupation					<0.001
Professional	22,060	81.08 (80.61-81.54)	5,149	18.92 (18.46-19.39)	
Managerial	11,986	82.38 (81.75-82.99)	2,564	17.62 (17.01-18.25)	
Technical trade	12,078	82.75 (82.13-83.35)	2,518	17.25 (16.65-17.87)	
Personal services	10,093	78.80 (78.08-79.50)	2,716	21.20 (20.50-21.92)	
Clerical	12,941	81.50 (80.89-82.10)	2,937	18.50 (17.90-19.11)	

Sales	8,199	81.93 (81.17-82.67)	1,808	18.07 (17.33-18.83)	
Machinery	5,193	81.48 (80.51-82.42)	1,180	18.52 (17.58-19.49)	
Labour work	7,622	78.87 (78.04-79.67)	2,042	21.13 (20.33-21.96)	
Industry					<0.001
Public services	6,076	81.62 (80.73-82.49)	1,368	18.38 (17.51-19.27)	
Agriculture	2,052	76.54 (74.90-78.10)	629	23.46 (21.90-25.10)	
Mining	1,667	84.53 (82.87-86.06)	305	15.47 (13.94-17.13)	
Manufacturing	7,327	82.22 (81.42-83.00)	1,584	17.78 (17.00-18.58)	
Electricity	927	83.97 (81.68-86.02)	177	16.03 (13.98-18.32)	
Construction	7,489	83.79 (83.01-84.54)	1,449	16.21 (15.46-16.99)	
Trade	12,034	82.31 (81.68-82.92)	2,587	17.69 (17.08-18.32)	
Hospitality	5,787	80.90 (79.98-81.80)	1,366	19.10 (18.20-20.02)	
Transport	5,633	81.13 (80.19-82.04)	1,310	18.87 (17.96-19.81)	
Finance	3,379	84.35 (83.19-85.44)	627	15.65 (14.56-16.81)	
Education	9,143	80.08 (79.34-80.80)	2,274	19.92 (19.20-20.66)	
Health	12,259	77.50 (76.84-78.14)	3,560	22.50 (21.86-23.16)	
Other services	16,399	81.68 (81.14-82.21)	3,678	18.32 (17.79-18.86)	
Supervisory responsibilities					<0.001
Yes	41,342	81.83 (81.49-82.16)	9,182	18.17 (17.84-18.51)	
No	48,830	80.63 (80.31-80.94)	11,732	19.37 (19.06-19.69)	
Employee association					<0.001
Yes	20,599	79.16 (78.67-79.65)	5,422	20.84 (20.35-21.33)	
No	69,573	81.79 (81.53-82.05)	15,492	18.21 (17.95-18.47)	
Paid sick leave					<0.001
Yes	66,664	81.75 (81.49-82.02)	14,879	18.25 (17.98-18.51)	
No	23,508	79.57 (79.11-80.03)	6,035	20.43 (19.97-20.89)	
Overall job satisfaction	90,172	7.73 (1.56)	20,914	7.32 (1.81)	<0.001

Table 3 displays the estimates of the association between obesity, LTHC, and presenteeism. To facilitate interpretation, this study presents the results in the form of odds ratios which indicate a change in the odds of presenteeism associated with a change in the level of an explanatory variable. The present study found that both obesity and LTHC were significant predictors of high presenteeism at work. The adjusted model demonstrates that the odds of presenteeism among the overweight and obese workers were 1.09 (95% CI: 1.05-1.14) and 1.38 (95% CI: 1.31-1.45) times higher, respectively, compared with workers with BMI<25. The results also revealed that workers having LTHC were 3.03 times (95% CI: 2.90-3.16) more likely to report presenteeism compared with peers not having LTHC.

Table 3: Multivariate analysis using Generalized Estimating Equation for factors associated with presenteeism.[a]

Variables	**Fully adjusted model**
	OR (95% CI), P-value
Health-related characteristics	
BMI categories categories	
BMI (<25) (ref)	
Overweight (25.00-29.99)	**1.09 (1.05-1.14), <0.001**

Obesity (≥30)	**1.38 (1.31-1.45), <0.001**
Long term health condition (LTHC)	
No (ref)	
Yes	**3.03 (2.90-3.16), <0.001**
Socio-demographic characteristics	
Age	
15-35 years (ref)	
36-55 years	**1.22 (1.16-1.27), <0.001**
56-64 years	**1.45 (1.36-1.55), <0.001**
Gender	
Male (ref)	
Female	**1.29 (1.23-1.36), <0.001**
Civil status	
Married / partnered (ref)	
Non-cohabitating	**1.07 (1.02-1.11), 0.005**
Education	
Year 12 or below (ref)	
Professional qualification	**1.10 (1.04-1.16), 0.001**
University qualification	**1.13 (1.05-1.20), <0.001**
Ethnicity	
Not of indigenous origin (ref)	
ATSI	1.11 (0.97-1.26), 0.119
Remoteness	
Major Cities	
Regional	1.01 (0.96-1.06), 0.795
Remote or very remote	0.92 (0.78-1.08), 0.317
Household income quintile	
Quintile 1 (bottom quintile)	**1.11 (1.05-1.18), <0.001**
Quintile 2	1.05 (0.99-1.10), 0.114
Quintile 3	1.00 (0.95-1.06), 0.994
Quintile 4	0.99 (0.94-1.04), 0.786
Quintile 5 (top quintile) (ref)	
Lifestyle factors	
Smoking status	
Non-smoker (ref)	
Current Smoker	**1.20 (1.15-1.26), <0.001**
Alcohol consumption	
Former/non-drinker (ref)	
Current drinker	**0.75 (0.72-0.80), <0.001**
Physical activity	
Inactive (ref)	
Some activity	**0.68 (0.65-0.72), <0.001**
Regular activity	**0.53 (0.50-0.56), <0.001**
Job-related characteristics	
Farm Size	
Small (ref)	
Medium	**0.93 (0.89-0.98), 0.003**
Large	0.96 (0.91-1.00), 0.071
Hours worked/week	
<35 hours a week	**1.10 (1.05-1.15), <0.001**
35-40 hours a week (ref)	
>40 hours a week	0.97 (0.93-1.02), 0.202

Employment contract	
Permanent (ref)	
Casual	1.04 (0.97-1.13), 0.304
Fixed-term	0.97 (0.91-1.03), 0.283
Occupation	
Professional (ref)	
Managerial	0.97 (0.90-1.04), 0.343
Technical trade	1.03 (0.95-1.12), 0.431
Personal services	1.04 (0.97-1.12), 0.293
Clerical	0.93 (0.87-1.01), 0.052
Sales	1.00 (0.92-1.09), 0.978
Machinery	0.98 (0.88-1.08), 0.681
Labour work	1.08 (0.99-1.18), 0.075
Industry	
Public services (ref)	
Agriculture	1.15 (0.98-1.34), 0.083
Mining	1.01 (0.85-1.19), 0.942
Manufacturing	0.93 (0.83-1.03), 0.152
Electricity	0.92 (0.75-1.11), 0.367
Construction	0.98 (0.88-1.09), 0.701
Trade	0.91 (0.83-1.01), 0.075
Hospitality	0.94 (0.84-1.04), 0.236
Transport	0.99 (0.88-1.10), 0.795
Finance	**0.86 (0.75-0.98), 0.024**
Education	0.99 (0.89-1.09), 0.795
Health	1.00 (0.91-1.10), 0.992
Other services	0.96 (0.88-1.05), 0.429
Supervisory responsibilities	
Yes (ref)	
No	0.97 (0.94-1.01), 0.157
Employee association	
Yes (ref)	
No	**0.93 (0.89-0.98), 0.004**
Paid sick leave	
Yes (ref)	
No	0.98 (0.91-1.05), 0.537
Overall job satisfaction (from 0 = worst to 10 = best)	**0.91 (0.90-0.92), <0.001**

Abbreviations: OR Odds Ratios; CI Confidence Interval; Ref Reference;
[a]Values in bold are statistically significant at p<0.05

Discussion

This population-based study found that the main effect of obesity and LTHC is strikingly similar. The study showed positive associations between obesity and LTHC with presenteeism among workers in different occupations in Australia.

Obese workers have higher odds of presenteeism than non-obese workers (BMI<25). The large disparity in the odds of diminished productivity at work associated with obesity is expected given that participants were explicitly asked about productivity loss stemming from physical problems. This finding is in line with previous studies where obesity has been identified as a strong predictor of presenteeism (Janssens et al., 2012; Sanchez Bustillos et al., 2015). Other observational studies conducted in the US have confirmed that obesity had a negative impact on work through presenteeism (Gates et al., 2008; Goetzel et al., 2010; Kudel et al., 2018). However, a recent study using a cross-sectional correlational design found that BMI was unrelated to presenteeism (Callen et al., 2013).

Presenteeism at work may occur due to health problems, such as the functional limitations of the workers. Another striking finding of the present study is that LTHC is linked to an increase in the odds of presenteeism. This finding is in line with an earlier study that found employees with chronic health conditions report higher rates of presenteeism compared with peers without having such health conditions (Hafner et al., 2015). A prior study also revealed that workers with moderate and severe functional limitations due to health problems were 1.28 and 1.63 times, respectively, more likely to report productivity loss at work (Alavinia et al., 2009). Besides, a recent study claimed that the likelihood of presenteeism is higher among workers with chronic health conditions (Sanchez Bustillos et al., 2015). However, this finding is contrary to other studies that have suggested that health conditions, such as allergies, asthma, arthritis, back pain, sinus problems, broken bones, heart disease, cancer, and diabetes are not associated with presenteeism in the workplace (Callen et al., 2013).

There are several reasons behind the positive association between obesity and LTHC with work productivity impairment. Obese workers often face difficulty in moving due to bodyweight/size and excess adiposity. Moreover, body pain, musculoskeletal pain, osteoarthritis, and rheumatoid arthritis are often associated with weight gain (Andersen et al., 2003). The presence of these co-morbidities may limit obese workers' ability to move without pain or discomfort and could result in productivity impairment in a physically demanding job (Stewart et al., 2003). Another possible explanation is that obese workers with sleep apnea and heart disease may experience weakness and dyspnea (shortness of breath). These health conditions make workers tired or slow to complete their job tasks on time (Gates et al., 2008).

The study findings confirm the need for effective interventions to reduce obesity in workers and improve their productivity at work. At present, the workplace has been considered as a potential avenue through which interventions could be implemented for managing healthy weight (Shrestha et al., 2016). The findings of this study are expected to serve as useful evidence to health policymakers and employers to initiate workplace-based interventions to combat the obesity epidemic at work and thus reducing the productivity loss of the workers. Organizations should focus on multi-pronged interventions, such as providing information, social support for promoting a healthy lifestyle, and modification of the work environment to facilitate weight management of employees. For example, organizations may introduce sit-stand desks to reduce sitting time at work among desk-based workers, offer healthier food choices in cafeteria menus and vending machines, encourage walking during breaks, support active commuting options, provide educational modules on physical activity, diet, and lifestyle change, and establish gym and activity centers for performing physical activities.

The present study offers an important contribution to the existing body of knowledge by revealing a longitudinal association between obesity and LTHC with workplace performance by using data of 111,086 Australian workers from 2006 through 2018. In the existing literature, the majority of studies were cross-sectionally designed and thus cannot reveal the within-person change in presenteeism due to obesity and LTHC. The present study has several important strengths. First, is that it measured presenteeism using three comprehensive questions. Many of the previous studies assessed presenteeism through a single question (Aronsson et al., 2000; Bergström et al., 2009; Janssens et al., 2012) and it is difficult to establish the validity of presenteeism measure through a single question. Moreover, this study incorporated a large number of employment controls including less investigated variables (supervisory responsibilities, member of employee association or union, paid sick leave, and overall job satisfaction) to precisely estimate the association between obesity and LTHC with presenteeism. Additionally, this study fills the gap of the lack of studies on the longitudinal association between obesity and LTHC with presenteeism.

The present study has certain limitations that should be considered when interpreting the findings. First, the study results might be vulnerable to self-reported bias, as data on BMI and presenteeism along with other covariates were self-reported. Previous studies demonstrated that self-reported BMI is usually less than actual BMI as respondents tend to underreport weight and overreport height (Gorber et al., 2007a; Maukonen et al., 2018). Besides, this study's unbalanced longitudinal research design prevents inferring the direction of causality. Given these limitations, the present study calls for prospective research that may capture the within-person change in presenteeism due to obesity and LTHC.

Conclusion and recommendations

In summary, the present study utilized a large nationally representative dataset over the period from 2006 to 2018 to examine the longitudinal association between obesity, LTHC, and presenteeism. The study findings demonstrated that obesity and LTHC have longitudinal associations with presenteeism, independent of health, socio-demographic, lifestyle, and job-related confounders. Overweight and obesity among workers increases the costs of employers as overweight and obese workers reported higher presenteeism than under and normal-weight counterparts (BMI<25) at work. This study adds evidence to the existing literature that has shown the negative impact of obesity on presenteeism.

Presenteeism is a perennial and costly problem that should be tackled. The study findings stress the importance of health promotion, more specifically promoting healthy weight maintenance to reduce presenteeism or productivity loss at work. Maintaining healthy weight among workers through a healthy lifestyle may result in lower presenteeism, leading to socio-economic benefits for individual workers, employers, and society as a whole.

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CHAPTER 4: STUDY 3

Obesity, long-term health problems, and workplace satisfaction: A longitudinal study of Australian workers

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Abstract

This study investigates the impact of obesity, long-term health problems and their interaction on three specific aspects of job satisfaction among Australian adult workers. Exploiting longitudinal data from the Household, Income and Labour Dynamics in Australia (HILDA) survey for the years 2006-2017, this study estimates overall job satisfaction, pay satisfaction and job security satisfaction using a common set of explanatory variables. Results from both random effects generalized least squares estimation and random effects ordered probit model confirm that obesity has a significant negative impact on workers' pay and job security satisfaction. The results indicate that overweight workers are dissatisfied about their job security compared to normal weight peers. The study results reveal that long-term health problems significantly reduce all aspects of job satisfaction of the workers. However, the results indicate that the interaction of obesity and long-term health problems positively influences workers' overall job satisfaction. Overall, the study findings are in line with the hypothesis that obese workers with long-term health problems have low expectations about their job.

Keywords: Australia, job security satisfaction, long-term health problems, obesity, overall job satisfaction, pay satisfaction

Introduction

In Australia, 2 in 3 adults and 1 in 4 children are either overweight or obese (Australian Bureau of Statistics, 2015). It is estimated that around 83% of males and 75% of females in Australia will either be pre-obese or obese by 2025 (Haby et al., 2012). The high prevalence of pre-obesity and obesity in Australia has become a serious public health concern due to its adverse health and socio-economic impacts. Pre-obesity and obesity are associated with a higher risk of developing many chronic diseases including type 2 diabetes, cardiovascular disease, musculoskeletal disease, gout, osteoarthritis, chronic kidney disease, gallbladder disease, asthma, dementia, and certain types of cancer (Australian Institute of Health and Welfare, 2017d; Peeters and Backholer, 2012). Moreover, obesity adversely affects psycho-social well-being and the productivity of individuals as workers (Pagan et al., 2016).

Illness, due to overweight and obesity, has a significant burden on the Australian economy with an estimated financial cost of obesity in 2011-12 of AUD 8.6 billion (Australian Institute of Health and Welfare, 2017a). This cost includes direct costs (obesity-related health care costs) of AUD 3.8 billion and indirect costs (e.g., productivity losses, increased sick leave, unemployment, early retirement, disability caregiver costs, and welfare payments) of AUD 4.8 billion (Australian Institute of Health and Welfare, 2017a). The rising number of obese people in Australia has serious implications for the workplace and employers. For example, Australian employers bear indirect costs due to the absenteeism (absent from work) and presenteeism (present at work but with lower productivity) of obese workers. Average absence days per annum of an obese worker (3.8 days) is higher than non-obese (3.0 days) in the workplace in Australia (Australian Institute of Health and Welfare, 2005). There is also evidence that 6.5 working days per employee are lost each year due to presenteeism in Australia (Econtech, 2011). Further, there are high hidden costs of obesity through early retirement, such as training replacement staff and administrative costs related to recruiting new employees.

To reduce the financial burden on the Australian economy, it is important to assess the consequences of obesity on health and labour market outcomes. There is substantial evidence that obesity has a negative association with labour market outcomes. Studies conducted in the United States (US) and many European countries have confirmed that obese people are less likely to be hired than their non-obese counterparts (Greve, 2007; Johansson et al., 2009; Lindeboom et al., 2010; Morris, 2007). The most common finding is that obese people, especially white women, receive lower incomes compared to their non-obese counterparts (Cawley, 2004; Greve, 2007; Johansson et al., 2009; Larose et al., 2016; Morris, 2006; Shimokawa, 2008). The possible reason is that obese people face taste-based (employers or customers have subjective distaste against obese workers) or statistical discrimination (employers have imperfect information about potential obese workers) in the labour market (Averett, 2014). Prevalence of discrimination against obese workers reduces their expectations from the workplace and it has a significant impact on job satisfaction of obese workers (Pagan et al., 2016).

Job satisfaction is a subjective measure of a worker's perception of their job (Bruno et al., 2015) and depends on their expectations (Clark, 1997). Due to low expectations about their job, it is hypothesized that obese workers have low satisfaction with different aspects of job satisfaction. There is some empirical evidence that explores the association between obesity and different aspects of job satisfaction (Bruno et al., 2015; Pagan et al., 2016). Mixed results have been observed in the literature while confirming the association between obesity and job security satisfaction (Bruno et al., 2015; Muenster et al., 2011). A recent longitudinal study revealed that obesity had no significant influence on pay and job security satisfaction among Italian workers (Bruno et al., 2015). However, another quantitative study confirmed that obesity significantly reduced German worker’s job security satisfaction (Muenster et al., 2011). In addition, a longitudinal study on Korean workers confirmed that obesity is negatively associated with job quality (an index where job security was a component) (Kim and Han, 2015). Apart from obesity, studies demonstrate that long-term health problems in the form of disability and work limitations reduce the level of overall job satisfaction (Pagan et al., 2016; Rodríguez et al., 2014). Further, a recent investigation reported that workers with a disability have lower psychosocial job security compared with workers without a disability in Australia (LaMontagne et al., 2016). However, another study revealed that the interaction of obesity and disability has a positive impact on overall job satisfaction (Pagan et al., 2016).

Job satisfaction is an important component of labour market outcomes as it carries information regarding a workers’ economic life and their decisions about participation in the labour market (Eurofound, 2007; Freeman, 2019). However, job satisfaction aspect of labour market outcomes does not receive significant attention in the literature. In the existing evidence, it is observed that the influence of obesity and disability on different aspects of job satisfaction, after controlling a wide array of workplace characteristics, have been absent. Further, to the best knowledge of the authors, no study has yet considered the effect of the interaction of obesity and long-term health problems on pay satisfaction and job security satisfaction. To address these gaps in knowledge, this study aims to examine the effects of obesity, long-term health problems, and their interaction after controlling diverse workplace characteristics on three aspects of job satisfaction.

The present study estimates the relationship between obesity, long-term health problems, and three aspects of job satisfaction (overall job satisfaction, pay satisfaction and job security satisfaction) by exploiting newly available longitudinal data from the Household, Income and Labour Dynamics in Australia (HILDA) survey. Based on previous evidence, this study hypothesizes that both obesity and long-term health problems of workers will result in a decrease in overall job satisfaction, pay satisfaction and job security satisfaction. Nowadays, there is a compelling interest of government and employers to reduce discrimination against obese workers and thus improving job satisfaction of the workers (Averett, 2014). The study might be used as important evidence for making policies to reduce discrimination against obese and disabled workers in the labour market and thus help to increase workers' job satisfaction.

Data and method

Sample

The empirical analysis is based on data collected by the annual HILDA survey in Australia. The survey is a nationally representative, household-based panel study that collects detailed information on an individual's demographic, health, social and economic characteristics. Data are collected from individuals aged 15 years or over through a combination of face-to-face interviews and self-completed questionnaires. HILDA survey has been conducted each year since 2001. The details of collecting data have been described elsewhere (Freidin et al., 2002).

This study follows longitudinal research design and analyzed data using 12 waves (wave 6 to wave 17) of the survey, from 2006 to 2017, as data on body mass index (BMI) are available only in these waves. The analysis is restricted to only employed participants aged 17 years to 64 years who responded to the questions relating to overall job satisfaction, pay satisfaction and job security satisfaction. Further, self-employed adults and women who were pregnant during the surveys were excluded for the subsample analysis. Following the exclusion criteria, the final sample is made up of 82,064 observations.

Measures

Outcome variables

The HILDA survey covers a wide range of individuals' job characteristics includes workplace satisfaction. Three different job satisfaction measures (overall job satisfaction, pay satisfaction and job security satisfaction) have been used as the dependent variables and are measured in an ordinal scale ranging from 0 (totally dissatisfied) to 10 (totally satisfied).

Exposure variables

The main variables of interest in this study are BMI and long-term health problems. BMI is calculated using self-reported height and weight following the formula weight (in kilograms) divided by height (in meters squared). This study categorized BMI into four groups following the World Health Organization (WHO) guidelines: <18.50 (underweight), 18.50–24.90 (normal/healthy weight), 25.00-29.90 (overweight), and ≥30.00 (obese) (World Health Organization, 2020a). This classification enables the authors to examine the effects of being pre-obese and obese on different aspects of job satisfaction compared to healthy weight peers.

Long-term health problems of an individual are measured in the HILDA survey following the guidelines of the International Classification of Functioning, Disability, and Health (ICF) under the WHO framework (LaMontagne et al., 2016). Participants were asked if they have any 'long-term health problems, impairment or disability that restricts them in everyday activities, and has lasted or are likely to last, for 6 months or more' (Melbourne Institute of Applied Economic and Social Research, 2018). Responses were taken in binary form (yes and no). Participants who answered yes were defined as an individual with long-term health problems.

Other covariates

This study selected potential covariates based on existing literature (Bruno et al., 2015; Kifle, 2014; Kifle et al., n.d.; Pagan et al., 2016). The variables included in this study are sex (male and female), age (young worker: 15-35 years, middle-aged worker: 36-55 years, and older worker: >55 years), marital status (married and non-cohabitating), education (three categories: year 12 and below; professional qualification and university qualification), place of living (three groups: major city, regional and remote areas), weekly wages and salary of the workers, hours per week usually worked (less than 30 hours, 30-40 hours and over 40 hours a week), tenure in current occupation (1-5 years and 6 or more years), tenure with current employer (1-5 years and 6 or more years), employment contract in current job (three groups: permanent, fixed-term and casual), farm size (3 groups: small, medium, and large), supervisory responsibilities (yes and no), union membership (yes and no), occupation (nine groups: professional, managerial, technical trade, personal services, clerical, sales, machinery, and labour work), workers' industry (thirteen groups: public services, agriculture, mining, manufacturing, electricity, construction, trade, hospitality, transport, finance, education, health and other services), paid holiday leave (yes and no), and paid sick leave (yes and no).

Methods

To examine the effect of obesity and long-term health problems on worker's job satisfaction, this study follows the theoretical framework of Clark and Oswald (1996) (Clark and Oswald, 1996). Under this framework, a worker's utility (job satisfaction) from the job can be expressed in the following way:

$U_j = U_j\ (y, h, i, w)$ (1)

Where y refers to the worker's income, h refers to hours worked, i is a vector of worker's personal characteristics and w is a set of job specific variables.

In this study, outcome variables (overall job satisfaction, pay satisfaction and job security satisfaction) are ordinal in nature ranging from 0 to 10. It is not ideal to employ ordinary least squares (OLS) estimates when the outcome variable is an ordinal variable as the distance between each of the scale points are not equal. Hence, the random effects ordered probit model is the best fit. The advantage of using that model is it can control unobserved time-invariant individual heterogeneity. Further, applying a random effect model is more appropriate when data are an unbalanced panel. However, there is a consensus that generalized least squares estimates (GLS) techniques offer similar results considering the ordinal variable as a continuous variable (Clark et al., 2010; Ferrer-i-Carbonell, 2014). The main advantage of using GLS technique over the ordered probit model is that coefficients are easily interpretable (Kifle et al., n.d.). Considering these issues, this study employed both models and took the coefficients as the study outcomes only when they are significant in both estimation techniques. As a result, this study results offer a more precise estimation of the effects.

The general form of the econometric model of three different aspects of job satisfaction is as follows:

$Y^*_{it} = B^/ x_{it} + \varepsilon_{it}$; I = 1,….N; t = 1…….,12 (2)

Where Y^*_{it} is a latent variable that indicates the unobserved level of job satisfaction of individual i at time t. $B^/$ is a vector of estimated coefficients and x_{it} is a vector of timevarying and time-invariant factors. ε_{it} is the error term that consists of time and the individual-specific error term. Due to the ordinal nature of the dependent variable (Y^*_{it}), it is estimated in terms of the explanatory variables and a set of cut-off point Zj (j = 0, 1, 2, …..,10).

$Y_{it} = 0$ if $Y^*_{it} \leq Z_1$

$Y_{it} = 1$ if $Z_1 < Y^*_{it} \leq Z_2$

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$Y_{it} = 10$ if $Z_{10} < Y^*_{it}$

The empirical specification of the random effect GLS estimation is similar to the general form ($Y^*_{it} = B^{/} x_{it} + \varepsilon_{it}$; I = 1,….N; t = 1…….,12) of a random effect probit model. However, the difference lies in the fact that GLS techniques considered an ordinal variable as a continuous variable (Clark et al., 2010; Ferrer-i-Carbonell, 2014).

Results

Descriptive analysis

Table 1 reports the descriptive statistics of the sample. Of the 82064 observations, 50.32% were male and 49.68% were female. Table 1 shows Australian workers' levels of satisfaction in terms of average overall job satisfaction (7.63), pay satisfaction (7.09), and job security satisfaction (7.93) on a 10-point job satisfaction scale. Obese and pre-obese workers make up 58% of the sample, whereas 42% of workers reported a healthy weight. This study also found that 17% of workers have long-term health problems.

Table 1: Background characteristics of the study participants

Variables	n	Mean (SD)/ (%)
Outcome Variable: Facets of job satisfaction		
Overall job satisfaction, mean (sd)	82064	7.63 (1.61)
Pay satisfaction, mean (sd)	82064	7.09 (1.99)
Job security satisfaction, mean (sd)	82064	7.93 (2.02)
Explanatory Variables		
Health status variable		
BMI		
Healthy weight	34,291	41.79
Overweight	29,102	35.46
Obesity	18,671	22.75
Long term health problems		
No	68,512	83.49
Yes	13,552	16.51
Socio-demographic characteristics		
Age		
15-35	32,148	39.17
36-55	39,131	47.68
56 to above	10,785	13.14

Sex		
Male	41,291	50.32
Female	40,773	49.68
Marital Status		
Married	40,034	48.78
Non-cohabitating	42,030	51.22
Education		
Year 12 and below	29,361	35.78
Professional qualifications	27,267	33.22
University qualifications	25,436	31.00
Place of living		
Major city	56,767	69.17
Regional	24,081	29.34
Remote	1,216	1.48
Job Characteristics		
Weekly gross wages and salary, mean (sd)	82064	1070.80 (865.43)
Hours per week usually worked		
<30 hours a week	18,970	23.12
30-40 hours a week	36,353	44.30
>40 hours a week	26,741	32.59
Tenure-current occupation		
1-5 years	35,312	43.03
6 or more years	46,752	56.97
Tenure-current employer		
1-5 years	43,791	53.36
6 or more years	38,273	46.64
Employment contract		
Permanent	57,166	69.66
Fixed-term	8,179	9.97
Casual	16,719	20.37
Farm size		
Small	31,122	37.92
Medium	24,472	29.82
Large	26,470	32.26
Supervisory responsibilities		
Yes	40,821	49.74
No	41,243	50.26
Union membership or employee association		
Yes (Reference)	21,015	25.61
No	61,049	74.39
Occupation		
Professional	20,284	24.72
Managerial	11,097	13.52
Technical trade	10,111	12.32
Personal services	9,354	11.4
Clerical	12,846	15.65
Sales	6,942	8.46
Machinery	4,909	5.98
Labour Work	6,521	7.95
Industry		
Public services	6,142	7.48
Agriculture	1,844	2.25
Mining	1,624	1.98
Manufacturing	6,888	8.39

electricity	885	1.08
Construction	5,827	7.10
Trade	10,833	13.20
Hospitality	4,874	5.94
Transport	5,318	6.48
Finance	3,091	3.77
Education	9,057	11.04
Health	12,261	14.94
Other services	13,420	16.35
Paid holiday leave		
Yes	62,640	76.33
No	19,424	23.67
Paid sick leave		
Yes	62,811	76.54
No	19,253	23.46

Table 2 shows the workers' different levels of job satisfaction according to their weight status, long-term health problems, and other characteristics. For the sake of simplicity, some previous studies have converted job satisfaction into a categorical variable (Ezzat and Ehab, 2018; Fabian and Breunig, 2016). Following the same approach, this study categorizes job satisfaction variables into three bands: dissatisfied (0-4 points), neutral (5-7 points), and satisfied (8-10 points). It is observed that over 5% of overweight and obese workers, combined were dissatisfied about their overall job satisfaction. The percentages of dissatisfaction of the same groups of workers were much higher in the case of pay (14%) and job security satisfaction (10%). Percentages of the dissatisfied worker with long-term health problems were higher in case of overall job satisfaction (4.12), pay satisfaction (9.69), and job security satisfaction (7.47) compared to workers without long-term health problems.

Table 2: Background characteristics of the study participants according to the categories of different aspects of job satisfaction

Variables	Overall satisfaction			Pay satisfaction			Job security satisfaction		
	Dissatisfied	Neutral	Satisfied	Dissatisfied	Neutral	Satisfied	Dissatisfied	Neutral	Satisfied
BMI									
Healthy weight	856 (2.50)	5272 (15.37)	28163 (82.13)	2179 (6.35)	7635 (22.27)	24477 (71.38)	1470 (4.29)	4423 (12.90)	28398 (82.81)
Overweight	711 (2.44)	4218 (14.49)	24173 (83.06)	1900 (6.53)	6189 (21.27)	21013 (72.20)	1400 (4.81)	3888 (13.36)	23814 (81.83)
Obesity	543 (2.57)	2763 (14.80)	15365 (82.29)	1401 (7.50)	4304 (23.05)	12966 (69.44)	985 (5.28)	2588 (13.86)	15098 (80.86)
Health problems									
No	1551 (2.26)	9804 (14.31)	57157 (83.43)	4167 (6.08)	14810 (21.62)	49535 (72.30)	2843 (4.15)	8773 (12.81)	56896 (83.05)
Yes	559 (4.12)	2449 (18.07)	10544 (77.80)	1313 (9.69)	3318 (24.48)	8921 (65.83)	1012 (7.47)	2126 (15.69)	10414 (76.84)
Age									
15-35	857 (2.67)	5311 (16.52)	25980 (80.81)	2171 (6.75)	7666 (23.85)	22311 (69.40)	1224 (3.81)	4168 (12.97)	26756 (83.23)
36-55	1018 (2.60)	5682 (14.52)	32431 (82.88)	2656 (6.79)	8331 (21.29)	28144 (71.92)	2086 (5.33)	5434 (13.89)	31611 (80.78)
56 to above	235 (2.18)	1260 (11.68)	9290 (86.14)	653 (6.05)	2131 (19.76)	8001 (74.19)	545 (5.05)	1297 (12.03)	8943 (82.92)
Sex									
Male	1090 (2.64)	6202 (15.02)	33999 (82.34)	2659 (6.44)	8869 (21.48)	29763 (72.08)	1854 (4.49)	5541 (13.42)	33896 (82.09)
Female	1020 (2.50)	6051 (14.84)	33702 (82.66)	2821 (6.92)	9259 (22.71)	28693 (70.37)	2001 (4.91)	5358 (13.14)	33414 (81.95)
Marital Status									
Married	885 (2.21)	5209 (13.01)	33940 (84.78)	2384 (5.95)	8033 (20.07)	29617 (73.98)	1814 (4.53)	5092 (12.72)	33128 (82.75)
Non-cohabitating	1225 (2.91)	7044 (16.76)	33761 (80.33)	3096 (7.37)	10095 (24.02)	28839 (68.62)	2041 (4.86)	5807 (13.82)	34182 (81.33)
Education									
Year 12 and below	760 (2.59)	4517 (15.38)	24084 (82.03)	2088 (7.11)	6910 (23.53)	20363 (69.35)	1179 (4.02)	3897 (13.27)	24285 (82.71)
Professional qualifications	750 (2.75)	3957 (14.51)	22560 (82.74)	2000 (7.33)	6301 (23.11)	18966 (69.56)	1419 (5.20)	3711 (13.61)	22137 (81.19)
University qualifications	600 (2.36)	3779 (14.86)	21057 (82.78)	1392 (5.47)	4917 (19.33)	19127 (75.20)	1257 (4.94)	3291 (12.94)	20888 (82.12)
Place of living									
Major city	1529 (2.69)	8767 (15.44)	46471 (81.86)	3759 (6.62)	12670 (22.32)	40338 (71.06)	2739 (4.82)	7660 (13.49)	46368 (81.68)
Regional	565 (2.35)	3338 (13.86)	20178 (83.79)	1651 (6.86)	5231 (21.72)	17199 (71.42)	1075 (4.46)	3095 (12.85)	19911 (82.68)
Remote	16 (1.32)	148 (12.17)	1052 (86.51)	70 (5.76)	227 (18.67)	919 (75.58)	41 (3.37)	144 (11.84)	1031 (84.79)
Job Characteristics									
Weekly gross salary, mean (sd)	907.37 (689.76)	997.56 (768.24)	1089.15 (885.49)	718.53 (576.26)	860.73 (619.7)	1168.97 (930.74)	999.61 (852.18)	1029.27 (838.32)	1081.60 (870.10)
Hours per week worked									
<30 hours a week	518 (2.73)	2838 (14.96)	15614 (82.31)	1386 (7.31)	4438 (23.39)	13146 (69.30)	1050 (5.54)	2873 (15.14)	15047 (79.32)
30-40 hours a week	916 (2.52)	5237 (14.41)	30200 (83.07)	2367 (6.51)	8378 (23.05)	25608 (70.44)	1686 (4.64)	4766 (13.11)	29901 (82.25)
>40 hours a week	676 (2.53)	4178 (15.62)	21887 (81.85)	1727 (6.46)	5312 (19.86)	19702 (73.68)	1119 (4.18)	3260 (12.19)	22362 (83.62)
Tenure-current occupation									
1-5 years	932 (2.64)	5758 (16.31)	28622 (81.05)	2605 (7.38)	8515 (24.11)	24192 (68.51)	1683 (4.77)	4974 (14.09)	28655 (81.15)
6 or more years	1178 (2.52)	6495 (13.89)	39079 (83.59)	2875 (6.15)	9613 (20.56)	34264 (73.29)	2172 (4.65)	5925 (12.67)	38655 (82.68)
Tenure-current employer									
1-5 years	1279 (2.92)	7175 (16.38)	35337 (80.69)	3283 (7.50)	10559 (24.11)	29949 (68.39)	2178 (4.97)	6328 (14.45)	35285 (80.58)
6 or more years	831 (2.17)	5078 (13.27)	32364 (84.56)	2197 (5.74)	7569 (19.78)	28507 (74.48)	1677 (4.38)	4571 (11.94)	32025 (83.68)
Employment contract									
Permanent	1319 (2.31)	8075 (14.13)	47772 (83.57)	3582 (6.27)	12463 (21.8)	41121 (71.93)	1749 (3.06)	6085 (10.64)	49332 (86.30)

Fixed-term	196 (2.40)	1215 (14.86)	6768 (82.75)	564 (6.90)	1746 (21.35)	5869 (71.76)	763 (9.33)	1649 (20.16)	5767 (70.51)
Casual	595 (3.56)	2963 (17.72)	13161 (78.72)	1334 (7.98)	3919 (23.44)	11466 (68.58)	1343 (8.03)	3165 (18.93)	12211 (73.04)
Farm size									
Small	816 (2.62)	4425 (14.22)	25881 (83.16)	2660 (8.55)	7731 (24.84)	20731 (66.61)	1364 (4.38)	4084 (13.12)	25674 (82.49)
Medium	655 (2.68)	3807 (15.56)	20010 (81.77)	1565 (6.40)	5395 (22.05)	17512 (71.56)	1200 (4.90)	3147 (12.86)	20125 (82.24)
Large	639 (2.41)	4021 (15.19)	21810 (82.40)	1255 (4.74)	5002 (18.90)	20213 (76.36)	1291 (4.88)	3668 (13.86)	21511 (81.27)
Supervisory responsibilities									
Yes	902 (2.21)	5712 (13.99)	34207 (83.80)	2497 (6.12)	8551 (20.95)	29773 (72.94)	1493 (3.66)	4300 (10.53)	35028 (85.81)
No	1208 (2.93)	6541 (15.86)	33494 (81.21)	2983 (7.23)	9577 (23.22)	28683 (69.55)	2362 (5.73)	6599 (16.00)	32282 (78.27)
Union membership									
Yes	497 (2.36)	3100 (14.75)	17418 (82.88)	1067 (5.08)	4130 (19.65)	15818 (75.27)	985 (4.69)	2574 (12.25)	17456 (83.06)
No	1613 (2.64)	9153 (14.99)	50283 (82.36)	4413 (7.23)	13998 (22.93)	42638 (69.84)	2870 (4.70)	8325 (13.64)	49854 (81.66)
Occupation									
Professional	394 (1.94)	2666 (13.14)	17224 (84.91)	968 (4.77)	3788 (18.67)	15528 (76.55)	1029 (5.07)	2448 (12.07)	16807 (82.86)
Managerial	243 (2.19)	1482 (13.35)	9372 (84.46)	773 (6.97)	2067 (18.63)	8257 (74.41)	411 (3.70)	1182 (10.65)	9504 (85.64)
Technical trade	251 (2.48)	1462 (14.46)	8398 (83.06)	727 (7.19)	2415 (23.88)	6969 (68.92)	463 (4.58)	1397 (13.82)	8251 (81.60)
Personal services	266 (2.84)	1384 (14.80)	7704 (82.36)	850 (9.09)	2472 (26.43)	6032 (64.49)	454 (4.85)	1294 (13.83)	7606 (81.31)
Clerical	319 (2.48)	1856 (14.45)	10671 (83.07)	770 (5.99)	2737 (21.31)	9339 (72.70)	632 (4.92)	1708 (13.30)	10506 (81.78)
Sales	208 (3.00)	1270 (18.29)	5464 (78.71)	507 (7.30)	1814 (26.13)	4621 (66.57)	243 (3.50)	890 (12.82)	5809 (83.68)
Machinery	195 (3.97)	918 (18.70)	3796 (77.33)	383 (7.80)	1102 (22.45)	3424 (69.75)	281 (5.72)	873 (17.78)	3755 (76.49)
Labour Work	234 (3.59)	1215 (18.63)	5072 (77.78)	502 (7.70)	1733 (26.58)	4286 (65.73)	342 (5.24)	1107 (16.98)	5072 (77.78)
Industry									
Public services	120 (1.95)	773 (12.59)	5249 (85.46)	183 (2.98)	1011 (16.46)	4948 (80.56)	247 (4.02)	665 (10.83)	5230 (85.15)
Agriculture	36 (1.95)	261 (14.15)	1547 (83.89)	238 (12.91)	492 (26.68)	1114 (60.41)	101 (5.48)	242 (13.12)	1501 (81.40)
Mining	32 (1.97)	253 (15.58)	1339 (82.45)	46 (2.83)	199 (12.25)	1379 (84.91)	113 (6.96)	346 (21.31)	1165 (71.74)
Manufacturing	237 (3.44)	1132 (16.43)	5519 (80.12)	534 (7.75)	1620 (23.52)	4734 (68.73)	406 (5.89)	1085 (15.75)	5397 (78.35)
electricity	22 (2.49)	115 (12.99)	748 (84.52)	24 (2.71)	124 (14.01)	737 (83.28)	58 (6.55)	150 (16.95)	677 (76.50)
Construction	112 (1.92)	754 (12.94)	4961 (85.14)	342 (5.87)	1302 (22.34)	4183 (71.79)	271 (4.65)	792 (13.59)	4764 (81.76)
Trade	342 (3.16)	1900 (17.54)	8591 (79.30)	854 (7.88)	2644 (24.41)	7335 (67.71)	364 (3.36)	1375 (12.69)	9094 (83.95)
Hospitality	201 (4.12)	1051 (21.56)	3622 (74.31)	448 (9.19)	1390 (28.52)	3036 (62.29)	167 (3.43)	701 (14.38)	4006 (82.19)
Transport	169 (3.18)	872 (16.4)	4277 (80.42)	335 (6.30)	1104 (20.76)	3879 (72.94)	296 (5.57)	867 (16.30)	4155 (78.13)
Finance	69 (2.23)	447 (14.46)	2575 (83.31)	153 (4.95)	608 (19.67)	2330 (75.38)	130 (4.21)	402 (13.01)	2559 (82.79)
Education	151 (1.67)	1049 (11.58)	7857 (86.75)	458 (5.06)	1572 (17.36)	7027 (77.59)	663 (7.32)	1143 (12.62)	7251 (80.06)
Health	273 (2.23)	1620 (13.21)	10368 (84.56)	873 (7.12)	2917 (23.79)	8471 (69.09)	418 (3.41)	1331 (10.86)	10512 (85.74)
Other services	346 (2.58)	2026 (15.10)	11048 (82.32)	992 (7.39)	3145 (23.44)	9283 (69.17)	621 (4.63)	1800 (13.41)	10999 (81.96)
Paid holiday leave									
Yes (Reference)	1446 (2.31)	9011 (14.39)	52183 (83.31)	3949 (6.30)	13715 (21.89)	44976 (71.80)	2340 (3.74)	7298 (11.65)	53002 (84.61)
No	664 (3.42)	3242 (16.69)	15518 (79.89)	1531 (7.88)	4413 (22.72)	13480 (69.40)	1515 (7.8)	3601 (18.54)	14308 (73.66)
Paid sick leave									
Yes (Reference)	1438 (2.29)	9007 (14.34)	52366 (83.37)	3953 (6.29)	13743 (21.88)	45115 (71.83)	2375 (3.78)	7340 (11.69)	53096 (84.53)
No	672 (3.49)	3246 (16.86)	15335 (79.65)	1527 (7.93)	4385 (22.78)	13341 (69.29)	1480 (7.69)	3559 (18.49)	14214 (73.83)

Empirical outcomes

The main aim of this study was to examine the effects of pre-obesity, obesity and long-term health problems on three aspects of worker's job satisfaction. The same set of covariates have been used to test the effects on their overall job, pay and job security satisfaction. Table 3 presents the estimated coefficients with respective standard errors obtained from the random effect GLS estimation and random effect ordered probit model. The results indicate that obesity has a significant negative impact on pay satisfaction (-0.09 points). Moreover, both overweight (-0.06 points) and obesity (-0.14 points) has a significant negative effect on job security satisfaction. These results are broadly consistent with the hypothesis that obesity lowers pay and job security satisfaction. However, this study does not find any evidence that obesity influences workers' overall job satisfaction.

Table 3: Effects of obesity and long-term health problems on different aspects of job satisfaction

Variables	**Overall**		**Pay**		**Job Security**	
	GLS	Ordered Probit	GLS	Ordered Probit	GLS	Ordered Probit
BMI						
Healthy weight (Reference)						
Overweight	0.01	0.01	-0.02	-0.02	-0.06**	-0.04**
	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)
Obesity	-0.03	-0.02	-0.09**	-0.06***	-0.14***	-0.10***
	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)
Long term health problems						
No (Reference)						
Yes	-0.21***	-0.15***	-0.16***	-0.10***	-0.19***	-0.11***
	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)
Interaction terms						
overweight × having health problems	0.05	0.04	0.02	0.02	-0.04	-0.02
	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)
obesity × having health problems	0.10***	0.07*	0.08	0.05	0.01	0.01
	(0.04)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)
Age						
15-35 (Reference)						
36-55	0.05**	0.06***	-0.03	-0.01	-0.24***	-0.17***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
56 to above	0.18***	0.18***	0.09**	0.10***	-0.19***	-0.14***
	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)
Sex						
Male (Reference)						
Female	0.05*	0.05**	0.11***	0.10***	0.01	0.02
	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)
Marital status						
Married (Reference)						
Non-cohabitating	-0.07***	-0.06***	-0.09***	-0.06***	-0.06**	-0.04*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Education						
Year 12 and below						
Professional qualifications	-0.15***	-0.14***	-0.21***	-0.15***	-0.22***	-0.14***
	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)
University qualifications	-0.35***	-0.34***	-0.28***	-0.21***	-0.29***	-0.20***
	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)
Place of living						

Major city (Reference)						
Regional	0.13***	0.12***	0.16***	0.13***	0.08**	0.06**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Remote	0.29***	0.26***	0.35***	0.28***	0.28***	0.22***
	(0.06)	(0.06)	(0.07)	(0.07)	(0.07)	(0.06)
log of weekly gross salary	0.08***	0.06***	0.55	0.38***	-0.09***	-0.07***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Hours per week worked						
<30 hours	0.12***	0.12***	0.32***	0.25***	0.01	-0.01
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
30-40 hours (Reference)						
>40 hours	-0.11***	-0.10***	0.03	0.03*	0.09***	0.06***
	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)
Tenure-current occupation						
1-5 years (Reference)						
6 or more years	-0.04**	-0.03*	0.02	0.01	-0.03	-0.01
	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)
Tenure-current employer						
1-5 years (Reference)						
6 or more years	-0.01	-0.02	0.02	0.02	-0.02	-0.01
	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)
Employment contract						
Permanent (Reference)						
Fixed-term	0.01	0.01	0.04	0.04	-0.72***	-0.46***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Casual	-0.11***	-0.10**	0.15***	0.10***	-0.56***	-0.38***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Farm size						
Small (Reference)						
Medium	-0.09***	-0.09***	0.08***	0.04**	-0.06**	-0.05**
	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)
Large	-0.08***	-0.09***	0.20***	0.14***	-0.05*	-0.04*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Supervisory responsibilities						
Yes (Reference)						
No	0.01	0.01	0.03	0.03*	-0.25***	-0.19*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Union membership						
Yes (Reference)						
No	0.08***	0.07***	-0.06**	-0.03*	0.04	0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Occupation						
Professional (Reference)						
Managerial	-0.03	-0.02	0.02	0.03	0.03	0.01
	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)
Technical trade	-0.08**	-0.06*	-0.14***	-0.08**	0.01	0.01
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Personal services	-0.06*	-0.05	-0.21***	-0.14***	0.01	-0.01
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Clerical	-0.08**	-0.06*	0.01	0.02	-0.01	-0.01
	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)
Sales	-0.20***	-0.17***	-0.08*	-0.07*	0.06	0.02
	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)
Machinery	-0.23***	-0.18***	-0.19***	-0.12***	-0.11*	-0.07*
	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)	(0.03)
Labour work	-0.30***	-0.24***	-0.21***	-0.13***	-0.05	-0.03
	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)
Industry						
Public services (Reference)						

Agriculture	0.07	0.06	-0.18*	-0.12	-0.06	-0.05
	(0.06)	(0.07)	(0.08)	(0.06)	(0.08)	(0.06)
Mining	-0.07	-0.08	0.17*	0.15*	-0.75***	-0.57***
	(0.06)	(0.06)	(0.07)	(0.06)	(0.07)	(0.06)
Manufacturing	-0.23***	-0.19***	-0.30***	-0.21***	-0.4***	-0.32***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
electricity	-0.1	-0.07	0.09	0.06	-0.37***	-0.30***
	(0.07)	(0.07)	(0.08)	(0.06)	(0.08)	(0.07)
Construction	-0.05	-0.06	-0.13**	-0.10**	-0.3***	-0.25***
	(0.04)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)
Trade	-0.28***	-0.26***	-0.29***	-0.22***	-0.13**	-0.15***
	(0.04)	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)
Hospitality	-0.50***	-0.44***	-0.41***	-0.30***	-0.05	-0.11**
	(0.04)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)
Transport	-0.21***	-0.18***	-0.23***	-0.17***	-0.35***	-0.29***
	(0.04)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)
Finance	-0.16***	-0.15**	-0.22***	-0.15**	-0.30***	-0.29***
	(0.05)	(0.04)	(0.06)	(0.05)	(0.06)	(0.05)
Education	0.11***	0.11**	0.01	0.01	-0.17***	-0.08*
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Health	0.01	0.01	-0.24***	-0.17***	0.04	-0.01
	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)
Other services	-0.17***	-0.14***	-0.29***	-0.20***	-0.23***	-0.19***
	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)
Paid holiday leave						
Yes (Reference)						
No	0.15**	0.13**	0.20**	0.16**	-0.26***	-0.15
	(0.05)	(0.05)	(0.06)	(0.05)	(0.07)	(0.05)
Paid sick leave						
Yes (Reference)						
No	-0.13*	-0.10*	0.10	0.08	-0.09	-0.04
	(0.05)	(0.05)	(0.06)	(0.05)	(0.07)	(0.05)

*P < 0.05, **P < 0.01, ***P < 0.001
GLS refers to random effect generalized least squares (GLS) estimates, and Ordered probit refers to random effect ordered probit model.

As expected, having long-term health problems has a significant negative impact on overall job satisfaction (-0.21 points), pay satisfaction (-0.16 points) and job security satisfaction (-0.19 points). These findings indicate that workers' long-term health problems lower overall job, pay and job security satisfaction. These outcomes support the hypothesis that long-term health problems reduce all aspects of job satisfaction.

This study reports an interesting finding when interactions of weight status with long-term health problems were considered. Specifically, the coefficient of 'obesity × long-term health problems' is positive and significant (0.10 points) at the 1% level. However, there was no evidence of a statistically significant effect for the interaction of obesity with long-term health problems on pay and job security satisfaction. Similarly, no significant interaction of overweight with long-term health problems on overall, pay and job security satisfaction was found.

With respect to the other covariates, ‘age’, ‘education’, ‘place of living’, ‘log of weekly gross salary’, ‘hours per week usually worked’, ‘employment contract’, ‘farm size’, ‘union membership’, ‘occupation’, ‘industry’, and ‘paid holiday leave’, all variables were statistically significant for all three aspects of job satisfaction.

Discussion

This study analyzed the impact of obesity, long-term health problems, and their interaction, on three aspects of job satisfaction of Australian adult workers. Random effect GLS estimation and random effect ordered probit model were employed using data from twelve waves (wave 6 to wave 17) of the HILDA survey. The most striking result to emerge is that a general negative relationship exists between obesity, pay, and job security satisfaction. Worker’s long-term health problems also affect all the three aspects of job satisfaction negatively. However, the interaction of obesity and long-term health problems has a positive influence on overall job satisfaction. The findings of this study may contribute to a greater understanding of the labour market consequences of obesity and help in designing policies and strategies to improve worker's job satisfaction.

This study found a negative relationship between overweight, obesity and job security satisfaction. It was also found that obese workers are significantly dissatisfied over their job security. This accords with existing evidence, which reports a significant association between obesity and job insecurity (Muenster et al., 2011). However, this outcome also contradicts some previous research (Bruno et al., 2015). A possible explanation for this inconsistency may be that obesity affects job satisfaction through job insecurity as it is a major source of psychological burden that affects job satisfaction (Muenster et al., 2011).

Another important finding is that obesity affects pay satisfaction of the worker negatively. This finding is contrary to previous evidence (Bruno et al., 2015). This may be explained by the fact that obesity reduces pay satisfaction through wage discrimination, as there is evidence that obese white female workers faced a wage penalty (Cawley, 2004; Moro et al., 2019).

The most obvious finding to emerge from the analysis is that having long-term health problems has a statistically significant negative influence on overall job, pay and job security satisfaction. Previous evidence has also demonstrated that disability reduces the levels of overall job satisfaction (Pagan et al., 2016; Rodríguez et al., 2014). In contrast to the present study findings, no evidence of an association between disability and job satisfaction was detected (Uppal, 2005). This may be due to lower expectations about the job. Workers with poor health status have a weaker position in the labour market that reduces their expectations about the job (Carr and Friedman, 2005a).

Surprisingly, this study found that interactions of obesity and long-term health problems have a positive impact on overall job satisfaction. This supports evidence from a previous study that showed obese individuals with a disability had higher overall job satisfaction compared to healthy non-disabled counterparts (Pagan et al., 2016). This outcome can also be explained by lower expectations about the job. Obese people face workplace discrimination in the forms of wage penalty, job stability, and promotion. Further, poor health status put workers in a vulnerable position in the labour market. All these factors together may lead obese workers with a disability to report higher levels of overall job satisfaction (Carr and Friedman, 2005a; Pagan et al., 2016).

From the viewpoint of public policy, this study outcomes will help policymakers to have a more comprehensive understanding of the workplace satisfaction of obese people with or without long-term health problems. High overall job satisfaction of obese workers with long-term health problems is mostly sourced from their lower job expectations from the labour market. Again, obese workers' pay and job security satisfaction are linked to lower job expectations and stress received from job insecurity, respectively. This reflects the worse labour market conditions they confront. In this scenario, policymakers may need to design and implement strategies to reduce job discrimination, reduce the wage pay gap, maintaining working hours and ensure job security. This suggestion also aligns with the economic security part of the Australian National Disability Strategy 2010-2020 to support people with disabilities to improve their living standards.

Further, to reduce the negative consequences of obesity in the workplace, employers should implement further workplace-based initiatives. Ensuring healthy behaviours in the workplace (e.g., the inclusion of physical activity and offering healthy food services following dietary guidelines) may help to tackle obesity and thus increase workers' job satisfaction. These strategies are in line with those proposed by the National Health and Medical Research Council (1997).

Conclusion

The present study was designed to investigate the relationship between obesity, long-term health problems and three aspects of job satisfaction for Australian workers. The study has used 12 waves of data from a recent nationally representative longitudinal data set. Results from the random effect GLS and random effect ordered probit estimation techniques indicate that obesity reduces workers' pay and job security satisfaction. Overweight workers are also dissatisfied about their job security. This study has also found that long-term health problems affect overall, pay and job security satisfaction negatively. However, the interaction of obesity with long-term health problems indicates high overall job satisfaction. Contrary to the hypothesis, this study found that overweight or obesity do not have any significant influence on workers' overall job satisfaction. The main reason behind these outcomes is low satisfaction of the workers from the job that indicates worse labour market conditions. The situation could be improved through the design and implementation of policies in the labour market for obese and disabled people.

The present study makes several noteworthy contributions to the existing literature. To the best of the authors' knowledge, this is the first study that firmly establishes a significant association between obesity, long-term health problems, pay, and job security satisfaction through using the interaction of obesity and long-term health problems. This study has used a broader range of ages, workers from different occupations and industry to examine the association among obesity, long-term health problems and job satisfaction more accurately for a broader group of workers. Besides, this study has considered a wide range of work-related factors as covariates, which have not been considered in similar studies.

This study also acknowledges some limitations. The most important is the use of self-reported BMI that may likely underestimate the worker's obesity status. An important limitation of this study is that there could be endogeneity of obesity in the job satisfaction models. The endogeneity issue may result in underestimating the relationship between obesity and job satisfaction. Due to the unavailability of appropriate instrumental variables, the present study cannot control the potential endogeneity issue. Therefore, caution should be needed while interpreting the results as a causal effect. Further research is needed to solve this issue. Another limitation is that it focuses on the worker's job satisfaction in only one country. Future research may test if these relationships also exist in different country settings or across countries.

Conflict of Interest

The authors declare that they have no conflict of interest.

Ethics approval

Ethics approval is not required for the study as it used secondary data from the HILDA survey data set. Researchers working in Australia may avail this data set after following certain regulations. There is no identifiable information of the individual in the data.

Availability of data and materials

The data used for the current study were collected from the Melbourne Institute of Applied Economic and Social Research. There are some restrictions on this data and it is not available to the public. Those interested in accessing this data should contact the Melbourne Institute of Applied Economic and Social Research, The University of Melbourne, VIC 3010, Australia.

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CHAPTER 4: STUDY 4

Age and gender differences in the relationship between obesity and disability with self-perceived employment discrimination: Results from a retrospective study of an Australian national sample

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Abstract

Background: Health status is a crucial determinant of an individuals' labour market outcomes. The present study investigates the association between obesity and disability with employment discrimination within Australia.

Methods: A total of 17,174 person-year observations from the 11,079 respondents were analysed using four waves of data from the Household, Income, and Labour Dynamics in Australia (HILDA) survey. The primary outcome examined was employment discrimination, using obesity and disability as the main exposure variables. The longitudinal random-effects regression technique was applied to investigate the between-person differences in employment discrimination associated with obesity and disability.

Results: The findings suggest that more than one in ten (12.68%) Australians experienced employment discrimination. The odds of being discriminated against while applying for a job were 1.56 times (aOR: 1.56, 95% CI: 1.15-2.11) higher for obese than their healthy weight counterparts in youngest women. Adults with a disability had 1.89 times (aOR: 1.89, 95% CI: 1.65-2.17) higher odds of being discriminated against than peers without disability.

Conclusion: Results provide evidence that obesity and disability contribute to employment discrimination in Australia. The findings can assist government and related agencies to consider the adequacy of existing discrimination legislation and help organisations to develop appropriate policies to address discrimination against obese and disabled people in their workplaces.

Keywords: Australia; disability; employment discrimination; HILDA; Obesity

Introduction

Obesity and disability are crucial indicators of population health. Globally, the prevalence of obesity has increased rapidly, and it is becoming a major public health concern. Over 650 million people worldwide are classified as obese (World Health Organization, 2020a). An increasing rate of obesity is also a significant public health issue in Australia, as in 2019, over one in four adults aged 15 years and over were obese (26%) (Keramat et al., 2021b). Overweight and obesity were responsible for 7% of Australia's total burden of disease and injuries (Australian Institute of Health and Welfare, 2017b). Like obesity, the prevalence of disability is also rising worldwide. Over one billion people live with some form of disability globally, and this is projected to double by 2050 (World Health Organization, 2018). In 2018, an estimated one in five adults (18%) were diagnosed with some form of disability in Australia (Australian Institute of Health and Welfare, 2019e), and around 5.7% of adults had a severe disability (Australian Bureau of Statistics, 2018d). However, a recent study found that over one in four Australian adults (28%) have some form of disability (Keramat et al., 2021d).

Obesity and disability are responsible for rising adverse labour market outcomes, such as a high rate of absenteeism (Keramat et al., 2020a), the rise of presenteeism (Keramat et al., 2020b), and low job satisfaction (Keramat et al., 2020c). People experiencing both obesity and disability are often subject to workplace discrimination. For example, a study on European workers revealed that obese workers faced higher discrimination in the hiring process (Flint et al., 2015). Besides, a Canadian study concluded that disabled people faced higher levels of harassment and discrimination in the workplace (Jones et al., 2018). Recent empirical evidence also reveals that workplace harassment and discrimination continue to grow among workers with disabilities in the USA and UK despite protective legislation (Fevre et al., 2013; Snyder et al., 2010). Further, there is evidence that obese people experience higher unemployment levels than healthy-weight peers in the USA (Tunceli et al., 2006). Studies of American adults showed that obesity is associated with several forms of discrimination, including in the workplace (Hunte and Williams, 2009; Lewis et al., 2011). A few studies conducted in European countries (e.g., UK (Morris, 2006), Finland (Böckerman et al., 2019; Sarlio-Lahteenkorva and Lahelma, 1999) and Denmark (Greve, 2008)) found that obese people tend to earn less than their non-obese counterparts and that overweight people were also more likely to report employment discrimination and discriminatory experiences than healthy weight counterparts (Roehling et al., 2007).

Physical disabilities also prevent people from securing continuous employment (Waterhouse et al., 2010). According to the Australian Institute of Health and Welfare (AIHW), people with disabilities are under-represented in the Australian workforce (53% compared to 84% of those without disabilities) (Australian Institute of Health and Welfare, 2020f), and the rate of employment is declining (Australian Institute of Health and Welfare, 2017c). The empirical evidence demonstrates that people with psychiatric disabilities have unemployment of longer durations, lower probability of securing highly-paid jobs, have lower earnings, and are denied training opportunities and promotions (Baldwin and Marcus, 2006; Stuart, 2006). There is also evidence that people with physical and sensory impairments face large-scale hiring discrimination in the USA (McMahon, 2012).

Few studies have quantified the longitudinal association between obesity and disability with employment discrimination, and those that do exist have mainly been undertaken in the USA and UK. Longitudinal studies monitor individual changes over time which can evaluate the relationship more accurately than other study designs. No research has examined to what extent people with obesity and disability receive disparate treatment at work in Australia. A longitudinal study on obesity, disability and perceived employment discrimination nexus using Australian data is non-existent.

Therefore, the objectives of the present study are twofold: firstly, to determine the current state of perceived employment discrimination and, secondly, to examine the relationships between obesity and disability with perceived employment discrimination in the Australian adult population. Findings will assist in developing a broader conceptual framework for understanding and tackling obesity and disability-related prejudice and discrimination in a workplace setting and developing more inclusive workplaces in Australia. Moreover, the evidence will assist organisations and the government to develop and implement evidence-based anti-discrimination policies covering weight and disability-related workplace discrimination. Furthermore, the study findings may help policymakers and organisations to develop and implement workplace health promotion programs to reduce obesity problems of employees and increase productivity in the workplace.

Methods

Data source and sample selection

The data utilised in this study were obtained from the Household Income and Labour Dynamics in Australia (HILDA) survey. HILDA is a nationally representative longitudinal study of Australian households that collects information annually from the adult members of the same household. The survey gathers information on a wide range of topics, including wealth, retirement, fertility, health, education, skills, abilities, job-related discrimination, intentions and plans, non-co-residential family relationships, health insurance, youth, literacy and numeracy, diet, and material deprivation from household members aged 15 years or over through both self-completion questionnaires and face-to-face interviews by trained interviewers. The HILDA survey commenced in 2001 and collected information on 19,914 individuals from 7682 households. Since then, the survey gathers information annually from over 17,000 Australians. HILDA survey selects sample households through multi-stage sampling techniques that are representative of the Australian population. A detailed description of the HILDA sampling technique and survey methodology has been outlined elsewhere (Freidin et al., 2002).

This study acquired data from four waves of the HILDA survey: Wave 8 (2008), Wave 10 (2010), Wave 14 (2014), and Wave 18 (2018). These waves were selected as they included specific questions related to employment discrimination. The analytic sample was restricted to respondents aged 15 years or over, and excludes observations with missing values on the outcome variable (employment discrimination) and primary variables of interest (obesity and disability status). These selection criteria resulted in an unbalanced panel comprising 17,174 person-year observations from 11,079 participants.

Outcome variable

The primary outcome variable of the present study is perceived employment discrimination. Participants aged 15 years or over were asked, “thinking of the jobs you have applied for in the past two years, do you think you were ever unsuccessful because the employer discriminated against you?” Responses to the questions were taken in binary form; 0 indicates no, and 1 indicates yes. This reflects respondents’ perception of discrimination and may not be actual discrimination. Since it is difficult to measure actual labour market discrimination, existing studies have relied on participants’ perceptions (Biddle, 2013; Jones et al., 2018). As data on real labour market discrimination is not available in the HILDA survey, the present study has taken into account the study participants’ perceptions concerning employment discrimination.

Key explanatory variables

The primary variables of interest of this study are the obesity and disability status of the study participants. One of the primary exposure, obesity, was measured through Body Mass Index (BMI). The HILDA survey collects self-reported weight and height by asking questions, “What is your current weight (kilograms)” and “how tall are you, without shoes (metres)?”, respectively. Each participant’s BMI was then calculated by applying the formula, weight in kilograms divided by height in metres squared. The present analysis categorised BMI into four groups: 'underweight' (BMI <18.50), 'healthy weight' (18.50 ≤ BMI <25), 'overweight' (25 ≤ BMI <30), and 'obese' (BMI ≥ 30) following the World Health Organization's BMI cut-off points to define an individual's weight status (World Health Organization, 2020a).

Another primary exposure variable of this study is self-reported disability. The HILDA survey collects information on each respondent's disability status through personal interviews following the definition of the International Classification of Functioning, Disability, and Health (ICF) framework (LaMontagne et al., 2016; Lopez Silva et al., 2020). Participants' disability status was ascertained by asking if they have any long-term health condition, impairment, or disability that restricted their daily activities and has lasted for six months or more. The survey presents 17 categories of disabilities (e. g., sight problems not corrected by glasses or lenses, hearing problems, speech problems, limited use of feet or legs, and chronic or recurring pain) to the respondents to define their disability status. The responses were taken into binary form (yes and no); yes indicates that the participant has a disability, and no indicates otherwise.

Covariates assessed in the model

This study included a range of covariates to account for confounding effects in the multivariate regression models following previous studies (Biddle, 2013; Jones et al., 2018; Tunceli et al., 2006). The covariates included in the study were age (youngest [15-30], middle-age [31-50], and oldest [51 and over]), gender (male and female), education (school not completed, year 12/certificate/diploma, and bachelor degree or greater), civil status (partnered and unpartnered), household yearly disposable income quintile (quintile 1 [lowest] to quintile 5 [highest]), labour force status (employed, unemployed, and not in the labour force), indigenous status (non-indigenous, and Aboriginal or Torres Strait Islander), state of residence (New South Wales [NSW], Victoria [VIC], Queensland [QLD], South Australia [SA], Western Australia [WA], Tasmania [TAS], Northern Territory [NT], and Australian Capital Territory [ACT]), and country of birth (Australia or other country).

Estimation methods

The present analysis formed an unbalanced panel data set that includes 17,174 person-year observations from 11,079 unique respondents. The data set was constructed by linking de-identified individuals' records who participated in any of the four waves (waves 8, 10, 14, and 18) of the HILDA survey spanning the period of 2008 to 2018.

Descriptive statistics in terms of frequency (n) and percentages (%) with 95% Confidence Intervals (CIs) were used to present the pooled characteristics of the study sample. The bivariate relationships between employment discrimination and the primary variables of interest and other covariates were then assessed through chi-square tests. A covariate was included in the adjusted model only if it was statistically significant at 5% in the chi-square test. However, some exceptions have been considered to evaluate whether a variable is statistically significant at any levels in the multivariate regression models despite being insignificant in the chi-square tests. This study employed the longitudinal random-effects logistic regression approach to examine the association between perceived employment discrimination and obesity and disability. The random-effects regression modelling allows identifying the between-person differences in perceived employment discrimination concerning change in obesity and disability. For the present study, the random-effect regression approach is appropriate as this technique considers the effects of a variable that changes over time, such as the age of the individuals (Milner and LaMontagne, 2017). The study conducted both unadjusted and adjusted models. Age, gender, civil status, education, household yearly disposable income, labour force status, indigenous status, state of residence, and country of birth served as the confounders in the adjusted model. Besides, the between-person effect models were stratified by age and gender as part of the sensitivity analysis to examine the differences in employment discrimination associated with obesity and disability. This study replaced missing observations in one covariate, Indigenous status, through imputation (last observation carried forward). However, no survey weights have been used in the analyses.

The test results are displayed in the form of odds ratio with 95% confidence intervals (CIs) along with respective p-values for each variable. A predictor was considered statistically significant if the respective p-value of a particular exposure was less than or equal to 0.05 in the multivariate regression analyses. This study performed all statistical analyses using the statistical software Stata (version 16).

Results

Table 1 demonstrates the distribution of the study participants' characteristics in the first and last waves and pooled across all waves. A total of 17,174 person-year observations from 11,079 participants were included in the analyses. Over one in ten adults (12.68%) experienced employment discrimination in Australia. The proportion of employment discrimination reported in the baseline and final waves was 11.58% and 12.52%, respectively. Among the study sample, 18.07% were obese, and 15.90% had a disability in the baseline. The prevalence of obesity (23.47%) and disability (21.13%) were highest in the final waves (Table 1). Table 1 (all waves pooled) also shows that 53.97% were aged 15-30 years, 51.72% were female, 24.64% did not complete school, and 51.91% were partnered. The majority of the participants were employed (77%), non-indigenous (95.50%), residing in NSW (27.60%), and born in Australia (84.07%).

Table 1: Distribution of the analytic sample: Baseline, final and pooled across all waves (persons = 11,079, observations = 17,174)

Characteristics	**Baseline wave (2008)**		**Final wave (2018)**		**All waves pooled (2008 to 2018)**	
	n	%	n	%	n	%
Outcome variable						
Perceived employment discrimination						
No	3,420	88.42	4,156	87.48	14,996	87.32
Yes	448	11.58	595	12.52	2,178	12.68
Exposures and covariates						
BMI						
Underweight	130	3.36	164	3.45	593	3.45
Healthy weight	1,849	47.80	2,055	43.25	7,785	45.33
Overweight	1,190	30.77	1,417	29.83	5,249	30.56
Obesity	699	18.07	1,115	23.47	3,547	20.65
Disability						
No	3,253	84.10	3,747	78.87	14,006	81.55
Yes	615	15.90	1,004	21.13	3,168	18.45
Age						
Youngest (15-30 years)	2,069	53.49	2,469	51.97	9,268	53.97
Middle-age (31-50 years)	1,389	35.91	1,658	34.90	5,882	34.25
Oldest (51 years and over)	410	10.60	624	13.13	2,024	11.79
Gender						
Male	1,816	46.95	2,303	48.47	8,291	48.28
Female	2,052	53.05	2,448	51.53	8,883	51.72
Civil Status						
Partnered	2,062	53.31	2,416	50.85	8,915	51.91
Unpartnered	1,806	46.69	2,335	49.15	8,259	48.09
Education						
School not completed	1,193	30.84	933	19.64	4,232	24.64
Year 12/certificate/diploma	1,814	46.90	2,437	51.29	8,568	49.89
Bachelor degree or greater	861	22.26	1,381	29.07	4,374	25.47
Household yearly disposable income quintile						
Quintile 1 (lowest)	774	20.01	951	20.02	3,440	20.03
Quintile 2	775	20.04	952	20.04	3,430	19.97
Quintile 3	773	19.98	948	19.95	3,436	20.01

Quintile 4	773	19.98	951	20.02	3,434	20.00
Quintile 5 (highest)	773	19.98	949	19.97	3,434	20.00
Labour force status						
Employed	3,073	79.45	3,685	77.56	13,224	77.00
Unemployed	347	8.97	541	11.39	1,949	11.35
Not in the labour force	448	11.58	525	11.05	2,001	11.65
Indigenous status						
Non-indigenous	3,734	96.54	4,484	94.38	16,401	95.50
Aboriginal or Torres Strait Islander	134	3.46	267	5.62	773	4.50
State of residence						
NSW	1,057	27.33	1,302	27.40	4,740	27.60
VIC	939	24.28	1,299	27.34	4,463	25.99
QLD	946	24.46	1,075	22.63	3,921	22.83
SA	326	8.43	373	7.85	1,437	8.37
WA	341	8.82	394	8.29	1,498	8.72
TAS	120	3.10	152	3.20	550	3.20
NT	34	0.88	38	0.80	140	0.82
ACT	105	2.71	118	2.48	425	2.47
Country of birth						
Australia	3,253	84.10	4,012	84.45	14,438	84.07
Other country	615	15.90	739	15.55	2,736	15.93

Figure 1 shows the distribution of perceived employment discrimination by age and gender. As can be seen, the oldest age group reported the highest rate of employment discrimination for all the survey years. The rate of perceived employment discrimination was highest among the oldest male (33.77%) in 2014, followed by the oldest female (32.98%) in 2010.

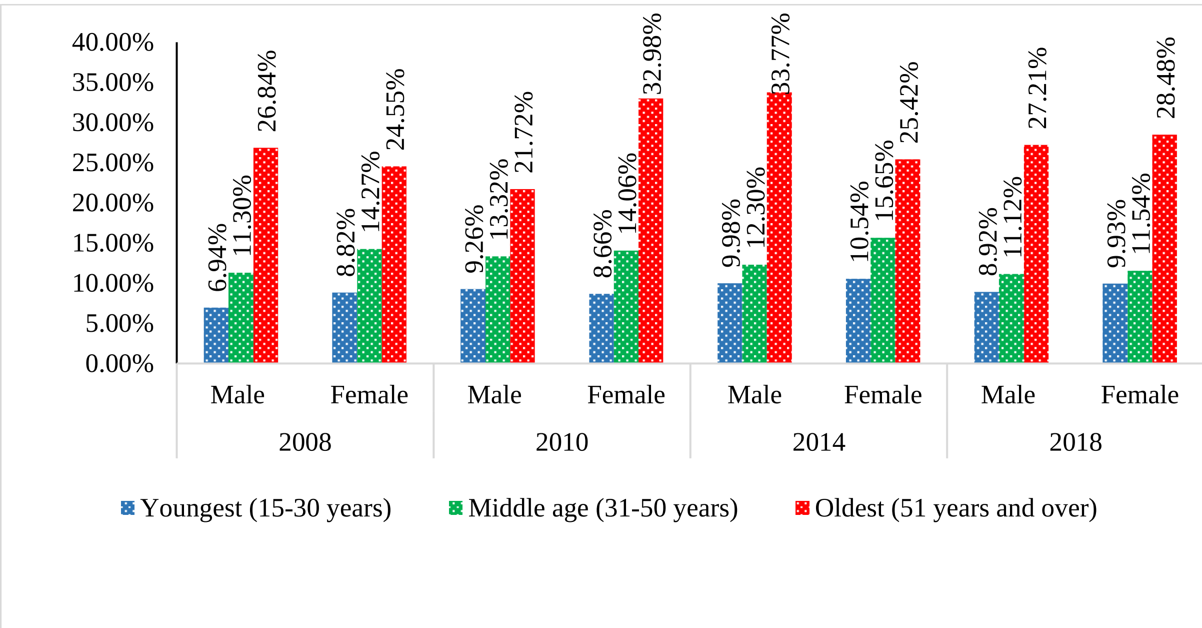

Figure 1: Point estimates of perceived employment discrimination by age and gender, 2008-2018

Figure 2 presents the trend in the prevalence of perceived employment discrimination by different age groups. The rate of perceived discrimination is highest among the oldest and ranges from 25.61% (2008) to 29.62% (2014). The figure also shows that the prevalence of job discrimination among the youngest and middle-age adults is less than 15% over the study period.

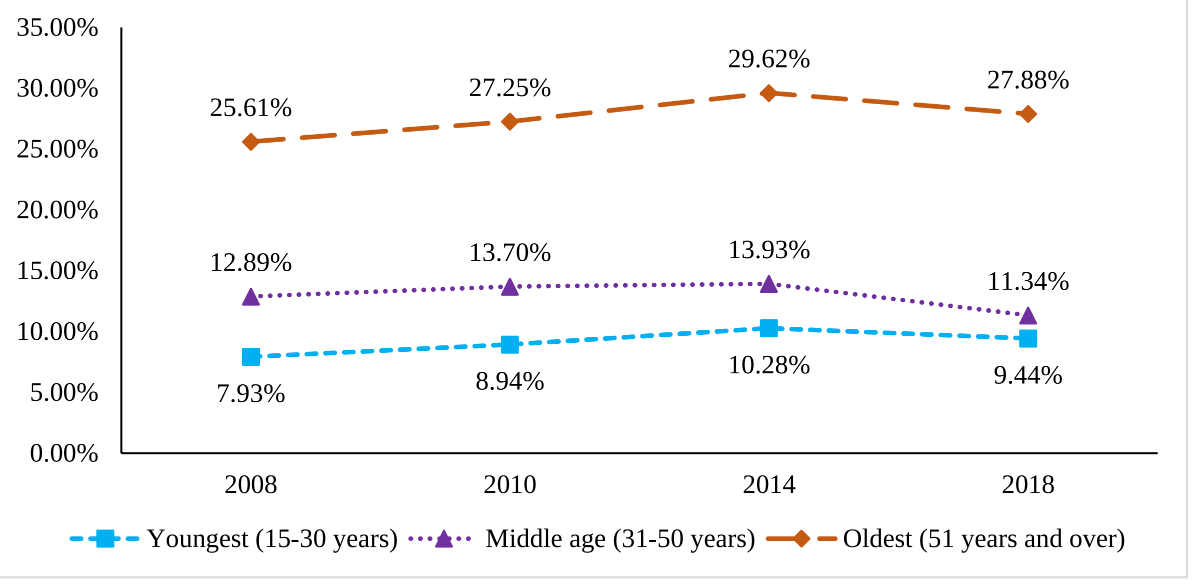

Figure 2: Point estimates of perceived employment discrimination by age groups, 2008-2018

Figure 3 demonstrates the point in time rates of self-perceived employment discrimination by gender. The figure shows that the job discrimination rate is higher in women than men over the study period. The prevalence of job discrimination in women ranged from 12.48% (2008) to 13.92% (2014).

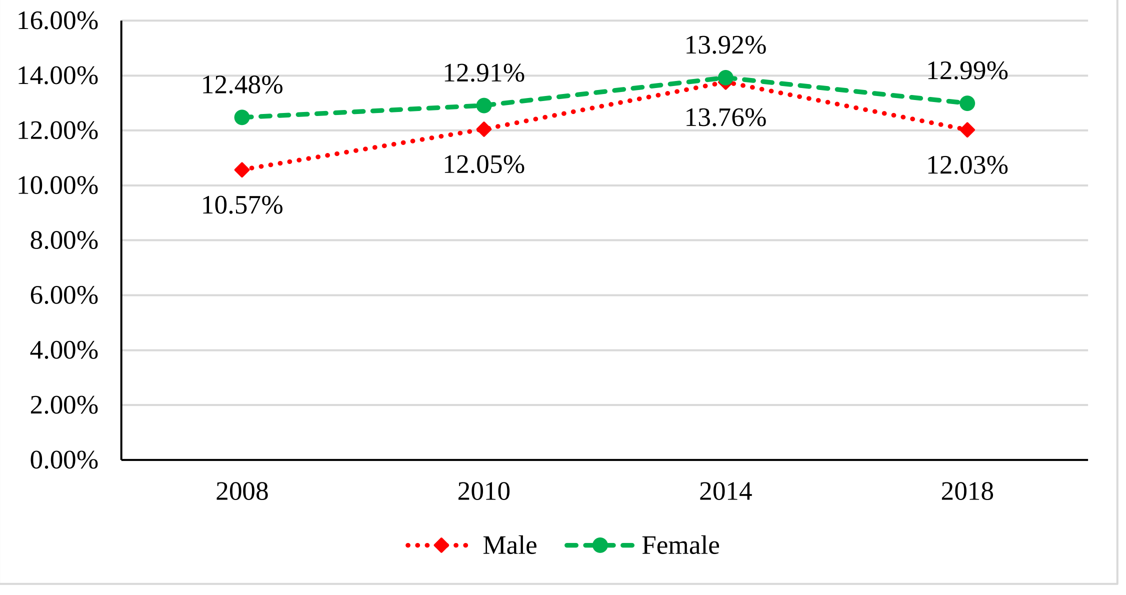

Figure 3: Point estimates of perceived employment discrimination by gender, 2008-2018

Table 2 reports the distribution of perceived employment discrimination patterns varied by BMI, disability, and other characteristics of the study participants in the baseline and final waves. The table also shows the bivariate association between the primary exposures and other covariates with perceived employment discrimination using chi-square tests. The prevalence of employment discrimination among the obese was 13.88% in 2008 and 15.61% in 2018. However, the rates were comparatively higher among adults with some form of disability. Over one in five adults with disabilities faced employment discrimination (Table 2). In addition, the percentage of perceived employment discrimination among the disabled participants were two times higher (21.95 vs 9.62 in 2008 and 20.22 vs 10.46 in 2018) than those with no disability.

Table 2: Description of obesity, disability and other covariates by perceived employment discrimination at baseline and final waves

Characteristics	**Baseline wave (2008)**				**P value**	**Final wave (2018)**				**P value**
	Not discriminated		Discriminated			Not discriminated		Discriminated		
	n	%	n	%		n	%	n	%	
BMI					0.08					0.01
Underweight	117	90.00	13	10.00		143	87.20	21	12.80	
Healthy weight	1,656	89.56	193	10.44		1,822	88.66	233	11.34	
Overweight	1,045	87.82	145	12.18		1,250	88.21	167	11.79	
Obesity	602	86.12	97	13.88		941	84.39	174	15.61	
Disability					<0.001					<0.001
No	2,940	90.38	313	9.62		3,355	89.54	392	10.46	
Yes	480	78.05	135	21.95		801	79.78	203	20.22	
Age					<0.001					<0.001
Youngest (15-30 years)	1,905	92.07	164	7.93		2,236	90.56	233	9.44	
Middle-age (31-50 years)	1,210	87.11	179	12.89		1,470	88.66	188	11.34	
Oldest (50 years and over)	305	74.39	105	25.61		450	72.12	174	27.88	
Gender					0.07					0.31
Male	1,624	89.43	192	10.57		2,026	87.97	277	12.03	
Female	1,796	87.52	256	12.48		2,130	87.01	318	12.99	
Civil Status					0.85					0.96
Partnered	1,825	88.51	237	11.49		2,114	87.50	302	12.50	
Unpartnered	1,595	88.32	211	11.68		2,042	87.45	293	12.55	
Education					0.19					0.04
School not completed	1,038	87.01	155	12.99		810	86.82	123	13.18	
Year 12/certificate/diploma	1,616	89.08	198	10.92		2,112	86.66	325	13.34	
Bachelor degree or greater	766	88.97	95	11.03		1,234	89.36	147	10.64	
Household yearly disposable income quintile					<0.001					<0.001
Quintile 1 (lowest)	652	84.24	122	15.76		764	80.34	187	19.66	
Quintile 2	668	86.19	107	13.81		833	87.50	119	12.50	

Quintile 3	688	89.0	85	11.00		841	88.71	107	11.29	
Quintile 4	698	90.30	75	9.70		858	90.22	93	9.78	
Quintile 5 (highest)	714	92.37	59	7.63		860	90.62	90.62	9.38	
Labour force status					<0.001					<0.001
Employed	2,774	90.27	299	9.73		3,298	89.50	387	10.50	
Unemployed	267	76.95	80	23.05		422	78.00	119	22.00	
Not in the labour force	379	84.60	69	15.40		436	83.05	89	16.95	
Indigenous status					0.34					0.64
Non-indigenous	3,305	88.51	429	11.49		3,920	87.42	564	12.58	
Aboriginal or Torres Strait Islander	115	85.82	19	14.18		236	88.39	31	11.61	
State of residence					0.11					0.01
NSW	923	87.32	134	12.68		1,166	89.55	136	10.45	
VIC	848	90.31	91	9.69		1,140	87.76	159	12.24	
QLD	827	87.42	119	12.58		934	86.88	141	13.12	
SA	279	85.58	47	14.42		326	87.40	47	12.60	
WA	310	90.91	31	9.09		320	81.22	74	18.78	
TAS	108	90.00	12	10.00		134	88.16	18	11.84	
NT	29	85.29	5	14.71		33	86.84	5	13.16	
ACT	96	91.43	91.43	8.57		103	87.29	15	12.71	
Country of birth					<0.001					0.04
Australia	2,903	89.24	350	10.76		3,527	87.91	485	12.09	
Other country	517	84.07	98	15.93		629	85.12	110	14.88	

* P values were derived from chi-square tests to examine the bivariate association between obesity and disability with self-perceived employment discrimination

Table 3 presents the unadjusted and adjusted multivariate regression results. Results of the random-effects logistic model represent the between-person differences in perceived employment discrimination through the unadjusted main effects of obesity (Model 1), the unadjusted main effects of disability (Model 2), and the adjusted effects of obesity and disability (Model 3). Models 1 and 2 indicate a strong positive relationship between obesity (OR: 1.61, 95% CI: 1.37-1.89) and disability (OR: 2.73, 95% CI: 2.38-3.12) with employment discrimination in the unadjusted models. However, Model 3 shows that only disability has substantial direct effects on perceived employment discrimination. The results demonstrate that persons with some forms of disability were 1.89 (aOR: 1.89, 95% CI: 1.65-2.17) times more likely to be discriminated against in the job market (Model 3).
Results for the other covariates in the model display that middle-aged (aOR: 1.55, 95% CI: 1.34-1.78) and oldest (aOR: 4.26, 95% CI: 3.57-5.08) age groups have higher odds of being discriminated against. Individuals belonging to lower household yearly disposable income quintiles were more likely to be discriminated against. Besides, unemployed (aOR: 2.54, 95% CI: 2.15-2.99) and adults not in the labour force (aOR: 1.48, 95% CI: 1.25-1.76) had a greater discrimination rate against compared with employed peers. Further, individuals born outside of Australia (aOR: 1.29, 95% CI: 1.10-1.51) reported increased odds of being discriminated against relative to those born in Australia.

Table 3: Unadjusted and adjusted random-effect regression results for the between-person difference in self-perceived employment discrimination due to obesity and disability

Exposure Variables	**Unadjusted model (1)**	**Unadjusted model (2)**	**Fully adjusted model (3)**
	Discrimination (yes versus no)	Discrimination (yes versus no)	Discrimination (yes versus no)
	OR (95% CI), P-value	OR (95% CI), P-value	aOR (95% CI), P-value
BMI			
Underweight	1.01 (0.71-1.42), 0.97		0.99 (0.72-1.38), 0.97
Healthy weight (ref)			
Overweight	**1.18 (1.02-1.36), 0.02**		0.99 (0.86-1.13), 0.85
Obesity	**1.61 (1.37-1.89), <0.001**		1.16 (0.99-1.35), 0.06
Disability			
No (ref)			
Yes		**2.73 (2.38-3.12), <0.001**	**1.89 (1.65-2.17), <0.001**
Age			
Youngest (15-30 years) (ref)			
Middle-age (31-50 years)			**1.55 (1.34-1.78), <0.001**
Oldest (51 years and over)			**4.26 (3.57-5.08), <0.001**
Gender			
Male (ref)			

Female	1.10 (0.98-1.24), 0.12
Civil Status	
Partnered (ref)	
Unpartnered	1.05 (0.93-1.19), 0.41
Education	
School not completed (ref)	
Year 12/certificate/diploma	1.09 (0.94-1.26), 0.24
Bachelor degree or greater	0.99 (0.82-1.19), 0.92
Household yearly disposable income quintile	
Quintile 1 (lowest)	**2.06 (1.70-2.50), <0.001**
Quintile 2	**1.56 (1.29-1.89), <0.001**
Quintile 3	**1.33 (1.10-1.62), 0.01**
Quintile 4	1.09 (0.90-1.33), 0.36
Quintile 5 (highest) (ref)	
Labour force status	
Employed (ref)	
Unemployed	**2.54 (2.15-2.99), <0.001**
Not in the labour force	**1.48 (1.25-1.76), <0.001**
Indigenous status	
Non-indigenous (ref)	
Aboriginal or Torres Strait Islander	0.80 (0.60-1.07), 0.13
State of residence	
NSW (ref)	
VIC	0.96 (0.82-1.13), 0.64
QLD	1.01 (0.86-1.20), 0.89
SA	1.14 (0.90-1.43), 0.27
WA	1.17 (0.93-1.46), 0.17
TAS	0.74 (0.52-1.07), 0.11
NT	1.04 (0.54-2.00), 0.91
ACT	0.81 (0.53-1.25), 0.34
Country of birth	
Australia (ref)	
Other country	**1.29 (1.10-1.51), 0.01**

Abbreviations: aOR, Adjusted Odds Ratio; ref, reference.

Values in bold are statistically significant.

The results from the random-effects logistic regression models to explain the age and gender differences in the relationship between obesity and disability with employment discrimination are presented in Table 4. There is strong evidence that the odds of being discriminated against was 1.56 times (aOR: 1.56, 95% CI: 1.15-2.11) higher in the obese population than peers of healthy weight among the female and youngest age group (Model 2). The results also showed that disability was significantly associated with greater perceived employment discrimination in both male and female youngest and middle-age groups (Models 1-4). However, no significant associations have been observed between disability and perceived job discrimination in both the male and female oldest age groups (Models 5-6).

Table 4: Multivariate regression results for the between-person difference in self-perceived employment discrimination due to obesity and disability stratified by age and gender, 2008 to 2018

Characteristics	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
	Male and youngest (15-30)	Female and youngest (15-30)	Male and Middle-age (31-50)	Female and Middle-age (31-50)	Male and oldest (51 and over)	Female and oldest (51 and over)
	aOR (95% CI), P-value	aOR (95% CI), P-value	aOR (95% CI), P-value	aOR (95% CI), P-value	aOR (95% CI), P-value	aOR (95% CI), P-value
BMI						
Underweight	1.13 (0.62-2.03), 0.69	1.16 (0.73-1.85), 0.52	0.18 (0.02-1.81), 0.15	1.17 (0.46-2.99), 0.74	0.15 (0.01-2.23), 0.17	0.66 (0.16-2.67), 0.58
Healthy weight (ref)						
Overweight	1.12 (0.83-1.51), 0.47	0.80 (0.60-1.08), 0.15	1.07 (0.77-1.48), 0.69	0.90 (0.66-1.24), 0.53	0.98 (0.60-1.62), 0.95	1.06 (0.66-1.71), 0.80
Obesity	1.37 (0.97-1.94), 0.07	**1.56 (1.15-2.11), 0.01**	1.09 (0.75-1.57), 0.66	0.95 (0.68-1.33), 0.77	1.13 (0.66-1.93), 0.67	0.95 (0.57-1.58), 0.85
Disability						
No (ref)						
Yes	**2.77 (2.03-3.80), <0.001**	**2.06 (1.57-2.71), <0.001**	**2.26 (1.63-3.13), <0.001**	**1.63 (1.20-2.22), 0.01**	1.42 (0.92-2.21), 0.12	1.12 (0.74-1.71), 0.59

* All models (1 to 6) were adjusted for civil status, education, household yearly disposable income, labour force status, indigenous status, state of residence, and country of birth

Abbreviations: aOR, Adjusted Odds Ratio; ref, reference.

Values in bold are statistically significant.

Discussion

This study explored the association between obesity and disability with perceived employment discrimination using longitudinal data. The study results revealed that obesity in the youngest women is responsible for higher employment discrimination. The findings also indicate that disability is significantly associated with higher employment discrimination.

These findings concur with the existing literature concerning the influence of obesity. Prior research has shown, for example, that individuals with obesity experience employment discrimination (Carr and Friedman, 2005b; Tunceli et al., 2006; Vallejo-Torres et al., 2018). Several studies provided evidence that obesity was positively associated with employment discrimination in the form of lower starting salaries, individuals were considered less qualified, less competent, and made to work longer hours (Levine and Schweitzer, 2015; Schulte et al., 2007). There is also evidence that obese people experience discrimination in the initial hiring process for employment (Bartels and Nordstrom, 2013; Flint and Snook, 2014). Our study results confirm that obesity among the Australian youngest women led to higher employment-related discrimination. One of the reasons for this finding could be that managers had negative obesity stereotypes. As a result, obese applicants may be less likely to be invited for an interview and employed (Agerström and Rooth, 2011). Another potential explanation could be that obese people were perceived as less "successful" and judged as possessing lower leadership qualities than non-obese peers when reviewing applicants' suitability for employment (Flint et al., 2015; Flint and Snook, 2014; Roehling et al., 2007).

The present findings are consistent with previous studies suggesting that disability is associated with increased workplace harassment and discrimination (Jones et al., 2018; Snyder et al., 2010). Earlier studies provide evidence that disability is associated with increased workplace harassment and discrimination rates due to lower levels of skill and occupational power (Landsbergis et al., 2014; Lopez et al., 2009; Maroto and Pettinicchio, 2014).

Any type of employment or workplace discrimination against a large section of the population is undesirable. The Australian Human Rights Commission Act (1986) and Fair Work Act (2009) specifically protect people from workplace discrimination because of race, colour, sex, age, and physical and mental disability. Despite this protective legislation, this study uncovered workplace discrimination due to obesity and disability in Australia. This issue requires immediate attention, and it is incumbent upon the government to review the adequacy of legislation and for organisations to review the limitations of existing discrimination and employment policies. These reviews should facilitate the involvement of employers in education, advocacy, and workforce development efforts to ensure the rights of obese and disabled workers are protected. Additionally, an educational campaign may be helpful to raise awareness of weight and disability-related discrimination (Kungu et al., 2019). Creating an inclusive, supportive environment for workers with disabilities and other marginalised groups is likely to reduce harassment and discrimination in the workplace.

The current study has several strengths. Previous studies focused on a particular aspect of health while checking its association with employment discrimination and were based on cross-sectional data. However, this study was the first reported empirical study to consider the separate impacts of obesity and disability on employment discrimination. This study also incorporated a large Australian sample to evaluate the relationship between obesity and disability with employment discrimination and considered a wide range of employment discrimination-related factors as covariates. Collectively, these considerations set this study apart from other similar studies.

The present study has several limitations that should be considered when interpreting the findings. First, the study findings might be vulnerable to self-reported bias, as data on BMI, disability, and employment discrimination may be underestimated or overestimated. Secondly, this study did not consider some essential variables, such as the occupational skill set of the respondents, due to data unavailability. Another limitation is that the study focuses on employment discrimination in a particular country setting. Taking into accout the limitations of the present study, future studies should investigate more closely how obese and disable people are discriminated against in the workplace. Besides, future research may test if these relationships also exist in different country settings or across countries.

Conclusion

This paper is the first to investigate the longitudinal association between obesity and disability with employment discrimination in Australia. It used a nationally representative data set by linking the four waves of the HILDA survey over the period 2008 to 2018. The longitudinal random-effects regression technique was fitted to investigate the differences in employment discrimination due to obesity and disability. The study findings offer clear evidence that obesity and disability were associated with employment discrimination in Australia. The estimated outcomes are significant for Australia and instructive, in general, for other countries with similar labour market characteristics. The authors expect that the findings will support the development of more effective legislation and policies to prevent health-related employment discrimination in the workplace.

Abbreviations

BMI	Body Mass Index
GEE	Generalized Estimating Equation
HILDA	Household, Income and Labour Dynamics in Australia Survey
OR	Odds Ratios
WHO	World Health Organization

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Ethics approval

This study did not require ethical approval as the analysis used only de-identified existing unit record data from the HILDA survey. However, the authors completed and signed the Confidentiality Deed Poll and sent it to NCLD (ncldresearch@dss.gov.au) and ADA (ada@anu.edu.au) before the data applications' approval. Therefore, datasets analysed and/or generated during the current study are subject to the signed confidentiality deed.

Author's contributions

SAK, RHR, SDS and BK initiated the study, conducted the data analysis, and drafted the manuscript. KA, JG, and SB offered advice, critical comments and edited the draft manuscript. All the authors read and approved the final manuscript.

Conflict of interest

The authors declare that they have no conflicts of interest.

Availability of data and materials

The data used for the study were collected from the Melbourne Institute of Applied Economic and Social Research. There are some restrictions on this data, and it is not available to the public. Those interested in accessing this data should contact the Melbourne

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CHAPTER 5: CONCLUSION AND POLICY IMPLICATIONS

5.1 Chapter summary

The prevalence and severity of obesity continue to rise in Australia. It is a serious public health problem that leads to additional direct and indirect costs. The key objective of this thesis was to investigate the relationship between obesity, health burden and labour market outcomes in the Australian context. The research initially attempted to report the trend in the prevalence of obesity and to investigate the effect of (i) geographic remoteness, (ii) disadvantaged neighbourhoods and lifestyle factors, and (iii) job-related characteristics on the obesity status of Australians. Relationships were then examined between obesity and (i) chronic disease burden, (ii) disability, (iii) healthcare services utilisation, (iv) self-assessed health and mental health, and (v) health-related quality of life. The thesis finally assesses the effects of obesity on (i) absenteeism, (ii) presenteeism, (iii) job satisfaction, and (iv) employment discrimination in the workplace. This study utilised longitudinal data from the nationally representative HILDA survey to investigate these relationships. This study followed Grossman's (1972) model of 'demand for health and health care' and Becker's theory of the 'economics of discrimination' to assess the relationships between obesity and adverse labour market outcomes.

5.2 Summary of the key findings

- **Geographic remoteness and obesity (Study 1, Chapter 2)**

This study explored the most recent national prevalence and trends of adult overweight and obesity in Australia. It also investigated geographic remoteness as a potential risk factor for an individual being overweight or obese in adulthood. The results revealed that the prevalence of overweight, obesity and combined overweight and obesity among Australian adults in 2019 were 34%, 26% and 60%, respectively. The analysis showed that the prevalence of overweight and obesity varied by geographic remoteness. Adults from regional city urban and rural areas were more likely to be obese than their counterparts from major city urban areas. The results also showed that adults living in major city urban areas, regional city urban areas, and regional city rural areas in Australia were more likely to be overweight than their counterparts from major city urban areas in Australia.

- **Disadvantaged neighbourhoods, lifestyle factors and obesity (Study 2, Chapter 2)**

This study aimed to investigate the impact of disadvantaged neighbourhoods and lifestyle factors on obesity amongst Australian adults. The study results showed that adults living in the most disadvantaged areas were more prone to be overweight and obese than peers living in the least disadvantaged areas. Study results also revealed that adults who consumed fruit regularly and performed high levels of physical activity were less likely to be obese than their counterparts. Current alcohol drinkers were highly likely to be obese compared to peers not consuming alcohol.

- **Job-related characteristics and obesity (Study 3, Chapter 2)**

This study aimed to examine the longitudinal association between nine job-related characteristics and obesity among Australian employees using a nationally representative sample. This study found that 59% of Australian employees were either overweight or obese. In addition, employees working more than 40 hours per week were more prone to become overweight and obese than their counterparts who worked 31-40 hours per week. The study also revealed that self-perceived job insecurity was positively associated with obesity. However, this study did not find evidence that work schedule, job type, employment contract, firm size, supervisory role, paid sick leave, and self-perceived job stress were associated with obesity.

- **Obesity and chronic disease burden (Study 1, Chapter 3)**

This study aimed to investigate whether obesity is a significant risk factor for type 2 diabetes, heart diseases, asthma, arthritis and depression in Australian adults, using nationally representative panel data. The study found that obesity was associated with a higher prevalence of chronic diseases among Australians. Obese people (BMI $\geq$ 30) were at higher risk of having type 2 diabetes, heart disease, asthma, arthritis, and depression compared with healthy weight (BMI of 18.50–24.99) counterparts. However, the study did not find any evidence of a statistically significant longitudinal association between obesity and cancer.

- **Obesity, disability, and physical activity (Study 2, Chapter 3)**

The purposes of this study were to outline trends in the prevalence of disability among Australian adults and to analyse the relationship between obesity and physical activity with disability. The pooled prevalence of disability in adults was 28%. The prevalence of disability among older adults (65 and above years) was more than 50%, irrespective of gender. Further, it identified obesity and physical activity as risk and protective factors of disability for adults, respectively. The odds of acquisition of a disability was higher among obese adults than healthy-weight counterparts. However, adults undertaking the recommended level of physical activity (more than thrice a week to every day) per week had lower chances of disability acquisition.

- **Obesity, multimorbidity, and healthcare services utilisation (Study 3, Chapter 3)**

Obesity and multimorbidity are long-term health chronic conditions that impact the use of healthcare services. However, few studies have investigated the association between obesity and multimorbidity with health service utilisation using a longitudinal research design. This study examined this relationship in a cohort of Australian adults. The research found that rates of doctor visits were higher among obese and adults with multimorbidity than healthy weight and peers without multimorbidity, respectively. The results also showed that obese adults were highly likely to visit hospital doctors, specialist doctors, and mental health professionals and had health check-ups, respectively, than their healthy-weight counterparts. The results also showed that individuals with multimorbidity had greater utilisation of the above-mentioned healthcare services. Moreover, hospital admission rates were greater among obese and adults with multimorbidity. Furthermore, night's stay in hospital was higher among adults with multimorbidity than others.

- **Obesity, disability, and health outcomes (Study 4, Chapter 3)**

Both obesity and disability have been widely recognised as major public health challenges because they play significant roles in determining self-rated health and mental health. However, longitudinal studies of the relationship between obesity and disability with self-reported health outcomes are scarce. Therefore, the present study examined the relationship between obesity and disability with self-reported health and mental health among Australian adults aged 15 years and above. The results revealed that obese adults with some form of disability were more likely to report poor health and mental health. Furthermore, the odds of self-reporting poor or fair health were higher among obese adults with some form of disability relative to the healthy weight and without disability counterparts. The results also showed that self-reported poor or fair mental health was higher among obese and adults with disability, respectively, compared to their healthy weight peers and peers without disability.

- **Comorbid chronic diseases and health-related quality of life in the obese population (Study 5, Chapter 3)**

This study examined the relationship between nine comorbid chronic conditions and HRQoL separately, along with the number of chronic diseases among the Australian obese population. This study found a negative relationship between the number of comorbid chronic conditions and sub-scale, summary measures, and health utility index of the SF-36. Obese adults with 1, 2, 3, and 3+ comorbid chronic diseases scored lower points on the SF-36 physical component summary, mental component summary, and the short-form six-dimension utility index (SF-6D) scale compared to obese peers without comorbid chronic diseases. The number of chronic conditions was associated with reductions in the score of all eight dimensions of the SF-36. Obese people with any of the nine studied comorbid chronic diseases (heart disease, circulatory disease, hypertension, type 1 diabetes, type 2 diabetes, asthma, bronchitis, arthritis, and cancer) were associated with lower HRQoL than peers without that particular comorbid chronic disease.

- **Obesity and absenteeism in the workplace (Study 1, Chapter 4)**

This study examined gender differences in the longitudinal association between obesity and disability with absenteeism in the workplace. The findings showed that overweight, obesity and disability were associated with prolonged workplace absenteeism irrespective of gender. This study found that the multiplicative interaction between weight status and gender was significantly associated with absenteeism. The results revealed that the rate of absenteeism was higher among overweight and obese women than their male counterparts. Moreover, this study found that the weight status of male workers was not associated with absenteeism. However, disability was positively associated with longer days of absence among male workers. Finally, the study results showed that the rate of absenteeism was higher among overweight, obese, and female workers with a disability, respectively, compared with their lower weight counterparts.

- **Obesity and presenteeism in the workplace (Study 2, Chapter 4)**

Obesity and long-term health condition (LTHC) are major public health concerns that impact productivity losses at work. Little is known about the longitudinal association between obesity and LTHC with impaired productivity. This study explored the longitudinal association between obesity and LTHC with presenteeism or going to work while sick. The findings suggest that overweight, obesity, and LTHC are significantly positively associated with presenteeism.

- **Obesity and job satisfaction (Study 3, Chapter 4)**

This study investigated the impact of obesity, long-term health problems and their interaction on three specific aspects of job satisfaction among Australian adult workers. Results from both random effects generalised least squares estimation and random effects ordered probit model confirmed that obesity had a significant negative impact on workers' pay and job security satisfaction. The results indicate that overweight workers were dissatisfied with their job security compared to their normal-weight peers. The study results reveal that long-term health problems significantly reduced all aspects of job satisfaction of workers. Moreover, the results indicate that the interaction of obesity and long-term health problems positively influenced workers' overall job satisfaction. Overall, the study findings aligned with the hypothesis that obese workers with long-term health problems had low job satisfaction.

- **Obesity, disability, and employment discrimination (Study 4, Chapter 4)**

Health status is a crucial determinant of an individuals' labour market outcomes. The present study investigated the association between obesity and disability with employment discrimination within Australia. The findings suggest that more than one in ten (12.68%) Australians experienced employment discrimination. The odds of being discriminated against while applying for a job were higher for healthy weight people with disability compared with their healthy weight counterparts without a disability. Obese adults with a disability had higher odds of being discriminated against than healthy weight peers without disability.

5.3 Contributions to the field of research

Overall, this thesis enriches the literature by revealing the risk factors and direct and indirect burden of adult obesity in Australia. It is the first systematic study that has investigated health and labour market outcomes where obesity is significantly influential. This thesis consists of twelve individual studies, and each of the studies has a significant contribution to the existing literature. The contribution of each study has been described broadly in earlier chapters (2 to 4). For example, article 8 provides first-hand evidence on the impact of comorbid chronic diseases on the diminishing HRQoL of obese adults. Besides, article 9 first explores the gender differences in the longitudinal association between obesity, disability, and absenteeism from the Australian context. Another study (article 10) fills the existing literature gap by proving evidence on a longitudinal association between obesity and productivity loss in the workplace.

Individual-level longitudinal data, with careful analysis, can generate robust evidence to inform many policy debates. All twelve studies in the thesis followed a longitudinal research design and methods to generate more robust and consistent estimates. This thesis contributes to the current body of literature by estimating the effects of obesity on five health and four labour market aspects in the Australian context. More specifically, the main contribution of this study is to extend the literature on the relationship between obesity and health burden (chronic diseases, disability, higher healthcare services utilisations, self-assessed health and mental health, and health-related quality of life) and labour market outcomes (absenteeism, presenteeism, lower level of job satisfaction and employment discrimination in the workplace) in Australia, following a longitudinal research design. To the best of the researcher's knowledge, this is the first study that provides the first empirical evidence on the diverse effects of obesity on health and labour market outcomes from an Australian perspective using longitudinal data.

One major strength of the present research is the large sample size and utilisation of the most recent longitudinal data (waves 2 to 19 of HILDA survey, 2002-2019). The inclusion of the most recent data is useful as the prevalence of obesity in Australia is a rapidly increasing trend, and previous study outcomes may be outdated. The present study also enriches the literature by revealing the effects of obesity by controlling many socio-demographic correlations.

5.4 Policy implications

All twelve studies included in the thesis have discussed policy implications in detail. This study provides first-hand evidence to labour market and health policymakers as it reveals the impact of obesity on the Australian labour force, economy and society. The present research provides evidence that obesity has a direct health burden regarding chronic diseases, disability, higher healthcare services utilisations, self-assessed health, mental health, and health-related quality of life. This thesis also revealed that obesity has hidden productivity costs in terms of higher absenteeism, higher presenteeism, lower levels of job satisfaction and higher employment discrimination in the workplace. Evidence on the effects of obesity on labour market outcomes and identification of the sources of these outcomes are necessary for formulating effective potential public policy interventions.

Policymakers have a compelling interest in reducing obesity and thus reducing adverse labour market outcomes. This study provides systematic evidence on the current obesity status of people living in Australia and provides governments, health researchers and the community with important insights into the direct and indirect costs of obesity in Australia. Further, labour market policymakers will be informed about how the different labour market outcomes influence the obesity status of the Australian people.

Obesity is a major public health concern that requires long-term management. This study particularly emphasises preventive measures to halt the epidemic in Australia and thus avoid the heavy costs of obesity. First, the study findings highlight the establishment of healthier places to lead a healthier lifestyle. Healthier places create and keep space for children to play, engage with recreational activities, and encourage people to perform modest exercises through walking, cycling, and sport. Second, the present study suggests that firms should improve their workers' health by implementing integrated lifestyle programs. For example, a firm may enforce workplace wellness policies, such as offering food service facilities that follow healthy nutrition guidelines, provide incentives for weight management, and promote physical activities in the workplace. The creation of healthier places helps people maintain a healthy lifestyle to prevent weight gain and other illnesses (Local Government Association, 2018). This suggestion is in line with the Australian Health and Wellbeing Strategic Framework 2017-2026, where the emphasis has also been on creating healthier places to lead a healthy lifestyle.

Third, implementing comprehensive science-based nutrition interventions that promote healthy weight is needed. For example, public education and outreach programs help adults follow a healthy lifestyle through healthy eating habits (e.g., reducing calorie intake, increasing fruit and vegetable consumption, and minimising alcohol intake). This study recommends that adults enjoy a wide variety of nutritious foods from the following five groups every day: i) vegetables, and legumes/beans; ii) fruit; iii) wholegrain (cereal) foods, such as bread, cereals, oats, quinoa and barley; iv) lean meats and poultry, fish, eggs, tofu, nuts and seeds; and v) milk, yoghurt, cheese and mainly reduced fat. Additionally, adults should drink plenty of water, and limit foods containing saturated fat, added salt, added sugars and alcohol. This suggestion also aligns with the specific targets of the Australian Health and Wellbeing Strategic Framework 2017-2026 to reduce adult obesity.

5.5 Limitations and future work

The limitations of each study have been mentioned in detail in previous chapters. One drawback of the present research is that BMI has been utilised to measure obesity. Most previous studies have used BMI as the measure of obesity yet it is only a marker of adiposity and has limitations, especially when assessed via self-report (Gorber et al., 2007a; Mocan and Tekin, 2009). Future research may use a composite score to overcome this limitation, which combines waist circumference and BMI or, in the case of smaller samples, appropriate devices and tools such as bioelectrical impedence. An earlier study has used a composite indicator in obesity research and argues that this can more accurately predict body fat percentage (Jang et al., 2013).

Another drawback is that the study results might be vulnerable due to self-reported bias. Data on BMI, lifestyle factors and health-related characteristics were self-reported, which might underestimate or overestimate the study findings. Self-reported bias is high among overweight and obese adults, as they tend to overestimate their height and underestimate their weight (Gorber et al., 2007a; Maukonen et al., 2018).

For some of the studies included in the present thesis, control over the selection of covariates was also limited, as several relevant factors, such as dietary habits, exercise patterns, sedentary behaviours, screen time, and the presence of comorbidities, were not available in all waves of the HILDA survey.

5.6 Conclusion

Obesity is a rising epidemic in Australia. Many factors are associated with the incidence of obesity. However, few studies thus far have quantified the complex relationships between geographic remoteness, disadvantaged neighbourhoods and lifestyle factors, and job-related characteristics with obesity using a longitudinal research design. To date, little attention has been paid in the literature regarding the effects of obesity on health and labour market outcomes. To address these issues, this thesis includes twelve individual studies. The thesis extracted data from the nationally representative HILDA survey. All the studies followed a longitudinal research design. The first three studies examined the effects of geographic remoteness, disadvantaged neighbourhoods and lifestyle factors, and job-related characteristics on the risk of being obese. A further five articles articulated the health and well-being costs of obesity in terms of chronic disease, disability, healthcare services utilisation, self-assessed physical and mental health, and health-related quality of life. The final four articles demonstrated that obese people have higher absenteeism, higher presenteeism, lower levels of job satisfaction, and face employment discrimination. The findings of these studies have substantial policy implications. This thesis provides first-hand evidence to Australian policymakers regarding the rising prevalence of obesity, associated risk factors, heavy health burden and the adverse labour market outcomes of increasing levels of obesity. It is hoped that the thesis findings may contribute to formulating appropriate policies to halt the obesity epidemic and reducing health burden and adverse labour market outcomes.

COMPLETE LIST OF REFERENCES

Adriaanse, M.C., Drewes, H.W., van der Heide, I., Struijs, J.N., Baan, C.A., 2016. The impact of comorbid chronic conditions on quality of life in type 2 diabetes patients. Qual. Life Res. 25, 175–182. https://doi.org/10.1007/s11136-015-1061-0

Agerström, J., Rooth, D.-O., 2011. The role of automatic obesity stereotypes in real hiring discrimination. J. Appl. Psychol. 96, 790–805. https://doi.org/10.1037/a0021594

Akil, L., Ahmad, H.A., 2011. Relationships between Obesity and Cardiovascular Diseases in Four Southern States and Colorado. J. Health Care Poor Underserved 22, 61–72. https://doi.org/10.1353/hpu.2011.0166

Al Snih, S., Graham, J.E., Kuo, Y.F., Goodwin, J.S., Markides, K.S., Ottenbacher, K.J., 2010. Obesity and disability: Relation among older adults living in latin america and the caribbean. Am. J. Epidemiol. 171, 1282–1288. https://doi.org/10.1093/aje/kwq087

Alavinia, S.M., Molenaar, D., Burdorf, A., 2009. Productivity loss in the workforce: Associations with health, work demands, and individual characteristics. Am. J. Ind. Med. 52, 49–56. https://doi.org/10.1002/ajim.20648

Allender, S., Gleeson, E., Crammond, B., Sacks, G., Lawrence, M., Peeters, A., Loff, B., Swinburn, B., 2012. Policy change to create supportive environments for physical activity and healthy eating: Which options are the most realistic for local government? Health Promot. Int. 27, 261–274. https://doi.org/10.1093/heapro/dar018

Alley, D., Lloyd, J., Shaffer, T., Stuart, B., 2012. Changes in the association between body mass index and Medicare costs, 1997-2006. Arch. Intern. Med. 172, 277–278.

Alley, D.E., Chang, V.W., 2007. The changing relationship of obesity and disability, 1988-2004. J. Am. Med. Assoc. 298, 2020–2027. https://doi.org/10.1001/jama.298.17.2020

Alonso, J., Vilagut, G., Adroher, N.D., Chatterji, S., He, Y., Andrade, L.H., Bromet, E., Bruffaerts, R., Fayyad, J., Florescu, S., de Girolamo, G., Gureje, O., Haro, J.M., Hinkov, H., Hu, C., Iwata, N., Lee, S., Levinson, D., Lépine, J.P., Matschinger, H., Medina-Mora, M.E., O'Neill, S., Hormel, J., Posada-Villa, J.A., Ismet Taib, N., Xavier, M., Kessler, R.C., 2013. Disability Mediates the Impact of Common Conditions on Perceived Health. PLoS One 8, e65858. https://doi.org/10.1371/journal.pone.0065858

Alonso, J., Vilagut, G., Chatterji, S., Heeringa, S., Schoenbaum, M., Bedirhan Üstün, T., Rojas-Farreras, S., Angermeyer, M., Bromet, E., Bruffaerts, R., de Girolamo, G., Gureje, O., Haro, J.M., Karam, A.N., Kovess, V., Levinson, D., Liu, Z., Medina-Mora, M.E., Ormel, J., Posada-Villa, J., Uda, H., Kessler, R.C., 2011. Including information about co-morbidity in estimates of disease burden: results from the World Health Organization World Mental Health Surveys. Psychol. Med. 41, 873–886. https://doi.org/10.1017/S0033291710001212

Andersen, R.E., Crespo, C.J., Bartlett, S.J., Bathon, J.M., Fontaine, K.R., 2003. Relationship between body weight gain and significant knee, hip, and back pain in older Americans. Obes. Res. 11, 1159–1162. https://doi.org/10.1038/oby.2003.159

Arnold, D., 2016. Determinants of the Annual Duration of Sickness Presenteeism: Empirical Evidence from European Data. Labour 30, 198–212. https://doi.org/10.1111/labr.12053

Aronsson, G., Gustafsson, K., Dallner, M., 2000. Sick but yet at work. An empirical study of sickness presenteeism. J. Epidemiol. Community Health 54, 502–509. https://doi.org/10.1136/jech.54.7.502

Artazcoz, L., Cortès, I., Benavides, F.G., Escribà-Agüir, V., Bartoll, X., Vargas, H., Borrell, C., 2016. Long working hours and health in Europe: Gender and welfare state differences in a context of economic crisis. Heal. Place 40, 161–168. https://doi.org/10.1016/j.healthplace.2016.06.004

Asay, G.R.B., Roy, K., Lang, J.E., Payne, R.L., Howard, D.H., 2016. Absenteeism and employer costs associated with chronic diseases and health risk factors in the US workforce. Prev. Chronic Dis. 13, 1–11. https://doi.org/10.5888/pcd13.150503

Atlantis, E., Lange, K., Wittert, G.A., 2009. Chronic disease trends due to excess body weight in Australia. Obes. Rev. 10, 543–553. https://doi.org/10.1111/j.1467-789X.2009.00590.x

Au, N., Hauck, K., Hollingsworth, B., 2013. The relationship between smoking, quitting smoking and obesity in Australia: A seemingly unrelated probit approach. Appl. Econ. 45, 2191–2199. https://doi.org/10.1080/00036846.2012.657353

Au, N., Hollingsworth, B., 2011. Employment patterns and changes in body weight among young women. Prev. Med. (Baltim). 52, 310–316. https://doi.org/10.1016/j.ypmed.2011.03.006

Audureau, E., Pouchot, J., Coste, J., 2016. Gender-Related Differential Effects of Obesity on Health-Related Quality of Life via Obesity-Related Comorbidities. Circ.

Cardiovasc. Qual. Outcomes 9, 246–256. https://doi.org/10.1161/CIRCOUTCOMES.115.002127

Australian Bureau of Statistics, 2018a. National Health Survey: first results, 2017–18. ABS cat. no. 4364.0.55.001. Canberra: ABS.

Australian Bureau of Statistics, 2018b. Socio-Economic Indexes for Areas (SEIFA) - 2016. Canberra:ABS. https://doi.org/2033.0.55.001

Australian Bureau of Statistics, 2018c. Labour Statistics: Concepts, Sources and Methods [WWW Document]. URL https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by Subject/6102.0.55.001~Feb 2018~Main Features~Employment~4 (accessed 9.4.19).

Australian Bureau of Statistics, 2018d. Disability, Ageing and Carers, Australia: Summary of Findings [WWW Document]. URL https://www.abs.gov.au/statistics/health/disability/disability-ageing-and-carers-australia-summary-findings/latest-release#data-download (accessed 11.3.20).

Australian Bureau of Statistics, 2016. Australian Statistical Geography Standard (ASGS): Volume 5 – Remoteness structure. ABS cat. no. 1270.0.55.005. Canberra: ABS.

Australian Bureau of Statistics, 2015. National Health Survey:first results, 2014-15. Canberra.

Australian Bureau of Statistics, 2010. Australian Labour Market Statistics [WWW Document]. URL https://www.abs.gov.au/ausstats/abs@.nsf/featurearticlesbyCatalogue/5461A9DAE97FF759CA2578C300153388?OpenDocument (accessed 9.2.19).

Australian Bureau of Statistics, 2001. Australian Standard Geographical Classification (ASGC), 2001. ABS Cat. No. 1216.0. Canberra: ABS.

Australian Bureau of Statistics, 1997. 1995 National health survey—SF-36 population norms, Australia. ABS Catalogue No. 4399.0. Canberra: ABS.

Australian Government Department of Jobs and Small Business, 2018. Australian Jobs 2018. Canberra.

Australian Institute of Health and Welfare, 2020a. Australian Burden of Disease Study 2015: Interactive data on risk factor burden. Cat. no. BOD 25. Canberra: AIHW.

Australian Institute of Health and Welfare, 2020b. Overweight and obesity [WWW Document]. URL https://www.aihw.gov.au/reports/australias-health/overweight-and-obesity (accessed 6.7.21).

Australian Institute of Health and Welfare, 2020c. A framework for monitoring overweight and obesity in Australia. Cat. no. PHE 272. Canberra: AIHW.

Australian Institute of Health and Welfare, 2020d. Chronic conditions and multimorbidity [WWW Document]. URL https://www.aihw.gov.au/reports/australias-health/chronic-conditions-and-multimorbidity (accessed 4.18.21).

Australian Institute of Health and Welfare, 2020e. Burden of disease [WWW Document]. https://doi.org/2021-04-18

Australian Institute of Health and Welfare, 2020f. People with disability in Australia. Cat. no. DIS 72. Canberra: AIHW.

Australian Institute of Health and Welfare, 2019a. Overweight and obesity: an interactive insight. Cat. no. PHE 251. Canberra: AIHW.

Australian Institute of Health and Welfare, 2019b. Australian Burden of Disease Study: impact and causes of illness and death in Australia 2015. Australian Burden of Disease series no. 19. Cat. no. BOD 22. Canberra: AIHW.

Australian Institute of Health and Welfare, 2019c. Overweight & obesity [WWW Document]. URL https://www.aihw.gov.au/reports-data/behaviours-risk-factors/overweight-obesity/overview (accessed 7.16.19).

Australian Institute of Health and Welfare, 2019d. Data sources for monitoring overweight and obesity in Australia. Cat. no. PHE 244. Canberra: AIHW.

Australian Institute of Health and Welfare, 2019e. People with disability in Australia 2019: in brief, Canberra: AIHW. Cat. no. DIS 74. Canberra: AIHW.

Australian Institute of Health and Welfare, 2018a. Australia’s health 2018. Australia’s health series no. 16. AUS 221. Canberra:AIHW.

Australian Institute of Health and Welfare, 2018b. Australia ’ s health 2018. Canberra:AIHW. https://doi.org/10.1145/3173574.3174019

Australian Institute of Health and Welfare, 2017a. A picture of overweight and obesity in Australia 2017. Cat. no. PHE 216. Canberra: AIHW.

Australian Institute of Health and Welfare, 2017b. Impact of overweight and obesity as a risk factor for chronic conditions: Australian burden of disease Study. Australian Burden of Disease Study series no. 11. Cat. no. BOD 12. Canberra: AIHW.

Australian Institute of Health and Welfare, 2017c. Disability in Australia: changes over time in inclusion and participation in employment. Cat. no. DIS 68. Canberra: AIHW.

Australian Institute of Health and Welfare, 2017d. Overweight and obesity in Australia : a birth cohort analysis. Canberra:AIHW.

Australian Institute of Health and Welfare, 2005. Obesity and workplace absenteeism

among older Australians. Cat. No. AUS 67. Canberra:AIHW.
Australian Institute of Health and Welfare, 2004. Rural, regional and remote health: a Guide to Remote Classification. Canberra:AIHW.
Averett, S., 2014. Obesity and labor market outcomes. IZA World Labor 1–10. https://doi.org/10.15185/izawol.32
Avsar, G., Ham, R., Tannous, W.K., 2017. Factors influencing the incidence of obesity in Australia: A generalized ordered probit model. Int. J. Environ. Res. Public Health 14. https://doi.org/10.3390/ijerph14020177
Backholer, K., Mannan, H.R., Magliano, D.J., Walls, H.L., Stevenson, C., Beauchamp, A., Shaw, J.E., Peeters, A., 2012. Projected socioeconomic disparities in the prevalence of obesity among Australian adults. Aust. N. Z. J. Public Health 36, 557–563. https://doi.org/10.1111/j.1753-6405.2012.00885.x
Baldwin, M.L., Marcus, S.C., 2006. Perceived and Measured Stigma Among Workers With Serious Mental Illness. Psychiatr. Serv. 57, 388–392. https://doi.org/10.1176/appi.ps.57.3.388
Balzi, D., Lauretani, F., Barchielli, A., Ferrucci, L., Bandinelli, S., Buiatti, E., Milaneschi, Y., Guralnik, J.M., 2009. Risk factors for disability in older persons over 3-year follow-up. Age Ageing 39, 92–98. https://doi.org/10.1093/ageing/afp209
Banegas, J.R., López-García, E., Graciani, A., Guallar-Castillón, P., Gutierrez-Fisac, J.L., Alonso, J., Rodríguez-Artalejo, F., 2007. Relationship between obesity, hypertension and diabetes, and health-related quality of life among the elderly. Eur. J. Cardiovasc. Prev. Rehabil. 14, 456–462. https://doi.org/10.1097/HJR.0b013e3280803f29
Bartels, L.K., Nordstrom, C.R., 2013. Too big to hire: factors impacting weight discrimination. Manag. Res. Rev. 36, 868–881. https://doi.org/10.1108/MRR-06-2012-0134
Becker, G.S., 2010. The economics of discrimination. University of Chicago press.
Befort, C.A., Nazir, N., Perri, M.G., 2012. Prevalence of Obesity Among Adults From Rural and Urban Areas of the United States: Findings From NHANES (2005-2008). J. Rural Heal. 28, 392–397. https://doi.org/10.1111/j.1748-0361.2012.00411.x
Bell, J.F., Zimmerman, F.J., Arterburn, D.E., MacIejewski, M.L., 2011. Health-care expenditures of overweight and obese males and females in the medical expenditures panel survey by age cohort. Obesity 19, 228–232. https://doi.org/10.1038/oby.2010.104
Bergström, G., Bodin, L., Hagberg, J., Aronsson, G., Josephson, M., 2009. Sickness

presenteeism today, sickness absenteeism tomorrow? A prospective study on sickness presenteeism and future sickness absenteeism. J. Occup. Environ. Med. 51, 629–638. https://doi.org/10.1097/JOM.0b013e3181a8281b

Bertakis, K.D., Azari, R., 2005. Obesity and the use of health care services. Obes. Res. 13, 372–379. https://doi.org/10.1038/oby.2005.49

Biddle, N., 2013. Comparing Self Perceived and Observed Labour Market Discrimination in Australia. Econ. Pap. A J. Appl. Econ. policy 32, 383–394. https://doi.org/10.1111/1759-3441.12044

Biring, M.S., Lewis, M.I., Liu, J.T., Mohsenifar, Z., 1999. Pulmonary Physiologic Changes of Morbid Obesity. Am. J. Med. Sci. 318, 293–297. https://doi.org/10.1016/S0002-9629(15)40641-X

Bjerregaard, L.G., Adelborg, K., Baker, J.L., 2020. Change in body mass index from childhood onwards and risk of adult cardiovascular disease,. Trends Cardiovasc. Med. 30, 39–45. https://doi.org/10.1016/j.tcm.2019.01.011

Black, J.L., Macinko, J., 2008. Neighborhoods and obesity. Nutr. Rev. 66, 2–20. https://doi.org/10.1111/j.1753-4887.2007.00001.x

Black, N., Johnston, D.W., Suziedelyte, A., 2017. Justification bias in self-reported disability: New evidence from panel data. J. Health Econ. 54, 124–134. https://doi.org/10.1016/j.jhealeco.2017.05.001

Blagojevic, M., Jinks, C., Jeffery, A., Jordan, K.P., 2010. Risk factors for onset of osteoarthritis of the knee in older adults: a systematic review and meta-analysis. Osteoarthr. Cartil. 18, 24–33. https://doi.org/10.1016/j.joca.2009.08.010

Böckerman, P., Cawley, J., Viinikainen, J., Lehtimäki, T., Rovio, S., Seppälä, I., Pehkonen, J., Raitakari, O., 2019. The effect of weight on labor market outcomes: An application of genetic instrumental variables. Health Econ. 28, 65–77. https://doi.org/10.1002/hec.3828

Bockerman, P., Laukkanen, E., 2010. Predictors of sickness absence and presenteeism: Does the pattern differ by a respondent’s health? J. Occup. Environ. Med. 52, 332–335. https://doi.org/10.1097/JOM.0b013e3181d2422f

Bowring, A.L., Peeters, A., Freak-Poli, R., Lim, M.S.C., Gouillou, M., Hellard, M., 2012. Measuring the accuracy of self-reported height and weight in a community-based sample of young people. BMC Med. Res. Methodol. 12. https://doi.org/10.1186/1471-2288-12-175

Boyle, P.A., Buchman, A.S., Wilson, R.S., Bienias, J.L., Bennett, D.A., 2007. Physical activity is associated with incident disability in community-based older persons. J. Am. Geriatr. Soc. 55, 195–201. https://doi.org/10.1111/j.1532-5415.2007.01038.x

Brettschneider, C., Leicht, H., Bickel, H., Dahlhaus, A., Fuchs, A., Gensichen, J., Maier, W., Riedel-Heller, S., Schäfer, I., Schön, G., Weyerer, S., Wiese, B., van den Bussche, H., Scherer, M., König, H.-H., 2013. Relative Impact of Multimorbid Chronic Conditions on Health-Related Quality of Life – Results from the MultiCare Cohort Study. PLoS One 8, e66742. https://doi.org/10.1371/journal.pone.0066742

Brucker, D.L., 2017. The association of food insecurity with health outcomes for adults with disabilities. Disabil. Health J. 10, 286–293. https://doi.org/10.1016/j.dhjo.2016.12.006

Brunello, G., D'Hombres, B., 2007. Does body weight affect wages?: Evidence from Europe. Econ. Hum. Biol. 5, 1–19. https://doi.org/10.1016/j.ehb.2006.11.002

Bruno, G.S.F., Caroleo, F.E., Dessy, O., 2015. Obesity and economic performance of young workers in Italy. Youth Cris. Unempl. Educ. Heal. Eur. 129–145. https://doi.org/10.4324/9781315708997

Bubonya, M., Cobb-Clark, D.A., Wooden, M., 2017. Mental health and productivity at work: Does what you do matter? Labour Econ. 46, 150–165. https://doi.org/10.1016/j.labeco.2017.05.001

Buist-Bouwman, M.A., Ormel, J., de Graaf, R., de Jonge, P., van Sonderen, E., Alonso, J., Bruffaerts, R., Vollebergh, W.A.M., 2008. Mediators of the association between depression and role functioning. Acta Psychiatr. Scand. 118, 451–458. https://doi.org/10.1111/j.1600-0447.2008.01285.x

Busetto, L., Pilone, V., Schettino, A.M., Furbetta, N., Zappa, M., Di Maro, A., Borrelli, V., Giardiello, C., Battistoni, M., Gardinazzi, A., Perrotta, N., Micheletto, G., De Meis, P., Martelli, S., Marangon, M., Forestieri, P., Pari, C., Gennai, S., Mozzi, E., Italian Group for Lap-Band, 2012. Determinants of health-related quality of life in morbid obese candidates to gastric banding. Eat. Weight Disord. 17, e93-100. https://doi.org/10.3275/8244

Busutil, R., Espallardo, O., Torres, A., Martínez-Galdeano, L., Zozaya, N., Hidalgo-Vega, Á., 2017. The impact of obesity on health-related quality of life in Spain. Health Qual. Life Outcomes 15, 197. https://doi.org/10.1186/s12955-017-0773-y

Butland, B., Jebb, S., Kopelman, P., McPherson, K., Thomas, S., Mardell, J., Parry, V., 2007. Tackling obesities: future choices-project report. Vol. 10. London: Department of Innovation, Universities and Skills.

Cain, G.G., 1986. Chapter 13 The economic analysis of labor market discrimination: A survey. pp. 693–785. https://doi.org/10.1016/S1573-4463(86)01016-7

Calle, E.E., Kaaks, R., 2004. Overweight, obesity and cancer: Epidemiological evidence and proposed mechanisms. Nat. Rev. Cancer 4, 579–591. https://doi.org/10.1038/nrc1408

Calle, E.E., Rodriguez, C., Walker-Thurmond, K., Thun, M.J., 2003. Overweight, Obesity, and Mortality from Cancer in a Prospectively Studied Cohort of U.S. Adults. N. Engl. J. Med. 348, 1625–1638. https://doi.org/10.1056/NEJMoa021423

Callen, B.L., Lindley, L.C., Niederhauser, V.P., 2013. Health risk factors associated with presenteeism in the workplace. J. Occup. Environ. Med. 55, 1312–1317. https://doi.org/10.1097/JOM.0b013e3182a200f4

Cameron, A.J., Welborn, T.A., Zimmet, P.Z., 2004. Overweight and obesity in Australia: the 1999-2000 Australian Diabetes, Obesity and Lifestyle Study (AusDiab). Med. J. Aust. 180, 418. https://doi.org/10.5694/j.1326-5377.2003.tb05283.x

Carlson, B., Pozehl, B., Hertzog, M., Zimmerman, L., Riegel, B., 2013. Predictors of Overall Perceived Health in Patients With Heart Failure. J. Cardiovasc. Nurs. 28, 206–215. https://doi.org/10.1097/JCN.0b013e31824987a8

Carr, D., Friedman, M.A., 2005a. Is Obesity Stigmatizing ? Body Weight , Perceived Discrimination , and Psycholog ... Library (Lond). 46, 244–259.

Carr, D., Friedman, M.A., 2005b. Is Obesity Stigmatizing? Body Weight, Perceived Discrimination, and Psychological Well-Being in the United States. J. Health Soc. Behav. 46, 244–259. https://doi.org/10.1177/002214650504600303

Caruana, E.J., Roman, M., Hernández-sánchez, J., Solli, P., 2015. Longitudinal studies. J. Thorac. Dis. 7, 537–540. https://doi.org/10.3978/j.issn.2072-1439.2015.10.63

Caruso, C.C., 2006. Possible broad impacts of long work hours. Ind. Health 44, 531–536. https://doi.org/10.2486/indhealth.44.531

Cawley, J., 2004. The Impact of Obesity on Wages. J. Hum. Resour. 39, 451. https://doi.org/10.2307/3559022

Cebulla, A., Zhu, R., 2016. Disability, and social and economic inclusion: who is in and out of the Australian National Disability Insurance Scheme? Scand. J. Disabil. Res. 18, 256–268. https://doi.org/10.1080/15017419.2015.1064026

Centers for Disease Control and Prevention, 2021. The Social-Ecological Model: A Framework for Prevention [WWW Document]. URL https://www.cdc.gov/violenceprevention/about/social-ecologicalmodel.html (accessed 6.10.21).

Centers for Disease Control and Prevention, 2020a. Disability and health overview [WWW Document]. URL https://www.cdc.gov/ncbddd/disabilityandhealth/disability.html (accessed 11.3.20).

Centers for Disease Control and Prevention, 2020b. Benefits of Physical Activity [WWW Document]. URL https://www.cdc.gov/physicalactivity/basics/pa-health/index.htm (accessed 11.4.20).

Centers for Disease Control and Prevention, 2017. Adult Obesity Causes & Consequences [WWW Document]. URL https://www.cdc.gov/obesity/adult/causes.html (accessed 9.4.19).

Centers for Disease Control and Prevention, 2016. Childhood Obesity Causes & Consequences [WWW Document]. URL https://www.cdc.gov/obesity/childhood/causes.html (accessed 6.10.21).

Cercato, C., Fonseca, F.A., 2019. Cardiovascular risk and obesity. Diabetol. Metab. Syndr. 11, 74. https://doi.org/10.1186/s13098-019-0468-0

Chen, H., Guo, X., 2008. Obesity and functional disability in elderly Americans. J. Am. Geriatr. Soc. 56, 689–694. https://doi.org/10.1111/j.1532-5415.2007.01624.x

Choi, B.K., Schnall, P.L., Yang, H., Dobson, M., Landsbergis, P., Israel, L., Karasek, R., Baker, D., 2010. Sedentary work, low physical job demand, and obesity in US workers. Am. J. Ind. Med. 53, 1088–1101. https://doi.org/10.1002/ajim.20886

Choi, S., Kim, K., Kim, S.M., Lee, G., Jeong, S.-M., Park, S.Y., Kim, Y.-Y., Son, J.S., Yun, J.-M., Park, S.M., 2018. Association of Obesity or Weight Change With Coronary Heart Disease Among Young Adults in South Korea. JAMA Intern. Med. 178, 1060. https://doi.org/10.1001/jamainternmed.2018.2310

Choo, J., Jeon, S., Lee, J., 2014. Gender differences in health-related quality of life associated with abdominal obesity in a Korean population. BMJ Open 4, 1–8. https://doi.org/10.1136/bmjopen-2013-003954

Chooi, Y.C., Ding, C., Magkos, F., 2019. The epidemiology of obesity. Metabolism. 92, 6–10. https://doi.org/10.1016/j.metabol.2018.09.005

Clark, A., Knabe, A., Rätzel, S., 2010. Boon or bane? Others' unemployment, well-being and job insecurity. Labour Econ. 17, 52–61. https://doi.org/10.1016/j.labeco.2009.05.007

Clark, A.E., 1997. Job satisfaction and gender: Why are women so happy at work? Labour Econ. 4, 341–372. https://doi.org/10.1016/S0927-5371(97)00010-9

Clark, A.E., Oswald, A.J., 1996. Satisfaction and comparison income. J. Public Econ. 61, 359–381. https://doi.org/10.1016/0047-2727(95)01564-7

Cois, A., Day, C., 2015. Obesity trends and risk factors in the South African adult population. BMC Obes. 2, 1–10. https://doi.org/10.1186/s40608-015-0072-2

Connery, G., 2017. More Australians are working night shifts, so how do they manage?

Cullinan, J., Gillespie, P., 2016. Does Overweight and Obesity Impact on Self-Rated Health? Evidence Using Instrumental Variables Ordered Probit Models. Health Econ. 25, 1341–1348. https://doi.org/10.1002/hec.3215

Dai, H., Alsalhe, T.A., Chalghaf, N., Riccò, M., Bragazzi, N.L., Wu, J., 2020. The global burden of disease attributable to high body mass index in 195 countries and territories, 1990–2017: An analysis of the Global Burden of Disease Study. PLOS Med. 17, e1003198. https://doi.org/10.1371/journal.pmed.1003198

DeRigne, L.A., Stoddard-Dare, P., Quinn, L., 2016. Workers without paid sick leave less likely to take time off for illness or injury compared to those with paid sick leave. Health Aff. 35, 520–527. https://doi.org/10.1377/hlthaff.2015.0965

DHS, 2016. Absence management & wellbeing survey report. NSW: Direct Health Solutions.

Di Milia, L., Mummery, K., 2009. The association between job related factors, short sleep and obesity. Ind. Health 47, 363–8.

Di Milia, L., Vandelanotte, C., Duncan, M.J., 2013. The association between short sleep and obesity after controlling for demographic, lifestyle, work and health related factors. Sleep Med. 14, 319–323. https://doi.org/10.1016/j.sleep.2012.12.007

Donini, L.M., Merola, G., Poggiogalle, E., Lubrano, C., Gnessi, L., Mariani, S., Migliaccio, S., Lenzi, A., 2016. Disability, physical inactivity, and impaired health-related quality of life are not different in metabolically healthy vs. Unhealthy obese subjects. Nutrients 8, 1–10. https://doi.org/10.3390/nu8120759

Drew, J.E., 2012. Molecular mechanisms linking adipokines to obesity-related colon cancer: Focus on leptin. Proc. Nutr. Soc. 71, 175–180. https://doi.org/10.1017/S0029665111003259

Econtech, 2011. Economic modelling of the cost of presenteeism in Australia. 12.

Elrashidi, M., Jacobson, D., Sauver, J., Fan, C., Lynch, B., Rutten, L., Ebbert, J., 2016. Body mass index trajectories and healthcare utilization in young and middle-aged adults. Medicine (Baltimore). 95.

Escoto, K.H., French, S.A., Harnack, L.J., Toomey, T.L., Hannan, P.J., Mitchell, N.R.,

2010. Work hours, weight status, and weight-related behaviors: A study of metro transit workers. Int. J. Behav. Nutr. Phys. Act. 7, 17–19. https://doi.org/10.1186/1479-5868-7-91

Eurofound, 2007. Job satisfaction and labour market mobility. Dublin: Eurofund.

Ezzat, A., Ehab, M., 2018. The determinants of job satisfaction in the Egyptian labor market. Rev. Econ. Polit. Sci. 4, 54–72. https://doi.org/10.1108/reps-10-2018-012

Fabian, M., Breunig, R., 2016. Long work-hours and job satisfaction: do over-workers get trapped in bad jobs? Introduction and Background 1–32.

Feng, X., Wilson, A., 2015. Do neighbourhood socioeconomic circumstances not matter for weight status among Australian men? Multilevel evidence from a household survey of 14 691 adults. BMJ Open 5. https://doi.org/10.1136/bmjopen-2014-007052

Ferrer-i-Carbonell, F.P.F., 2014. How Important Is Methodology for the Estimates of the Determinants of Happiness? Econ. J. 114, 641–659.

Ferrie, J.E., Head, J., Shipley, M.J., Vahtera, J., Marmot, M.G., Kivimäki, M., 2007. BMI, obesity, and sickness absence in the whitehall II study. Obesity 15, 1554–1564. https://doi.org/10.1038/oby.2007.184

Fevre, R., Robinson, A., Lewis, D., Jones, T., 2013. The ill-treatment of employees with disabilities in British workplaces. Work. Employ. Soc. 27, 288–307. https://doi.org/10.1177/0950017012460311

Finkelstein, E.A., Brown, D.S., Wrage, L.A., Allaire, B.T., Hoerger, T.J., 2010. Individual and Aggregate Years-of-life-lost Associated With Overweight and Obesity. Obesity 18, 333–339. https://doi.org/10.1038/oby.2009.253

Finkelstein, E.A., Khavjou, O.A., Thompson, H., Trogdon, J.G., Pan, L., Sherry, B., Dietz, W., 2012. Obesity and severe obesity forecasts through 2030. Am. J. Prev. Med. 42, 563–570.

Fitzgerald, S., Kirby, A., Murphy, A., Geaney, F., 2016. Obesity, diet quality and absenteeism in a working population. Public Health Nutr. 19, 3287–3295. https://doi.org/10.1017/S1368980016001269

Flegal, K.M., Kit, B.K., Orpana, H., Graubard, B.I., 2013. Association of All-Cause Mortality With Overweight and Obesity Using Standard Body Mass Index Categories. JAMA 309, 71. https://doi.org/10.1001/jama.2012.113905

Flint, S.W., Codreanu, S.C., Gomoiu, A., Čadek, M., Ivić, V., Zomer, C., Walton, P., 2015. Obesity Discrimination in the Workplace: “You’re Hired!” J. Eur. Psychol.

Students 6, 64–69. https://doi.org/10.5334/jeps.cu

Flint, S.W., Snook, J., 2014. Obesity and discrimination. Int. J. Discrim. Law 14, 183–193. https://doi.org/10.1177/1358229114534550

Folland, S., Goodman, A.C., Stano, M., 2016. The Economics of Health and Health Care: Pearson New International Edition, The Economics of Health and Health Care. Routledge. https://doi.org/10.4324/9781315510736

Ford, E.S., 2005. The epidemiology of obesity and asthma. J. Allergy Clin. Immunol. 115, 897–909. https://doi.org/10.1016/j.jaci.2004.11.050

Fortin, M., Lapointe, L., Hudon, C., Vanasse, A., Ntetu, A.L., Maltais, D., 2004. Multimorbidity and quality of life in primary care: A systematic review. Health Qual. Life Outcomes 2, 1–12. https://doi.org/10.1186/1477-7525-2-51

Fortin, M., Soubhi, H., Hudon, C., Bayliss, E.A., Akker, M. van den, 2007. Multimorbidity's many challenges. BMJ 334, 1016–1017. https://doi.org/10.1136/bmj.39201.463819.2C

Freeman, R.B., 2019. American Economic Association Job Satisfaction as an Economic Variable 68, 135–141.

Freidin, S., Watson, N., Wooden, M., 2002. Household, Income and Labour Dynamics in Australia (HILDA) Survey: Wave 1. Melbourne.

Frone, M.R., 2007. Obesity and absenteeism among U.S. workers: Do physical health and mental health explain the relation? J. Workplace Behav. Health 22, 65–79. https://doi.org/10.1080/15555240802157403

Garin, O., Ayuso-Mateos, J., Almansa, J., Nieto, M., Chatterji, S., Vilagut, G., Alonso, J., Cieza, A., Svetskova, O., Burger, H., Racca, V., Francescutti, C., Vieta, E., Kostanjsek, N., Raggi, A., Leonardi, M., Ferrer, M., 2010. Validation of the "World Health Organization Disability Assessment Schedule, WHODAS-2" in patients with chronic diseases. Health Qual. Life Outcomes 8, 51. https://doi.org/10.1186/1477-7525-8-51

Gates, D.M., Succop, P., Brehm, B.J., Gillespie, G.L., Sommers, B.D., 2008. Obesity and presenteeism: The impact of body mass index on workplace productivity. J. Occup. Environ. Med. 50, 39–45. https://doi.org/10.1097/JOM.0b013e31815d8db2

GBD 2015 Obesity Collaborators, 2017. Health Effects of Overweight and Obesity in 195 Countries over 25 Years. N. Engl. J. Med. 377, 13–27. https://doi.org/10.1056/NEJMoa1614362

Godard, M., 2016. Gaining weight through retirement? Results from the SHARE survey.

J. Health Econ. 45, 27–46. https://doi.org/10.1016/j.jhealeco.2015.11.002
Goetzel, R.Z., Gibson, T.B., Short, M.E., Chu, B.C., Waddell, J., Bowen, J., Lemon, S.C., Fernandez, I.D., Ozminkowski, R.J., Wilson, M.G., Dejoy, D.M., 2010. A multi-worksite analysis of the relationships among body mass index, medical utilization, and worker productivity. J. Occup. Environ. Med. 52, 1–16. https://doi.org/10.1097/JOM.0b013e3181c95b84
Gong, S., Wang, K., Li, Y., Alamian, A., 2018. Geographic differences in obesity prevalence and its risk factors among Asian Americans: findings from the 2013–2014 California Health Interview Survey. Sci. Rep. 8, 2–8. https://doi.org/10.1038/s41598-018-29906-5
Gorber, S.C., Tremblay, M., Moher, D., Gorber, B., 2007a. A comparison of direct vs. self-report measures for assessing height, weight and body mass index: A systematic review. Obes. Rev. 8, 307–326. https://doi.org/10.1111/j.1467-789X.2007.00347.x
Gorber, S.C., Tremblay, M., Moher, D., Gorber, B., 2007b. A comparison of direct vs. self-report measures for assessing height, weight and body mass index: A systematic review. Obes. Rev. 8, 307–326. https://doi.org/10.1111/j.1467-789X.2007.00347.x
Grantham, N.M., Magliano, D.J., Hodge, A., Jowett, J., Meikle, P., Shaw, J.E., 2013. The association between dairy food intake and the incidence of diabetes in Australia: the Australian Diabetes Obesity and Lifestyle Study (AusDiab). Public Health Nutr. 16, 339–345. https://doi.org/10.1017/S1368980012001310
Greve, J., 2008. Obesity and labor market outcomes in Denmark. Econ. Hum. Biol. 6, 350–362. https://doi.org/10.1016/j.ehb.2008.09.001
Greve, J., 2007. Obesity and Labor Market Outcomes : New Danish Evidence, Wp.
Grossman, M., 2017. The demand for health: a theoretical and empirical investigation. Columbia University Press.
Grundy, A., Cotterchio, M., Kirsh, V.A., Nadalin, V., Lightfoot, N., Kreiger, N., 2017. Rotating shift work associated with obesity in men from Northeastern Ontario. Heal. Promot. Chronic Dis. Prev. Canada 37, 238–247. https://doi.org/10.24095/hpcdp.37.8.02
Guh, D.P., Zhang, W., Bansback, N., Amarsi, Z., Birmingham, C.L., Anis, A.H., 2009. The incidence of co-morbidities related to obesity and overweight: A systematic review and meta-analysis. BMC Public Health 9, 1–20. https://doi.org/10.1186/1471-2458-9-88
Gurka, M.J., Filipp, S.L., Deboer, M.D., 2018. Geographical variation in the prevalence

of obesity, metabolic syndrome, and diabetes among US adults article. Nutr. Diabetes 8. https://doi.org/10.1038/s41387-018-0024-2

Gustafsson Sendén, M., Schenck-Gustafsson, K., Fridner, A., 2016. Gender differences in Reasons for Sickness Presenteeism - a study among GPs in a Swedish health care organization. Ann. Occup. Environ. Med. 28, 50. https://doi.org/10.1186/s40557-016-0136-x

Haby, M.M., Markwick, A., Peeters, A., Shaw, J., Vos, T., 2012. Future predictions of body mass index and overweight prevalence in Australia, 20052025. Health Promot. Int. 27, 250–260. https://doi.org/10.1093/heapro/dar036

Hafner, Marco, Christian Van Stolk, Catherine Saunders, Joachim Krapels, and B.B., 2015. Health, wellbeing and productivity in the workplace. RAND EUROPE.

Hafner, M., Stolk, C. van, Saunders, C., Krapels, J., Baruch, B., 2015. Health, wellbeing and productivity in the workplace.

Hardy, L.L., Mihrshahi, S., Gale, J., Drayton, B.A., Bauman, A., Mitchell, J., 2017. 30-year trends in overweight, obesity and waist-to-height ratio by socioeconomic status in Australian children, 1985 to 2015. Int. J. Obes. 41, 76–82. https://doi.org/10.1038/ijo.2016.204

Harvey, S.B., Glozier, N., Carlton, O., Mykletun, A., Henderson, M., Hotopf, M., Holland-Elliott, K., 2010. Obesity and sickness absence: Results from the CHAP study. Occup. Med. (Chic. Ill). 60, 362–368. https://doi.org/10.1093/occmed/kqq031

Hashmi, R., Alam, K., Gow, J., 2020. Socioeconomic inequalities in mental health in Australia: Explaining life shock exposure. Health Policy (New. York). 124, 97–105. https://doi.org/10.1016/j.healthpol.2019.10.011

Hauck, K., Hollingsworth, B., 2010. The impact of severe obesity on hospital length of stay. Med. Care 335–340.

Hayes, A.J., Lung, T.W.C., Bauman, A., Howard, K., 2017. Modelling obesity trends in Australia: Unravelling the past and predicting the future. Int. J. Obes. 41, 178–185. https://doi.org/10.1038/ijo.2016.165

He, Y., Pan, A., Wang, Y., Yang, Y., Xu, J., Zhang, Ya, Liu, D., Wang, Q., Shen, H., Zhang, Yiping, Yan, D., Peng, Z., Hu, F.B., Ma, X., 2017. Prevalence of overweight and obesity in 15.8 million men aged 15-49 years in rural China from 2010 to 2014. Sci. Rep. 7, 1–10. https://doi.org/10.1038/s41598-017-04135-4

Hellgren, M.I., Kitsche, E., Groot-Zevert, M., Lindblad, U., Daka, B., 2019. Association between body mass index and self-rated health: A Swedish population-based longitudinal study. Scand. J. Public Health 140349481987501. https://doi.org/10.1177/1403494819875012

Herman, K.M., Hopman, W.M., Rosenberg, M.W., 2013. Self-rated health and life satisfaction among Canadian adults: associations of perceived weight status versus BMI. Qual. Life Res. 22, 2693–2705. https://doi.org/10.1007/s11136-013-0394-9

Hitt, H.C., McMillen, R.C., Thornton-Neaves, T., Koch, K., Cosby, A.G., 2007. Comorbidity of Obesity and Pain in a General Population: Results from the Southern Pain Prevalence Study. J. Pain 8, 430–436. https://doi.org/10.1016/j.jpain.2006.12.003

Hoare, E., Crooks, N., Hayward, J., Allender, S., Strugnell, C., 2019. Associations between combined overweight and obesity, lifestyle behavioural risk and quality of life among Australian regional school children: Baseline findings of the Goulburn Valley health behaviours monitoring study. Health Qual. Life Outcomes 17, 1–10. https://doi.org/10.1186/s12955-019-1086-0

Hoeymans, N., Feskens, E.J.M., Kromhout, D., van den Bos, G.A.M., 1999. The Contribution of Chronic Conditions and Disabilities to Poor Self-Rated Health in Elderly Men. Journals Gerontol. Ser. A Biol. Sci. Med. Sci. 54, M501–M506. https://doi.org/10.1093/gerona/54.10.M501

Howard, J.T., Potter, L.B., 2014. An assessment of the relationships between overweight, obesity, related chronic health conditions and worker absenteeism. Obes. Res. Clin. Pract. 8, e1–e15. https://doi.org/10.1016/j.orcp.2012.09.002

Hruby, A., Hu, F.B., 2015. The Epidemiology of Obesity: A Big Picture. Pharmacoeconomics 33, 673–689. https://doi.org/10.1007/s40273-014-0243-x

Hu, L., Huang, X., You, C., Li, J., Hong, K., Li, P., Wu, Y., Wu, Q., Wang, Z., Gao, R., Bao, H., Cheng, X., 2017. Prevalence of overweight, obesity, abdominal obesity and obesity-related risk factors in southern China. PLoS One 12, 1–14. https://doi.org/10.1371/journal.pone.0183934

Hunger, M., Thorand, B., Schunk, M., Döring, A., Menn, P., Peters, A., Holle, R., 2011. Multimorbidity and health-related quality of life in the older population: results from the German KORA-Age study. Health Qual. Life Outcomes 9, 53. https://doi.org/10.1186/1477-7525-9-53

Hunte, H.E.R., Williams, D.R., 2009. The Association Between Perceived Discrimination and Obesity in a Population-Based Multiracial and Multiethnic Adult Sample. Am. J. Public Health 99, 1285–1292. https://doi.org/10.2105/AJPH.2007.128090

Huse, O., Hettiarachchi, J., Gearon, E., Nichols, M., Allender, S., Peeters, A., 2018. Obesity in Australia. Obes. Res. Clin. Pract. 12, 29–39. https://doi.org/10.1016/j.orcp.2017.10.002

Ichino, A., Moretti, E., 2009. Biological gender differences, absenteeism, and the earnings gap. Am. Econ. J. Appl. Econ. 1, 183–218. https://doi.org/10.1257/app.1.1.183

Imai, K., Gregg, E.W., Chen, Y.J., Zhang, P., de Rekeneire, N., Williamson, D.F., 2008. The Association of BMI With Functional Status and Self-rated Health in US Adults. Obesity 16, 402–408. https://doi.org/10.1038/oby.2007.70

Jaacks, L.M., Vandevijvere, S., Pan, A., McGowan, C.J., Wallace, C., Imamura, F., Mozaffarian, D., Swinburn, B., Ezzati, M., 2019. The obesity transition: stages of the global epidemic. Lancet Diabetes Endocrinol. 7, 231–240. https://doi.org/10.1016/S2213-8587(19)30026-9

Jakicic, J.M., Otto, A.D., 2005. Physical activity considerations for the treatment and prevention of obesity. Am. J. Clin. Nutr. 82, 226–229.

Jang, T.W., Kim, H.R., Lee, H.E., Myong, J.P., Koo, J.W., 2013. Long work hours and obesity in Korean adult workers. J. Occup. Health 55, 359–366. https://doi.org/10.1539/joh.13-0043-OA

Jans, M.P., Van Den Heuvel, S.G., Hildebrandt, V.H., Bongers, P.M., 2007. Overweight and obesity as predictors of absenteeism in the working population of the Netherlands. J. Occup. Environ. Med. 49, 975–980. https://doi.org/10.1097/JOM.0b013e31814b2eb7

Janssens, H., Clays, E., Kittel, F., De Bacquer, D., Casini, A., Braeckman, L., 2012. The association between body mass index class, sickness absence, and presenteeism. J. Occup. Environ. Med. 54, 604–609. https://doi.org/10.1097/JOM.0b013e31824b2133

Jia, H., Lubetkin, E.I., 2005. The impact of obesity on health-related quality-of-life in the general adult US population. J. Public Health (Bangkok). 27, 156–164. https://doi.org/10.1093/pubmed/fdi025

Johansson, E., Böckerman, P., Kiiskinen, U., Heliövaara, M., 2009. Obesity and labour market success in Finland: The difference between having a high BMI and being fat. Econ. Hum. Biol. 7, 36–45. https://doi.org/10.1016/j.ehb.2009.01.008

Johns, G., 2010. Presenteeism in the workplace: A review and research agenda. J. Organ. Behav. 31, 519–542.

Johnson, J. V., Lipscomb, J., 2006. Long working hours, occupational health and the changing nature of work organization. Am. J. Ind. Med. 49, 921–929. https://doi.org/10.1002/ajim.20383

Jones, A.M., Finkelstein, R., Koehoorn, M., 2018. Disability and workplace harassment and discrimination among Canadian federal public service employees. Can. J. Public Heal. 109, 79–88. https://doi.org/10.17269/s41997-018-0022-0

Kalkunte, S.S., Mselle, T.F., Norris, W.E., Wira, C.R., Charles L. Sentman, Sharma, S., 2012. VEGF C facilitates immune tolerance and endovascular activity of human uterine NK cells at the maternal-fetal interface Satyan. J. Immunol. (Baltimore, Md 1950) 29, 997–1003. https://doi.org/10.1016/j.biotechadv.2011.08.021.Secreted

Karlsson, T., 2016. Gender differences in absence from work : Lessons from two world wars. Work. Pap.

Kearns, K., Dee, A., Fitzgerald, A.P., Doherty, E., Perry, I.J., 2014. Chronic disease burden associated with overweight and obesity in Ireland: the effects of a small BMI reduction at population level. BMC Public Health 14, 143. https://doi.org/10.1186/1471-2458-14-143

Kelly, M.J., Dunstan, F.D., Lloyd, K., Fone, D.L., 2008. Evaluating cutpoints for the MHI-5 and MCS using the GHQ-12: a comparison of five different methods. BMC Psychiatry 8, 10. https://doi.org/10.1186/1471-244X-8-10

Kepka, D., Ayala, G.X., Cherrington, A., 2007. Do Latino immigrants link self-rated health with BMI and health behaviors? Am. J. Health Behav. 31, 535–44. https://doi.org/10.5555/ajhb.2007.31.5.535

Keramat, S.A., Alam, K., Ahinkorah, B.O., Islam, M.S., Islam, M.I., Hossain, M.Z., Ahmed, S., Gow, J., Biddle, S.J., 2021a. Obesity, Disability and Self-Perceived Health Outcomes in Australian Adults: A Longitudinal Analysis Using 14 Annual Waves of the HILDA Cohort. Clin. Outcomes Res. Volume 13, 777–788. https://doi.org/10.2147/CEOR.S318094

Keramat, S.A., Alam, K., Al-Hanawi, M.K., Gow, J., Biddle, S.J.H., Hashmi, R., 2021b. Trends in the prevalence of adult overweight and obesity in Australia, and its association with geographic remoteness. Sci. Rep. 11, 11320. https://doi.org/10.1038/s41598-021-90750-1

Keramat, S.A., Alam, K., Gow, J., Biddle, S.J.H., 2020a. Gender differences in the longitudinal association between obesity, and disability with workplace absenteeism in the Australian working population. PLoS ONE.15(5) e0233512, 1–14.

Keramat, S.A., Alam, K., Gow, J., Biddle, S.J.H., 2020b. A longitudinal exploration of the relationship between obesity , and long term health condition with presenteeism in Australian workplaces , 2006-2018. PLoS ONE. 15(8) e0238260, 1–17.

Keramat, S.A., Alam, K., Gow, J., Biddle, S.J.H., 2020c. Obesity, Long-Term Health Problems, and Workplace Satisfaction: A Longitudinal Study of Australian Workers. J. Community Health 45, 288–300. https://doi.org/10.1007/s10900-019-00735-5

Keramat, S.A., Alam, K., Gow, J., Biddle, S.J.H., 2020d. Impact of Disadvantaged Neighborhoods and Lifestyle Factors on Adult Obesity: Evidence From a 5-Year Cohort Study in Australia. Am. J. Heal. Promot. https://doi.org/10.1177/0890117120928790

Keramat, S.A., Alam, K., Gow, J., Biddle, S.J.H., 2020e. Job-Related Characteristics and Obesity in Australian Employees: Evidence From a Longitudinal Nationally Representative Sample. Am. J. Heal. Promot. https://doi.org/10.1177/0890117119901093

Keramat, S.A., Alam, K., Rana, R.H., Shuvo, S. Das, Gow, J., Biddle, S.J.H., Keating, B., 2021c. Age and gender differences in the relationship between obesity and disability with self-perceived employment discrimination: Results from a retrospective study of an Australian national sample. SSM - Popul. Heal. 16, 100923. https://doi.org/10.1016/j.ssmph.2021.100923

Keramat, S.A., Alam, K., Sathi, N.J., Gow, J., Biddle, S.J.H., Al-Hanawi, M.K., 2021d. Self-reported disability and its association with obesity and physical activity in Australian adults: Results from a longitudinal study. SSM - Popul. Heal. 14, 100765. https://doi.org/10.1016/j.ssmph.2021.100765

Khalaila, R.N.R., 2017. Socioeconomic Status, Health Behaviors, Obesity and Self-Rated Health among Older Arabs in Israel. J. Cross. Cult. Gerontol. 32, 115–130. https://doi.org/10.1007/s10823-016-9301-5

Kifle, T., 2014. Do Comparison Wages Play a Major Role in Determining Overall Job Satisfaction? Evidence from Australia. J. Happiness Stud. 15, 613–638. https://doi.org/10.1007/s10902-013-9439-6

Kifle, T., Kler, P., Shankar, S., n.d. Underemployment and its impact on job satisfaction : An Australian study on part-time employment.

Kim, J.M., Stewart, R., Glozier, N., Prince, M., Kim, S.W., Yang, S.J., Shin, I.S., Yoon, J.S., 2005. Physical health, depression and cognitive function as correlates of disability in an older Korean population. Int. J. Geriatr. Psychiatry 20, 160–167.

https://doi.org/10.1002/gps.1266

Kim, T.H., Han, E., 2015. Impact of body mass on job quality. Econ. Hum. Biol. 17, 75–85. https://doi.org/10.1016/j.ehb.2015.02.003

King, L.K., March, L., Anandacoomarasamy, A., 2013. Obesity & osteoarthritis. Indian J. Med. Res. 138, 185–93.

King, T., Kavanagh, A.M., Jolley, D., Turrell, G., Crawford, D., 2006. Weight and place: A multilevel cross-sectional survey of area-level social disadvantage and overweight/obesity in Australia. Int. J. Obes. 30, 281–287. https://doi.org/10.1038/sj.ijo.0803176

Klassen, A., Wickert, N., Tsangaris, E., Klaassen, R., Anthony, S., 2017. Health-Related Quality of Life, in: Pediatric Oncology. pp. 735–747. https://doi.org/10.1007/978-3-319-33679-4_30

Koliaki, C., Liatis, S., Kokkinos, A., 2019. Obesity and cardiovascular disease: revisiting an old relationship. Metabolism. 92, 98–107. https://doi.org/10.1016/j.metabol.2018.10.011

Kolotkin, R.L., Andersen, J.R., 2017. A systematic review of reviews: exploring the relationship between obesity, weight loss and health-related quality of life. Clin. Obes. 7, 273–289. https://doi.org/10.1111/cob.12203

Kolotkin, R.L., Crosby, R.D., Williams, G.R., Hartley, G.G., Nicol, S., 2001. The relationship between health-related quality of life and weight loss. Obes. Res. 9, 564–571. https://doi.org/10.1038/oby.2001.73

Korda, R.J., Joshy, G., Paige, E., Butler, J.R.G., Jorm, L.R., Liu, B., Bauman, A.E., Banks, E., 2015. The Relationship between Body Mass Index and Hospitalisation Rates, Days in Hospital and Costs: Findings from a Large Prospective Linked Data Study. PLoS One 10, e0118599. https://doi.org/10.1371/journal.pone.0118599

Kortt, M., Leigh, A., 2010. Does size matter in Australia? Econ. Rec. 86, 71–83. https://doi.org/10.1111/j.1475-4932.2009.00566.x

Kortt, M.A., Clarke, P.M., 2005. Estimating Utility Values for Health States of Overweight and Obese Individuals Using the SF-36. Qual. Life Res. 14, 2177–2185. https://doi.org/10.1007/s11136-005-8027-6

Kortt, M.A., Dollery, B., 2011. Association Between Body Mass Index and Health-Related Quality of Life Among an Australian Sample. Clin. Ther. 33, 1466–1474. https://doi.org/10.1016/j.clinthera.2011.08.009

Kpelitse, K., Devlin, R.A., Sarma, S., 2014. The Effect of Income on Obesity among

Canadian Adults. Working Paper No: 2014-C02. Canadian Centre for Health Economics. Toronto, Canada.

Kramer, A.F., Colcombe, S.J., McAuley, E., Scalf, P.E., Erickson, K.I., 2005. Fitness, aging and neurocognitive function. Neurobiol. Aging 26, 124–127. https://doi.org/10.1016/j.neurobiolaging.2005.09.009

Kudel, I., Huang, J.C., Ganguly, R., 2018. Impact of obesity on work productivity in different US occupations: Analysis of the National Health and Wellness Survey 2014 to 2015. J. Occup. Environ. Med. 60, 6–11. https://doi.org/10.1097/JOM.0000000000001144

Kungu, K., Melius, J., Cannonier, C., Wanga, V., 2019. Obesity, chronic job discrimination and social support. Manag. Res. Rev. 42, 586–604. https://doi.org/10.1108/MRR-02-2018-0060

Lahti-Koski, M., Taskinen, O., Similä, M., Männistö, S., Laatikainen, T., Knekt, P., Valsta, L.M., 2008. Mapping geographical variation in obesity in Finland. Eur. J. Public Health 18, 637–643. https://doi.org/10.1093/eurpub/ckn089

LaMontagne, A.D., Krnjacki, L., Milner, A., Butterworth, P., Kavanagh, A., 2016. Psychosocial job quality in a national sample of working Australians: A comparison of persons working with versus without disability. SSM - Popul. Heal. 2, 175–181. https://doi.org/10.1016/j.ssmph.2016.03.001

Landsbergis, P.A., Grzywacz, J.G., LaMontagne, A.D., 2014. Work organization, job insecurity, and occupational health disparities. Am. J. Ind. Med. 57, 495–515. https://doi.org/10.1002/ajim.22126

Larose, S.L., Kpelitse, K.A., Campbell, M.K., Zaric, G.S., Sarma, S., 2016. Does obesity influence labour market outcomes among working-age adults? Evidence from Canadian longitudinal data. Econ. Hum. Biol. 20, 26–41. https://doi.org/10.1016/j.ehb.2015.09.007

Lee, G.J., Kim, K., Kim, S. yeong, Kim, J.H., Suh, C., Son, B.C., Lee, C.K., Choi, J., 2016. Effects of shift work on abdominal obesity among 20-39-year-old female nurses: A 5-year retrospective longitudinal study. Ann. Occup. Environ. Med. 28, 1–7. https://doi.org/10.1186/s40557-016-0148-6

Lee, H.-W., Song, M., Yang, J.J., Kang, D., 2015. Determinants of Poor Self-rated Health in Korean Adults With Diabetes. J. Prev. Med. Public Heal. 48, 287–300. https://doi.org/10.3961/jpmph.15.048

Lee, S., Fung, S.C., Tsang, A., Zhang, M.Y., Huang, Y.Q., He, Y.L., Liu, Z.R., Shen, Y.C., Kessler, R.C., 2007. Delay in initial treatment contact after first onset of mental disorders in metropolitan China. Acta Psychiatr. Scand. 116, 10–16. https://doi.org/10.1111/j.1600-0447.2006.00933.x

Lee, Y., Park, K., 2008. Does physical activity moderate the association between depressive symptoms and disability in older adults? Int. J. Geriatr. Psychiatry 23, 249–256. https://doi.org/10.1002/gps.1870

Lehnert, T., Heider, D., Leicht, H., Heinrich, S., Corrieri, S., Luppa, M., Riedel-Heller, S., König, H., 2016. Health Care Utilization and Costs of Elderly Persons With Multiple Chronic Conditions. Med. Care Res. Rev. 68, 387–420. https://doi.org/10.1177/1077558711399580

Lehnert, T., Stuhldreher, N., Streltchenia, P., Riedel-Heller, S.G., König, H.H., 2014. Sick leave days and costs associated with overweight and obesity in Germany. J. Occup. Environ. Med. 56, 20–27. https://doi.org/10.1097/JOM.0000000000000065

Lemay, V., Caru, M., Samoilenko, M., Drouin, S., Alos, N., Lefebvre, G., Levy, E., Lippé, S., Marcil, V., Sultan, S., Bertout, L., Krajinovic, M., Laverdière, C., Raboisson, M.-J., Sinnett, D., Andelfinger, G., Curnier, D., 2019. Prevention of Long-term Adverse Health Outcomes With Cardiorespiratory Fitness and Physical Activity in Childhood Acute Lymphoblastic Leukemia Survivors. J. Pediatr. Hematol. Oncol. 41, e450–e458. https://doi.org/10.1097/MPH.0000000000001426

Lementowski, P.W., Zelicof, S.B., 2008. Obesity and osteoarthritis. Am. J. Orthop. (Belle Mead. NJ). 37, 148–151.

Lemstra, M.E., Rogers, M.R., 2016. Improving health-related quality of life through an evidence-based obesity reduction program: The Healthy Weights Initiative. J. Multidiscip. Healthc. 9, 103–109. https://doi.org/10.2147/JMDH.S100693

Levine, E.E., Schweitzer, M.E., 2015. The affective and interpersonal consequences of obesity. Organ. Behav. Hum. Decis. Process. 127, 66–84. https://doi.org/10.1016/j.obhdp.2015.01.002

Lewis, T.T., Kravitz, H.M., Janssen, I., Powell, L.H., 2011. Self-reported Experiences of Discrimination and Visceral Fat in Middle-aged African-American and Caucasian Women. Am. J. Epidemiol. 173, 1223–1231. https://doi.org/10.1093/aje/kwq466

Lim, W.-Y., Ma, S., Heng, D., Bhalla, V., Chew, S.K., 2007. Gender, ethnicity, health behaviour & self-rated health in Singapore. BMC Public Health 7, 184. https://doi.org/10.1186/1471-2458-7-184

Lima, M.G., De Azevedo Barros, M.B., César, C.L.G., Goldbaum, M., Carandina, L., Ciconelli, R.M., 2009. Impact of chronic disease on quality of life among the elderly in the state of Sao Paulo, Brazil: A population-based study. Rev. Panam. Salud Publica/Pan Am. J. Public Heal. 25, 314–321. https://doi.org/10.1590/S1020-49892009000400005

Lin, X., Xu, Y., Xu, J., Pan, X., Song, X., Shan, L., Zhao, Y., Shan, P.-F., 2020. Global burden of noncommunicable disease attributable to high body mass index in 195 countries and territories, 1990–2017. Endocrine 69, 310–320. https://doi.org/10.1007/s12020-020-02352-y

Lindeboom, M., Lundborg, P., Van Der Klaauw, B., 2010. Assessing the impact of obesity on labor market outcomes. Econ. Hum. Biol. 8, 309–319. https://doi.org/10.1016/j.ehb.2010.08.004

Liu, Q., Shi, J., Duan, P., Liu, B., Li, T., Wang, C., Li, H., Yang, T., Gan, Y., Wang, X., Cao, S., Lu, Z., 2018. Is shift work associated with a higher risk of overweight or obesity? A systematic review of observational studies with meta-analysis. Int. J. Epidemiol. 47, 1956–1971. https://doi.org/10.1093/ije/dyy079

Local Government Association, 2018. Developing healthier places. London.

Lopez, S.H., Hodson, R., Roscigno, V.J., 2009. Power, Status, and Abuse at Work: General and Sexual Harassment Compared. Sociol. Q. 50, 3–27. https://doi.org/10.1111/j.1533-8525.2008.01131.x

Lopez Silva, C.P., Singh, A., Calache, H., Derbi, H.A., Borromeo, G.L., 2020. Association between disability status and dental attendance in Australia—A population-based study. Community Dent. Oral Epidemiol. https://doi.org/10.1111/cdoe.12571

Lynch, B.A., Finney Rutten, L.J., Jacobson, R.M., Kumar, S., Elrashidi, M.Y., Wilson, P.M., Jacobson, D.J., St. Sauver, J.L., 2015. Health Care Utilization by Body Mass Index in a Pediatric Population. Acad. Pediatr. 15, 644–650. https://doi.org/10.1016/j.acap.2015.08.009

Machacova, K., Lysack, C., Neufeld, S., 2011. Self-rated health among persons with spinal cord injury: What is the role of physical ability? J. Spinal Cord Med. 34, 265–272. https://doi.org/10.1179/107902610X12883422813660

Macmillan, R., Duke, N., Oakes, J.M., Liao, W., 2011. Trends in the Association of Obesity and Self-Reported Overall Health in 30 Years of the Integrated Health Interview Series. Obesity 19, 1103–1105. https://doi.org/10.1038/oby.2010.286

Magee, C.A., Caputi, P., Lee, J.K., 2016. Distinct longitudinal patterns of absenteeism and their antecedents in full-time australian employees. J. Occup. Health Psychol. 21, 24–36. https://doi.org/10.1037/a0039138

Majumder, M.A., 2013. Does Obesity Matter for Wages? Evidence from the United States. Econ. Pap. A J. Appl. Econ. policy 32, 200–217. https://doi.org/10.1111/1759-3441.12030

Maradit Kremers, H., Visscher, S.L., Kremers, W.K., Naessens, J.M., Lewallen, D.G., 2014. Obesity increases length of stay and direct medical costs in total hip arthroplasty. Clin. Orthop. Relat. Res. 472, 1232–1239. https://doi.org/10.1007/s11999-013-3316-9

March, L.M., Bagga, H., 2004. Epidemiology of osteoarthritis in Australia. Med. J. Aust. 180. https://doi.org/10.5694/j.1326-5377.2004.tb05906.x

Marengoni, A., Angleman, S., Melis, R., Mangialasche, F., Karp, A., Garmen, A., Meinow, B., Fratiglioni, L., 2011. Aging with multimorbidity: a systematic review of the literature. Ageing Res. Rev. 10, 430–439.

Markowitz, S., Friedman, M.A., Arent, S.M., 2008. Understanding the relation between obesity and depression: Causal mechanisms and implications for treatment. Clin. Psychol. Sci. Pract. 15, 1–20. https://doi.org/10.1111/j.1468-2850.2008.00106.x

Maroto, M., Pettinicchio, D., 2014. Disability, structural inequality, and work: The influence of occupational segregation on earnings for people with different disabilities. Res. Soc. Stratif. Mobil. 38, 76–92. https://doi.org/10.1016/j.rssm.2014.08.002

Marrie, R.A., Horwitz, R., Cutter, G., Tyry, T., 2012. Cumulative impact of comorbidity on quality of life in MS. Acta Neurol. Scand. 125, 180–186. https://doi.org/10.1111/j.1600-0404.2011.01526.x

Mathers, C.D., Loncar, D., 2006. Projections of global mortality and burden of disease from 2002 to 2030. PLoS Med. 3, 2011–2030. https://doi.org/10.1371/journal.pmed.0030442

Maukonen, M., Männistö, S., Tolonen, H., 2018. A comparison of measured versus self-reported anthropometrics for assessing obesity in adults: a literature review. Scand. J. Public Health 46, 565–579. https://doi.org/https://doi.org/10.1177/1403494818761971

Maukonen, M., Männistö, S., Tolonen, H., 2018. A comparison of measured versus self-reported anthropometrics for assessing obesity in adults: a literature review. Scand. J. Public Health 46, 565–579. https://doi.org/10.1177/1403494818761971

McKercher, C., Patton, G.C., Schmidt, M.D., Venn, A.J., Dwyer, T., Sanderson, K., 2013. Physical activity and depression symptom profiles in young men and women with major depression. Psychosom. Med. 75, 366–374. https://doi.org/10.1097/PSY.0b013e31828c4d53

McMahon, B.T., 2012. An overview of workplace discrimination and disability. J. Vocat. Rehabil. 36, 135–139. https://doi.org/10.3233/JVR-2012-0588

Mehta, K.M., Yaffe, K., Covinsky, K.E., 2002. Cognitive Impairment, Depressive Symptoms, and Functional Decline in Older People. J. Am. Geriatr. Soc. 50, 1045–1050. https://doi.org/10.1046/j.1532-5415.2002.50259.x

Mehta, N.K., Patel, S.A., Ali, M.K., Narayan, K.M.V., 2017. Preventing disability: The influence of modifiable risk factors on state and national disability prevalence. Health Aff. 36, 626–635. https://doi.org/10.1377/hlthaff.2016.1281

Melbourne Institute of Applied Economic and Social Research, 2018. Household, Income and Labour Dynamics in Australia (HILDA) Survey: Wave 17 Restricted Release Marked Up Questionnaires. Melbourne, Australia.

Menigoz, K., Nathan, A., Heesch, K.C., Turrell, G., 2018. Neighbourhood disadvantage, geographic remoteness and body mass index among immigrants to Australia: A national cohort study 2006-2014. PLoS One 13, 1–17. https://doi.org/10.1371/journal.pone.0191729

Micciolo, R., Canal, L., Minniti, A., Mazzali, G., Fantin, F., Corzato, F., Antonioli, A., Harris, T.B., Zamboni, M., 2013. The association between excess weight and comorbidity and self-rated health in the Italian population. Ann. Epidemiol. 23, 172–178. https://doi.org/10.1016/j.annepidem.2013.02.003

Milner, A., LaMontagne, A.D., 2017. Underemployment and mental health: comparing fixed-effects and random-effects regression approaches in an Australian working population cohort. Occup. Environ. Med. 74, 344–350. https://doi.org/10.1136/oemed-2016-103706

Min-Ju, K., Kuk-Hui, S., Hyun-Young, P., Dong-Ju, C., Chang-Hwan, Y., Hea-Young, L., Eun-Young, C., Myeong-Chan, C., 2013. Association between shift work and obesity among female nurses: Korean Nurses' Survey. BMC Public Health 13, 1–15.

Mocan, N., Tekin, E., 2009. Obesity, Self-esteem and Wages. Working paper number: 15101. National Bureau of Economic Research. Cambridge, MA. https://doi.org/10.3386/w15101

Mond, J.M., Baune, B.T., 2009. Overweight, Medical Comorbidity and Health-related

Quality of Life in a Community Sample of Women and Men. Obesity 17, 1627–1634. https://doi.org/10.1038/oby.2009.27

Moro, A., Tello-Trillo, S., Tempesti, T., 2019. The Impact of Obesity on Wages: The Role of Personal Interactions and Job Selection. Labour 33, 125–146. https://doi.org/10.1111/labr.12145

Morris, S., 2007. The impact of obesity on employment. Labour Econ. 14, 413–433. https://doi.org/10.1016/j.labeco.2006.02.008

Morris, S., 2006. Body mass index and occupational attainment. J. Health Econ. 25, 347–364. https://doi.org/10.1016/j.jhealeco.2005.09.005

Morshed, A.B., Kasman, M., Heuberger, B., Hammond, R.A., Hovmand, P.S., 2019. A systematic review of system dynamics and agent-based obesity models: Evaluating obesity as part of the global syndemic. Obes. Rev. 20, 161–178. https://doi.org/10.1111/obr.12877

Muenster, E., Rueger, H., Ochsmann, E., Letzel, S., Toschke, A.M., 2011. Association between overweight, obesity and self-perceived job insecurity in German employees. BMC Public Health 11, 162. https://doi.org/10.1186/1471-2458-11-162

Mujica-Mota, R.E., Roberts, M., Abel, G., Elliott, M., Lyratzopoulos, G., Roland, M., Campbell, J., 2015. Common patterns of morbidity and multi-morbidity and their impact on health-related quality of life: evidence from a national survey. Qual. Life Res. 24, 909–918. https://doi.org/10.1007/s11136-014-0820-7

Must, A., 1999. The Disease Burden Associated With Overweight and Obesity. JAMA 282, 1523. https://doi.org/10.1001/jama.282.16.1523

Naghavi, M., Abajobir, A.A., Abbafati, C., Abbas, K.M., Abd-Allah, F., Abera, S.F., Aboyans, V., Adetokunboh, O., Afshin, A., Agrawal, A., Ahmadi, A., Ahmed, M.B., Aichour, A.N., Aichour, M.T.E., Aichour, I., Aiyar, S., Alahdab, F., Al-Aly, Z., Alam, K., Alam, N., Alam, T., Alene, K.A., Al-Eyadhy, A., Ali, S.D., Alizadeh-Navaei, R., Alkaabi, J.M., Alkerwi, A., Alla, F., Allebeck, P., Allen, C., Al-Raddadi, R., Alsharif, U., Altirkawi, K.A., Alvis-Guzman, N., Amare, A.T., Amini, E., Ammar, W., Amoako, Y.A., Anber, N., Andersen, H.H., Andrei, C.L., Androudi, S., Ansari, H., Antonio, C.A.T., Anwari, P., Ärnlöv, J., Arora, M., Artaman, A., Aryal, K.K., Asayesh, H., Asgedom, S.W., Atey, T.M., Avila-Burgos, L., Avokpaho, E.F.G., Awasthi, A., Babalola, T.K., Bacha, U., Balakrishnan, K., Barac, A., Barboza, M.A., Barker-Collo, S.L., Barquera, S., Barregard, L., Barrero, L.H., Baune, B.T., Bedi, N., Beghi, E., Béjot, Y., Bekele, B.B., Bell, M.L., Bennett, J.R., Bensenor, I.M., Berhane, A., Bernabé, E., Betsu, B.D., Beuran, M., Bhatt, S., Biadgilign, S., Bienhoff, K., Bikbov, B., Bisanzio, D., Bourne, R.R.A., Breitborde, N.J.K., Bulto, L.N.B., Bumgarner, B.R., Butt, Z.A., Cahuana-Hurtado, L., Cameron, E., Campuzano, J.C., Car, J., Cárdenas, R., Carrero, J.J., Carter, A., Casey, D.C., Castañeda-Orjuela, C.A., Catalá-López, F., Charlson, F.J., Chibueze, C.E., Chimed-Ochir, O., Chisumpa, V.H., Chitheer, A.A., Christopher, D.J., Ciobanu, L.G., Cirillo, M., Cohen, A.J., Colombara, D., Cooper, C., Cowie, B.C., Criqui, M.H., Dandona, L., Dandona, R., Dargan, P.I., das Neves, J., Davitoiu, D. V, Davletov, K., de Courten, B., Defo, B.K., Degenhardt, L., Deiparine, S., Deribe, K., Deribew, A., Dey, S., Dicker, D., Ding, E.L., Djalalinia, S., Do, H.P., Doku, D.T., Douwes-Schultz, D., Driscoll, T.R., Dubey, M., Duncan, B.B., Echko, M., El-Khatib, Z.Z., Ellingsen, C.L., Enayati, A., Ermakov, S.P., Erskine, H.E., Eskandarieh, S., Esteghamati, A., Estep, K., Farinha, C.S. e S., Faro, A., Farzadfar, F., Feigin, V.L., Fereshtehnejad, S.-M., Fernandes, J.C., Ferrari, A.J., Feyissa, T.R., Filip, I., Finegold, S., Fischer, F., Fitzmaurice, C., Flaxman, A.D., Foigt, N., Frank, T., Fraser, M., Fullman, N., Fürst, T., Furtado, J.M., Gakidou, E., Garcia-Basteiro, A.L., Gebre, T., Gebregergs, G.B., Gebrehiwot, T.T., Gebremichael, D.Y., Geleijnse, J.M., Genova-Maleras, R., Gesesew, H.A., Gething, P.W., Gillum, R.F., Giref, A.Z., Giroud, M., Giussani, G., Godwin, W.W., Gold, A.L., Goldberg, E.M., Gona, P.N., Gopalani, S.V., Gouda, H.N., Goulart, A.C., Griswold, M., Gupta, R., Gupta, T., Gupta, V., Gupta, P.C., Haagsma, J.A., Hafezi-Nejad, N., Hailu, A.D., Hailu, G.B., Hamadeh, R.R., Hambisa, M.T., Hamidi, S., Hammami, M., Hancock, J., Handal, A.J., Hankey, G.J., Hao, Y., Harb, H.L., Hareri, H.A., Hassanvand, M.S., Havmoeller, R., Hay, S.I., He, F., Hedayati, M.T., Henry, N.J., Heredia-Pi, I.B., Herteliu, C., Hoek, H.W., Horino, M., Horita, N., Hosgood, H.D., Hostiuc, S., Hotez, P.J., Hoy, D.G., Huynh, C., Iburg, K.M., Ikeda, C., Ileanu, B.V., Irenso, A.A., Irvine, C.M.S., Islam, S.M.S., Jacobsen, K.H., Jahanmehr, N., Jakovljevic, M.B., Javanbakht, M., Jayaraman, S.P., Jeemon, P., Jha, V., John, D., Johnson, C.O., Johnson, S.C., Jonas, J.B., Jürisson, M., Kabir, Z., Kadel, R., Kahsay, A., Kamal, R., Karch, A., Karimi, S.M., Karimkhani, C., Kasaeian, A., Kassaw, N.A., Kassebaum, N.J., Katikireddi, S.V., Kawakami, N., Keiyoro, P.N., Kemmer, L., Kesavachandran, C.N., Khader, Y.S., Khan, E.A., Khang, Y.-H., Khoja, A.T.A., Khosravi, M.H., Khosravi, A., Khubchandani, J., Kiadaliri, A.A., Kieling, C., Kievlan, D., Kim, Y.J., Kim, D., Kimokoti, R.W., Kinfu, Y., Kissoon, N., Kivimaki, M., Knudsen, A.K., Kopec, J.A., Kosen, S., Koul, P.A., Koyanagi, A., Kulikoff, X.R., Kumar, G.A., Kumar, P., Kutz, M., Kyu, H.H., Lal, D.K., Lalloo, R., Lambert, T.L.N., Lan, Q., Lansingh, V.C., Larsson, A., Lee, P.H., Leigh, J., Leung, J., Levi, M., Li, Y., Li Kappe, D., Liang, X., Liben, M.L., Lim, S.S., Liu, P.Y., Liu, A., Liu, Y., Lodha, R., Logroscino, G., Lorkowski, S., Lotufo, P.A., Lozano, R., Lucas, T.C.D., Ma, S., Macarayan, E.R.K., Maddison, E.R., Magdy Abd El Razek, M., Majdan, M., Majdzadeh, R., Majeed, A., Malekzadeh, R., Malhotra, R., Malta, D.C., Manguerra, H., Manyazewal, T., Mapoma, C.C., Marczak, L.B., Markos, D., Martinez-Raga, J., Martins-Melo, F.R., Martopullo, I., McAlinden, C., McGaughey, M., McGrath, J.J., Mehata, S., Meier, T., Meles, K.G., Memiah, P., Memish, Z.A., Mengesha, M.M., Mengistu, D.T., Menota, B.G., Mensah, G.A., Meretoja, T.J., Meretoja, A., Millear, A., Miller, T.R., Minnig, S., Mirarefin, M., Mirrakhimov, E.M., Misganaw, A., Mishra, S.R., Mohamed, I.A., Mohammad, K.A., Mohammadi, A., Mohammed, S., Mokdad, A.H., Mola, G.L.D., Mollenkopf, S.K., Molokhia, M., Monasta, L., Montañez, J.C., Montico, M., Mooney, M.D., Moradi-Lakeh, M., Moraga, P., Morawska, L., Morozoff, C., Morrison, S.D., Mountjoy-Venning, C., Mruts, K.B., Muller, K., Murthy, G.V.S., Musa, K.I., Nachega, J.B., Naheed, A., Naldi, L., Nangia, V., Nascimento, B.R., Nasher, J.T., Natarajan, G., Negoi, I., Ngunjiri, J.W., Nguyen, C.T., Nguyen, Q. Le, Nguyen, T.H., Nguyen, G., Nguyen, M., Nichols, E., Ningrum, D.N.A., Nong, V.M., Noubiap, J.J.N., Ogbo, F.A., Oh, I.-H., Okoro, A., Olagunju, A.T., Olsen, H.E., Olusanya, B.O., Olusanya, J.O., Ong, K., Opio, J.N., Oren, E., Ortiz, A., Osman, M., Ota, E., PA, M., Pacella, R.E., Pakhale, S., Pana, A., Panda, B.K., Panda-Jonas, S., Papachristou, C., Park, E.-K., Patten, S.B., Patton, G.C., Paudel, D., Paulson, K., Pereira, D.M., Perez-Ruiz, F., Perico, N., Pervaiz, A., Petzold, M., Phillips, M.R., Pigott, D.M., Pinho, C., Plass, D., Pletcher, M.A., Polinder, S., Postma, M.J., Pourmalek, F., Purcell, C., Qorbani, M., Quintanilla, B.P.A., Radfar, A., Rafay, A., Rahimi-Movaghar, V., Rahman, M.H.U., Rahman, M., Rai, R.K., Ranabhat, C.L., Rankin, Z., Rao, P.C., Rath, G.K., Rawaf, S., Ray, S.E., Rehm, J., Reiner, R.C., Reitsma, M.B., Remuzzi, G., Rezaei, S., Rezai, M.S., Rokni, M.B., Ronfani, L., Roshandel, G., Roth, G.A., Rothenbacher, D., Ruhago, G.M., SA, R., Saadat, S., Sachdev, P.S., Sadat, N., Safdarian, M., Safi, S., Safiri, S., Sagar, R., Sahathevan, R., Salama, J., Salamati, P., Salomon, J.A., Samy, A.M., Sanabria, J.R., Sanchez-Niño, M.D., Santomauro, D., Santos, I.S., Santric Milicevic, M.M., Sartorius, B., Satpathy, M., Schmidt, M.I., Schneider, I.J.C., Schulhofer-

Wohl, S., Schutte, A.E., Schwebel, D.C., Schwendicke, F., Sepanlou, S.G., Servan-Mori, E.E., Shackelford, K.A., Shahraz, S., Shaikh, M.A., Shamsipour, M., Shamsizadeh, M., Sharma, J., Sharma, R., She, J., Sheikhbahaei, S., Shey, M., Shi, P., Shields, C., Shigematsu, M., Shiri, R., Shirude, S., Shiue, I., Shoman, H., Shrime, M.G., Sigfusdottir, I.D., Silpakit, N., Silva, J.P., Singh, J.A., Singh, A., Skiadaresi, E., Sligar, A., Smith, D.L., Smith, A., Smith, M., Sobaih, B.H.A., Soneji, S., Sorensen, R.J.D., Soriano, J.B., Sreeramareddy, C.T., Srinivasan, V., Stanaway, J.D., Stathopoulou, V., Steel, N., Stein, D.J., Steiner, C., Steinke, S., Stokes, M.A., Strong, M., Strub, B., Subart, M., Sufiyan, M.B., Sunguya, B.F., Sur, P.J., Swaminathan, S., Sykes, B.L., Tabarés-Seisdedos, R., Tadakamadla, S.K., Takahashi, K., Takala, J.S., Talongwa, R.T., Tarawneh, M.R., Tavakkoli, M., Taveira, N., Tegegne, T.K., Tehrani-Banihashemi, A., Temsah, M.-H., Terkawi, A.S., Thakur, J.S., Thamsuwan, O., Thankappan, K.R., Thomas, K.E., Thompson, A.H., Thomson, A.J., Thrift, A.G., Tobe-Gai, R., Topor-Madry, R., Torre, A., Tortajada, M., Towbin, J.A., Tran, B.X., Troeger, C., Truelsen, T., Tsoi, D., Tuzcu, E.M., Tyrovolas, S., Ukwaja, K.N., Undurraga, E.A., Updike, R., Uthman, O.A., Uzochukwu, B.S.C., van Boven, J.F.M., Vasankari, T., Venketasubramanian, N., Violante, F.S., Vlassov, V.V., Vollset, S.E., Vos, T., Wakayo, T., Wallin, M.T., Wang, Y.-P., Weiderpass, E., Weintraub, R.G., Weiss, D.J., Werdecker, A., Westerman, R., Whetter, B., Whiteford, H.A., Wijeratne, T., Wiysonge, C.S., Woldeyes, B.G., Wolfe, C.D.A., Woodbrook, R., Workicho, A., Xavier, D., Xiao, Q., Xu, G., Yaghoubi, M., Yakob, B., Yano, Y., Yaseri, M., Yimam, H.H., Yonemoto, N., Yoon, S.-J., Yotebieng, M., Younis, M.Z., Zaidi, Z., Zaki, M.E.S., Zegeye, E.A., Zenebe, Z.M., Zerfu, T.A., Zhang, A.L., Zhang, X., Zipkin, B., Zodpey, S., Lopez, A.D., Murray, C.J.L., 2017. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet 390, 1151–1210. https://doi.org/10.1016/S0140-6736(17)32152-9

National Health and Medical Research Council, 2013. Clinical practice guidelines for the management of overweight and obesity in adults, adolescents and children in Australia. Canberra: NHMRC. https://doi.org/10.3389/fnins.2012.00033

Neovius, M., Rasmussen, F., 2008. Place of residence and obesity in 1,578,694 young Swedish men between 1969 and 2005. Obesity 16, 671–676. https://doi.org/10.1038/oby.2007.115

Ng, S.K., Martin, S.A., Adams, R.J., O'Loughlin, P., Wittert, G.A., 2020. The Effect of Multimorbidity Patterns and the Impact of Comorbid Anxiety and Depression on Primary Health Service Use: The Men Androgen Inflammation Lifestyle. Am. J. Mens. Health 14. https://doi.org/10.1177/1557988320959993

Nigatu, Y.T., Roelen, C.A.M., Reijneveld, S.A., Bültmann, U., 2015. Overweight and distress have a joint association with long-term sickness absence among Dutch employees. J. Occup. Environ. Med. 57, 52–57. https://doi.org/10.1097/JOM.0000000000000273

Noh, J.-W., Kim, J., Yang, Y., Park, J., Cheon, J., Kwon, Y.D., 2017. Body mass index and self-rated health in East Asian countries: Comparison among South Korea, China, Japan, and Taiwan. PLoS One 12, e0183881. https://doi.org/10.1371/journal.pone.0183881

Obesity Policy Coalition, 2018. Overweight, obesity and chronic diseases in Australia. Melbourne: OPC.

OECD, 2017. Obesity Update 2017. OECD Updat. Rep. 13, 331–341. https://doi.org/10.1007/s11428-017-0241-7

Olds, T.S., Tomkinson, G.R., Ferrar, K.E., Maher, C.A., 2010. Trends in the prevalence of childhood overweight and obesity in Australia between 1985 and 2008. Int. J. Obes. 34, 57–66. https://doi.org/10.1038/ijo.2009.211

Padez, C., 2006. Trends in overweight and obesity in Portuguese conscripts from 1986 to 2000 in relation to place of residence and educational level. Public Health 120, 946–952. https://doi.org/10.1016/j.puhe.2006.05.023

Pagan, R., Haro, C.O. De, Sánchez, C.R., 2016. Obesity, job satisfaction and disability at older ages in Europe. Econ. Hum. Biol. 20, 42–54. https://doi.org/10.1016/j.ehb.2015.10.001

Palladino, R., Tayu Lee, J., Ashworth, M., Triassi, M., Millett, C., 2016. Associations between multimorbidity, healthcare utilisation and health status: evidence from 16 European countries. Age Ageing 45, 431–435.

Palladino, Raffaele, Tayu Lee, J., Ashworth, M., Triassi, M., Millett, C., 2016. Associations between multimorbidity, healthcare utilisation and health status: evidence from 16 European countries. Age Ageing 45, 431–435. https://doi.org/10.1093/ageing/afw044

Park, S., Pan, L., Lankford, T., 2014. Relationship between employment characteristics and obesity among employed U.S. adults. Am. J. Heal. Promot. 28, 389–396.

https://doi.org/10.4278/ajhp.130207-QUAN-64
Pati, S., Agrawal, S., Swain, S., Lee, J.T., Vellakkal, S., Hussain, M.A., Millett, C., 2014. Non communicable disease multimorbidity and associated health care utilization and expenditures in India: Cross-sectional study. BMC Health Serv. Res. 14, 451. https://doi.org/10.1186/1472-6963-14-451
Pati, Sandipana, Pati, Sanghamitra, Akker, M. van den, Schellevis, F. (François) G., Jena, S., Burgers, J.S., 2020. Impact of comorbidity on health-related quality of life among type 2 diabetic patients in primary care. Prim. Health Care Res. Dev. 21, e9. https://doi.org/10.1017/S1463423620000055
Payne, R.A., Abel, G.A., Guthrie, B., Mercer, S.W., 2013. The effect of physical multimorbidity, mental health conditions and socioeconomic deprivation on unplanned admissions to hospital: a retrospective cohort. Can Med Assoc 185, E221–E228.
Peeters, A., Backholer, K., 2012. Is the health burden associated with obesity changing? Am. J. Epidemiol. 176, 840–845. https://doi.org/10.1093/aje/kws328
Penedo, F.J., Dahn, J.R., 2005. Exercise and well-being: a review of mental and physical health benefits associated with physical activity. Curr. Opin. Psychiatry 18, 189–193. https://doi.org/10.1097/00001504-200503000-00013
Perales, F., del Pozo-Cruz, Jose, del Pozo-Cruz, Jesus, del Pozo-Cruz, B., 2014. On the associations between physical activity and quality of life: findings from an Australian nationally representative panel survey. Qual. Life Res. 23, 1921–1933. https://doi.org/10.1007/s11136-014-0645-4
Perkins, A.J., Kroenke, K., Unützer, J., Katon, W., Williams, J.W., Hope, C., Callahan, C.M., 2004. Common comorbidity scales were similar in their ability to predict health care costs and mortality. J. Clin. Epidemiol. 57, 1040–1048.
Peterson, M.D., Mahmoudi, E., 2015. Healthcare Utilization Associated With Obesity and Physical Disabilities. Am. J. Prev. Med. 48, 426–435. https://doi.org/10.1016/j.amepre.2014.11.007
Pettinger, T., 2017. The economics of discrimination [WWW Document]. URL https://www.economicshelp.org/blog/26086/concepts/the-economics-of-discrimination/ (accessed 3.10.21).
Peytremann-Bridevaux, I., Faeh, D., Santos-Eggimann, B., 2007. Prevalence of overweight and obesity in rural and urban settings of 10 European countries. Prev. Med. (Baltim). 44, 442–446. https://doi.org/10.1016/j.ypmed.2006.11.011

Peytremann-Bridevaux, I., Santos-Eggimann, B., 2007. Healthcare utilization of overweight and obese Europeans aged 50-79 years. J. Public Health (Bangkok). 15, 377–384. https://doi.org/10.1007/s10389-007-0103-7

Pi-Sunyer, X., 2009. The Medical Risks of Obesity. Postgrad. Med. 121, 21–33. https://doi.org/10.3810/pgm.2009.11.2074

Pimenta, F.B.C., Bertrand, E., Mograbi, D.C., Shinohara, H., Landeira-Fernandez, J., 2015. The relationship between obesity and quality of life in Brazilian adults. Front. Psychol. 6, 1–7. https://doi.org/10.3389/fpsyg.2015.00966

Poirier, P., Giles, T.D., Bray, G.A., Hong, Y., Stern, J.S., Pi-Sunyer, F.X., Eckel, R.H., 2006. Obesity and cardiovascular disease: Pathophysiology, evaluation, and effect of weight loss: An update of the 1997 American Heart Association Scientific Statement on obesity and heart disease from the Obesity Committee of the Council on Nutrition, Physical. Circulation 113, 898–918. https://doi.org/10.1161/CIRCULATIONAHA.106.171016

Poston, W.S.C., Jitnarin, N., Haddock, C.K., Jahnke, S.A., Tuley, B.C., 2011. Obesity and injury-related absenteeism in a population-based firefighter cohort. Obesity 19, 2076–2081. https://doi.org/10.1038/oby.2011.147

Pouliou, T., Elliott, S.J., 2009. An exploratory spatial analysis of overweight and obesity in Canada. Prev. Med. (Baltim). 48, 362–367. https://doi.org/10.1016/j.ypmed.2009.01.017

Preiss, K., Brennan, L., Clarke, D., 2013. A systematic review of variables associated with the relationship between obesity and depression. Obes. Rev. 14, 906–918. https://doi.org/10.1111/obr.12052

PwC Australia, 2015. Weighing the cost of obesity: a case for action. Australia: PwC Australia.

Rachele, J.N., Kavanagh, A., Brown, W.J., Healy, A.M., Schmid, C.J., Turrell, G., 2017. Neighborhood socioeconomic disadvantage and body mass index among residentially stable mid-older aged adults: Findings from the HABITAT multilevel longitudinal study. Prev. Med. (Baltim). 105, 271–274. https://doi.org/10.1016/j.ypmed.2017.09.017

Raebel, M.A., Malone, D.C., Conner, D.A., Xu, S., Porter, J., Lanty, F.A., 2004. Health services use and health care costs of obese and nonobese individuals. Arch. Intern. Med. 164, 2135–2140.

Raebel, Marsha A., Malone, D.C., Conner, D.A., Xu, S., Porter, J.A., Lanty, F.A., 2004.

Health Services Use and Health Care Costs of Obese and Nonobese Individuals. Arch. Intern. Med. 164, 2135. https://doi.org/10.1001/archinte.164.19.2135

Rawal, L.B., Kanda, K., Mahumud, R.A., Joshi, D., Mehata, S., Shrestha, N., Poudel, P., Karki, S., Renzaho, A., 2018. Prevalence of underweight, overweight and obesity and their associated risk factors in Nepalese adults: Data from a nationwide survey, 2016. PLoS One 13, 1–14. https://doi.org/10.1371/journal.pone.0205912

Rebar, A.L., Duncan, M.J., Short, C., Vandelanotte, C., 2014. Differences in health-related quality of life between three clusters of physical activity, sitting time, depression, anxiety, and stress. BMC Public Health 14, 1088. https://doi.org/10.1186/1471-2458-14-1088

Reber, K.C., König, H.H., Hajek, A., 2018. Obesity and sickness absence: Results from a longitudinal nationally representative sample from Germany. BMJ Open 8, 1–8. https://doi.org/10.1136/bmjopen-2017-019839

Reidpath, D.D., Crawford, D., Tilgner, L., Gibbons, C., 2002. Relationship between Body Mass Index and the Use of Healthcare Services in Australia. Obes. Res. 10, 526–531. https://doi.org/10.1038/oby.2002.71

Renehan, A.G., Tyson, M., Egger, M., Heller, R.F., Zwahlen, M., 2008. Body-mass index and incidence of cancer: a systematic review and meta-analysis of prospective observational studies. Lancet 371, 569–578. https://doi.org/10.1016/S0140-6736(08)60269-X

Renzaho, A., Wooden, M., Houng, B., 2010. Associations between body mass index and health-related quality of life among Australian adults. Qual. Life Res. 19, 515–520. https://doi.org/10.1007/s11136-010-9610-z

Rodríguez, R.P., Sánchez, C.R., de Haro, C.O., Maldonado, J.S., 2014. Older Workers with Disabilities: Job Satisfaction Differences in the Public and Private Sectors in Europe. Appl. Res. Qual. Life 9, 711–731. https://doi.org/10.1007/s11482-013-9266-2

Roebroeck, M.E., Jahnsen, R., Carona, C., Kent, R.M., Chamberlain, M.A., 2009. Adult outcomes and lifespan issues for people with childhood-onset physical disability. Dev. Med. Child Neurol. 51, 670–678. https://doi.org/10.1111/j.1469-8749.2009.03322.x

Roehling, M. V., Roehling, P. V., Pichler, S., 2007. The relationship between body weight and perceived weight-related employment discrimination: The role of sex and race. J. Vocat. Behav. 71, 300–318. https://doi.org/10.1016/j.jvb.2007.04.008

Roos, E., Laaksonen, M., Rahkonen, O., Lahelma, E., Lallukka, T., 2015. Weight change and sickness absence - A prospective study among middle-aged employees. Eur. J. Public Health 25, 263–267. https://doi.org/10.1093/eurpub/cku087

Rozjabek, H., Fastenau, J., Laprade, A., Sternbach, N., 2020. Adult obesity and health-related quality of life, patient activation, work productivity, and weight loss behaviors in the United States. Diabetes, Metab. Syndr. Obes. Targets Ther. 13, 2049–2055. https://doi.org/10.2147/DMSO.S245486

Sacks, G., Veerman, J.L., Moodie, M., Swinburn, B., 2011. Traffic-light nutrition labelling and junk-food tax: A modelled comparison of cost-effectiveness for obesity prevention. Int. J. Obes. 35, 1001–1009. https://doi.org/10.1038/ijo.2010.228

Samouda, H., Ruiz-Castell, M., Bocquet, V., Kuemmerle, A., Chioti, A., Dadoun, F., Kandala, N.B., Stranges, S., 2018. Geographical variation of overweight, obesity and related risk factors: Findings from the European Health Examination Survey in Luxembourg, 2013-2015. PLoS One 13, e0197021. https://doi.org/10.1371/journal.pone.0197021

Sanchez Bustillos, A., Vargas, K.G., Gomero-Cuadra, R., 2015. Work productivity among adults with varied Body Mass Index: Results from a Canadian population-based survey. J. Epidemiol. Glob. Health 5, 191–199. https://doi.org/10.1016/j.jegh.2014.08.001

Sarlio-Lahteenkorva, S., Lahelma, E., 1999. The association of body mass index with social and economic disadvantage in women and men. Int. J. Epidemiol. 28, 445–449. https://doi.org/10.1093/ije/28.3.445

Schelbert, K.B., 2009. Comorbidities of Obesity. Prim. Care Clin. Off. Pract. 36, 271–285. https://doi.org/10.1016/j.pop.2009.01.009

Schienkiewitz, A., Mensink, G.B.M., Scheidt-Nave, C., 2012. Comorbidity of overweight and obesity in a nationally representative sample of German adults aged 18-79 years. BMC Public Health 12. https://doi.org/10.1186/1471-2458-12-658

Schootman, M., Deshpande, A.D., Pruitt, S., Aft, R., Jeffe, D.B., 2012. Estimated Effects of Potential Interventions to Prevent Decreases in Self-Rated Health Among Breast Cancer Survivors. Ann. Epidemiol. 22, 79–86. https://doi.org/10.1016/j.annepidem.2011.10.011

Schröder, H., Elosua, R., Vila, J., Marti, H., Covas, M.I., Marrugat, J., 2007. Secular trends of obesity and cardiovascular risk factors in a mediterranean population. Obesity 15, 557–562. https://doi.org/10.1038/oby.2007.574

Schulte, P.A., Wagner, G.R., Ostry, A., Blanciforti, L.A., Cutlip, R.G., Krajnak, K.M., Luster, M., Munson, A.E., O'Callaghan, J.P., Parks, C.G., Simeonova, P.P., Miller, D.B., 2007. Work, obesity, and occupational safety and health. Am. J. Public Health 97, 428–436. https://doi.org/10.2105/AJPH.2006.086900

Scott, K.D., Mabes, D.A., 1984. The job satisfaclion/absenteeism relationship: Gender as a moderating variable. Akron Bus. Econ. Rev. 15, 43–47.

Scott, K.D., McClellan, E.L., 1990. Gender differences in absenteeism. Public Pers. Manage. 19, 229–254. https://doi.org/10.1177/009102609001900210

Scott, K.M., McGee, M.A., Wells, J.E., Oakley Browne, M.A., 2008. Obesity and mental disorders in the adult general population. J. Psychosom. Res. 64, 97–105. https://doi.org/10.1016/j.jpsychores.2007.09.006

Sendi, P., Brunotte, R., Potoczna, N., Branson, R., Horber, F.F., 2005. Health-Related Quality of Life in Patients with Class II and Class III Obesity. Obes. Surg. 15, 1070–1076. https://doi.org/10.1381/0960892054621323

Serrano-Aguilar, P., Muñoz-Navarro, S.R., Ramallo-Fariña, Y., Trujillo-Martín, M.M., 2009. Obesity and health related quality of life in the general adult population of the Canary Islands. Qual. Life Res. 18, 171–177. https://doi.org/10.1007/s11136-008-9427-1

Shimokawa, S., 2008. The labour market impact of body weight in China: A semiparametric analysis. Appl. Econ. 40, 949–968. https://doi.org/10.1080/00036840600771239

Shrestha, N., Pedisic, Z., Neil-Sztramko, S., Kukkonen-Harjula, K.T., Hermans, V., 2016. The Impact of Obesity in the Workplace: a Review of Contributing Factors, Consequences and Potential Solutions. Curr. Obes. Rep. 5, 344–360. https://doi.org/10.1007/s13679-016-0227-6

Siddiqui, S.T., Kandala, N.B., Stranges, S., 2015. Urbanisation and geographic variation of overweight and obesity in India: a cross-sectional analysis of the Indian Demographic Health Survey 2005–2006. Int. J. Public Health 60, 717–726. https://doi.org/10.1007/s00038-015-0720-9

Sinclair, P.A., Lyness, J.M., King, D.A., Cox, C., Caine, E.D., 2001. Depression and self-reported functional status in older primary care patients. Am. J. Psychiatry 158, 416–419. https://doi.org/10.1176/appi.ajp.158.3.416

Slagter, S.N., Van Vliet-Ostaptchouk, J. V., Van Beek, A.P., Keers, J.C., Lutgers, H.L., Van Der Klauw, M.M., Wolffenbuttel, B.H.R., 2015. Health-Related quality of life in relation to obesity grade, type 2 diabetes, metabolic syndrome and inflammation. PLoS One 10, 1–17. https://doi.org/10.1371/journal.pone.0140599

Snyder, L.A., Carmichael, J.S., Blackwell, L. V., Cleveland, J.N., Thornton, G.C., 2010. Perceptions of Discrimination and Justice Among Employees with Disabilities. Empl. Responsib. Rights J. 22, 5–19. https://doi.org/10.1007/s10672-009-9107-5

Song, H.J., Lee, E.K., Kwon, J.W., 2015. Gender Differences in the Impact of Obesity on Health-Related Quality of Life. Asia-Pacific J. Public Heal. 28, 146–156. https://doi.org/10.1177/1010539515626267

Spencer, E.A., Appleby, P.N., Davey, G.K., Key, T.J., 2002. Validity of self-reported height and weight in 4808 EPIC–Oxford participants. Public Health Nutr. 5, 561–565. https://doi.org/10.1079/phn2001322

Spiegel, K., Tasali, E., Penev, P., Van Cauter, E., 2004. Brief communication: Sleep curtailment in healthy young men is associated with decreased leptin levels, elevated ghrelin levels, and increased hunger and appetite. Ann. Intern. Med. 141, 846–850. https://doi.org/10.7326/0003-4819-141-11-200412070-00008

State of Queensland, 2018. Health and Wellbeing Strategic Framework 2017 to 2026. Brisbane QLD 4001.

Stewart, W.F., Ricci, J.A., Chee, E., Morganstein, D., Lipton, R., 2003. Lost Productive Time and Cost Due to Common Pain Conditions in the US Workforce. J. Am. Med. Assoc. 290, 2443–2454. https://doi.org/10.1001/jama.290.18.2443

Stuart, H., 2006. Mental illness and employment discrimination. Curr. Opin. Psychiatry 19, 522–526. https://doi.org/10.1097/01.yco.0000238482.27270.5d

Summerfield, M., Bevitt, A., Fok, Y., Hahn, M., La, N., Macalalad, N., & Wooden, M., 2018. HILDA User Manual–Release 17. Melbourne Institute: Applied Economic and Social Research, University of Melbourne.

Sun, M., Feng, W., Wang, F., Li, P., Li, Z., Li, M., Tse, G., Vlaanderen, J., Vermeulen, R., Tse, L.A., 2018. Meta-analysis on shift work and risks of specific obesity types. Obes. Rev. 19, 28–40. https://doi.org/10.1111/obr.12621

Sun, Miaomiao, Feng, W., Wang, F., Zhang, L., Wu, Z., Li, Z., Zhang, B., He, Y., Xie, S., Li, M., Fok, J.P.C., Tse, G., Wong, M.C.S., Tang, J. ling, Wong, S.Y.S., Vlaanderen, J., Evans, G., Vermeulen, R., Tse, L.A., 2018. Night shift work exposure profile and obesity: Baseline results from a Chinese night shift worker cohort. PLoS One 13, 1–14. https://doi.org/10.1371/journal.pone.0196989

Sundh, J., Johansson, G., Larsson, K., Lindén, A., Löfdahl, C.-G., Janson, C., Sandström, T., 2015. Comorbidity and health-related quality of life in patients with severe chronic obstructive pulmonary disease attending Swedish secondary care units. Int. J. Chron. Obstruct. Pulmon. Dis. 10, 173–83. https://doi.org/10.2147/COPD.S74645

Sung, K.C., Kim, S.H., Reaven, G.M., 2007. Relationship among alcohol, body weight, and cardiovascular risk factors in 27,030 Korean men. Diabetes Care 30, 2690–2694. https://doi.org/10.2337/dc07-0315

Suter, P.M., 2005. Is alcohol consumption a risk factor for weight gain and obesity? Crit. Rev. Clin. Lab. Sci. 42, 197–227. https://doi.org/10.1080/10408360590913542

Suter, P.M., Tremblay, A., 2005. Is alcohol consumption a risk factor for weight gain and obesity? Crit. Rev. Clin. Lab. Sci. 42, 197–227. https://doi.org/10.1080/10408360590913542

Svensson, E., Nygård, J.F., Reas, D.L., Sandanger, I., 2007. Urban—rural differences in BMI, overweight and obesity in Norway (1990 and 2001). Scand. J. Public Health 35, 555–558. https://doi.org/10.1080/14034940701349217

Swift, D.L., McGee, J.E., Earnest, C.P., Carlisle, E., Nygard, M., Johannsen, N.M., 2018. The Effects of Exercise and Physical Activity on Weight Loss and Maintenance. Prog. Cardiovasc. Dis. 61, 206–213. https://doi.org/10.1016/j.pcad.2018.07.014

Taş, Ü., Verhagen, A.P., Bierma-Zeinstra, S.M.A., Hofman, A., Odding, E., Pols, H.A.P., Koes, B.W., 2007. Incidence and risk factors of disability in the elderly: The Rotterdam Study. Prev. Med. (Baltim). 44, 272–278. https://doi.org/10.1016/j.ypmed.2006.11.007

Tas, Ü., Verhagen, A.P., Bierma-Zeinstra, S.M.A., Odding, E., Koes, B.W., 2007. Prognostic factors of disability in older people: A systematic review. Br. J. Gen. Pract. 57, 319–323.

The Herald/Age, 2011. Lateral Economics Index of Australia's Wellbeing: Final Report. Melbourne.

The National Institutes of Health (NIH), 2020. Overweight and Obesity [WWW Document]. URL https://www.nhlbi.nih.gov/health-topics/overweight-and-obesity?fbclid=IwAR3lk_AhXPs29h21t3Ng3h_UwjWZK2Kr78-pL58sn4yFjcgcXLAXuuoBCr4 (accessed 3.15.20).

Thomas, A., Schüßler, M.N., Fischer, J.E., Terris, D.D., 2009. Employees' sleep duration and body mass index: Potential confounders. Prev. Med. (Baltim). 48, 467–470. https://doi.org/10.1016/j.ypmed.2009.03.012

Trasande, L., Chatterjee, S., 2009. The Impact of Obesity on Health Service Utilization and Costs in Childhood. Obesity 17, 1749–1754. https://doi.org/10.1038/oby.2009.67

Traversy, G., Chaput, J.P., 2015. Alcohol Consumption and Obesity: An Update. Curr. Obes. Rep. 4, 122–130. https://doi.org/10.1007/s13679-014-0129-4

Trewin, D., 2004. Census of Population and Housing: Socio-Economic Indexes For Areas (SEIFA) Australia 2001. (Technical Paper Cat. No. 2039.0.55.001). Canberra: Australian Bureau of Statistics.

Trindade, D.D.B., Ospina, R., Amorim, L.D., 2015. Choosing the right strategy to model longitudinal count data in epidemiology: An application with CD4 cell counts. Epidemiol. Biostat. Public Heal. 12, 1–11. https://doi.org/10.2427/11520

Trogdon, J.G., Finkelstein, E.A., Hylands, T., Dellea, P.S., Kamal-Bahl, S.J., 2008. Indirect costs of obesity: A review of the current literature. Obes. Rev. 9, 489–500. https://doi.org/10.1111/j.1467-789X.2008.00472.x

Tucker, L.A., Friedman, G.M., 1998. Obesity and absenteeism: An epidemiologic study of 10,825 employed adults. Am. J. Heal. Promot. 12, 202–207. https://doi.org/10.4278/0890-1171-12.3.202

Tunceli, K., Li, K., Keoki Williams, L., 2006. Long-term effects of obesity on employment and work limitations among U.S. adults, 1986 to 1999. Obesity 14, 1637–1646. https://doi.org/10.1038/oby.2006.188

Tyack, Z., Kuys, S., Cornwell, P., Frakes, K.-A., McPhail, S., 2018. Health-related quality of life of people with multimorbidity at a community-based, interprofessional student-assisted clinic: Implications for assessment and intervention. Chronic Illn. 14, 169–181. https://doi.org/10.1177/1742395317724849

Tyrrell, J., Mulugeta, A., Wood, A.R., Zhou, A., Beaumont, R.N., Tuke, M.A., Jones, S.E., Ruth, K.S., Yaghootkar, H., Sharp, S., Thompson, W.D., Ji, Y., Harrison, J., Freathy, R.M., Murray, A., Weedon, M.N., Lewis, C., Frayling, T.M., Hyppönen, E., 2019. Using genetics to understand the causal influence of higher BMI on depression. Int. J. Epidemiol. 48, 834–848. https://doi.org/10.1093/ije/dyy223

UCLA, 2019a. Zero-inflated negative binomial regression [WWW Document]. URL https://stats.idre.ucla.edu/stata/output/zero-inflated-negative-binomial-regression/ (accessed 10.4.19).

UCLA, 2019b. zero-inflated negative binomial regression. [WWW Document]. URL https://stats.idre.ucla.edu/r/dae/zinb/ (accessed 10.5.19).

Ul-Haq, Z., Mackay, D.F., Fenwick, E., Pell, J.P., 2012. Impact of metabolic comorbidity on the association between body mass index and health-related quality of life: a Scotland-wide cross-sectional study of 5,608 participants. BMC Public Health 12, 143. https://doi.org/10.1186/1471-2458-12-143

Uppal, S., 2005. Disability, workplace characteristics and job satisfaction. Int. J. Manpow. 26, 336–349. https://doi.org/10.1108/01437720510609537

Vallejo-Torres, L., Morris, S., Lopez-Valcarcel, B.G., 2018. Obesity and perceived work discrimination in Spain. Appl. Econ. 50, 3870–3884. https://doi.org/10.1080/00036846.2017.1400654

van Amelsvoort, L.G.P.M., Spigt, M.G., Swaen, G.M.H., Kant, Ij., 2006. Leisure time physical activity and sickness absenteeism; a prospective study. Occup. Med. (Chic. Ill). 56, 210–212. https://doi.org/10.1093/occmed/kqj026

Van Baal, P.H.M., Polder, J.J., De Wit, G.A., Hoogenveen, R.T., Feenstra, T.L., Boshuizen, H.C., Engelfriet, P.M., Brouwer, W.B.F., 2008. Lifetime medical costs of obesity: Prevention no cure for increasing health expenditure. PLoS Med. 5, 0242–0249. https://doi.org/10.1371/journal.pmed.0050029

van den Heuvel, S.G., Boshuizen, H.C., Hildebrandt, V.H., Blatter, B.M., Ariëns, G.A., Bongers, P.M., 2005. Effect of sporting activity on absenteeism in a working population. Br. J. Sports Med. 39, 5–9. https://doi.org/10.1136/bjsm.2004.013052

Vanwormer, J.J., Linde, J.A., Harnack, L.J., Stovitz, S.D., Jeffery, R.W., 2012. Weight change and workplace absenteeism in the healthworks study. Obes. Facts 5, 745–752. https://doi.org/10.1159/000345119

Veerman, J.L., Barendregt, J.J., Forster, M., Vos, T., 2011. Cost-effectiveness of pharmacotherapy to reduce obesity. PLoS One 6. https://doi.org/10.1371/journal.pone.0026051

Vidra, N., Trias-Llimós, S., Janssen, F., 2019. Impact of obesity on life expectancy among different European countries: secondary analysis of population-level data over the 1975–2012 period. BMJ Open 9, e028086. https://doi.org/10.1136/bmjopen-2018-028086

Vingård, E., Lindberg, P., Josephson, M., Voss, M., Heijbel, B., Stark, S., Nygren, Å., Alfredsson, L., 2005. Long-term sick-listing among women in the public sector and its associations with age, social situation, lifestyle, and work factors: A three-year follow-up study. Scand. J. Public Health 33, 370–375. https://doi.org/10.1080/14034940510005860

Wallis, D.J., Hetherington, M.M., 2009. Emotions and eating. Self-reported and experimentally induced changes in food intake under stress. Appetite 52, 355–362. https://doi.org/10.1016/j.appet.2008.11.007

Walls, H.L., Magliano, D.J., Stevenson, C.E., Backholer, K., Mannan, H.R., Shaw, J.E., Peeters, A., 2012. Projected progression of the prevalence of obesity in Australia. Obesity 20, 872–878. https://doi.org/10.1038/oby.2010.338

Wang, J.-W., Sun, L., Ding, N., Li, J., Gong, X.-H., Chen, X.-F., Yu, D.-H., Luo, Z.-N., Yuan, Z.-P., Yu, J.-M., 2016. The association between comorbidities and the quality of life among colorectal cancer survivors in the People's Republic of China. Patient Prefer. Adherence 10, 1071. https://doi.org/10.2147/PPA.S100873

Wang, Y.C., McPherson, K., Marsh, T., Gortmaker, S.L., Brown, M., 2011. Health and economic burden of the projected obesity trends in the USA and the UK. Lancet 378, 815–825. https://doi.org/10.1016/S0140-6736(11)60814-3

Wardle, J., Steptoe, A., Oliver, G., Lipsey, Z., 2000. Stress, dietary restraint and food intake. J. Psychosom. Res. 48, 195–202. https://doi.org/10.1016/S0022-3999(00)00076-3

Ware, J.E., Snow, K.K., Kosinski, M., Gandek, B., 2000. SF-36 health survey: manual and interpretation guide. Lincoln (RI): QualityMetric Incorporated.

Waterhouse, P., Kimberley, H., Jonas, P., Nurka, C., 2010. What Would It Take? Employer Perspectives on Employing People with a Disability--Literature Review. Support Document. Adelaide, South Australia: National Centre for Vocational Education Research.

Watson, N., Wooden, M., n.d. Mixed and multiple collection modes: The HILDA survey experience, in: Paper Presented to XXV International Methodology Symposium-Longitudinal Surveys: From Design to Analysis. Statistics Canada, Ottawa-Gatineau, 27-30 October.

Wee, L.H., Yeap, L.L.L., Chan, C.M.H., Wong, J.E., Jamil, N.A., Swarna Nantha, Y., Siau, C.S., 2019. Anteceding factors predicting absenteeism and presenteeism in urban area in Malaysia. BMC Public Health 19, 1–12. https://doi.org/10.1186/s12889-019-6860-8

Wilkins, R., 2013. Families, Incomes, and Jobs. Volume 8: A statistical Report on Waves 1 to 10 of the Household, Income, and Labour Dynamics in Australia Survey. Melbourne.

Withrow, D., Alter, D.A., 2011. The economic burden of obesity worldwide: A systematic review of the direct costs of obesity. Obes. Rev. 12, 131–141.

https://doi.org/10.1111/j.1467-789X.2009.00712.x
Wolfenden, L., Hardy, L.L., Wiggers, J., Milat, A.J., Bell, C., Sutherland, R., 2011. Prevalence and socio-demographic associations of overweight and obesity among children attending child-care services in rural and regional Australia. Nutr. Diet. 68, 15–20. https://doi.org/10.1111/j.1747-0080.2010.01487.x
Wong, E., Stevenson, C., Backholer, K., Woodward, M., Shaw, J.E., Peeters, A., 2015a. Predicting the risk of physical disability in old age using modifiable mid-life risk factors. J. Epidemiol. Community Health 69, 70–76. https://doi.org/10.1136/jech-2014-204456
Wong, E., Tanamas, S.K., Wolfe, R., Backholer, K., Stevenson, C., Abdullah, A., Peeters, A., 2015b. The role of obesity duration on the association between obesity and risk of physical disability. Obesity 23, 443–447. https://doi.org/10.1002/oby.20936
Wooden, M., 2014. The Measurement of Physical Activity in Wave 13 of the HILDA Survey. HILDA Project Discussion Paper Series No. 3/14. Melbourne Institute of Applied Economic and Social Research.
Wooden, M., Freidin, S., Watson, N., 2002. The Household, Income and Labour Dynamics in Australia (HILDA)Survey: Wave 1. Aust. Econ. Rev. 35, 339–348. https://doi.org/10.1111/1467-8462.00252
World Health Organization, 2021. Body mass index - BMI [WWW Document]. URL https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi (accessed 3.15.21).
World Health Organization, 2020a. Obesity and overweight [WWW Document]. URL https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight (accessed 4.18.21).
World Health Organization, 2020b. Obesity [WWW Document]. URL https://www.who.int/news-room/facts-in-pictures/detail/6-facts-on-obesity (accessed 4.18.21).
World Health Organization, 2018. Disability and health [WWW Document]. URL https://www.who.int/news-room/fact-sheets/detail/disability-and-health (accessed 11.3.20).
World Health Organization, 2015. WHO global disability action plan 2014-2021. Better health for all people with disability. Geneva, Switzerland.
World Health Organization, 2013. Global action plan for the prevention and control of noncommunicable diseases 2013-2020. Geneva, Switzerland.

World Health Organization, 2001. International classification of functionning, disability, and health (ICF) [WWW Document]. URL http://www.who.int/classifications/icf/en/ (accessed 1.5.21).

World Health Organization (WHO), 2019. Increasing fruit and vegetable consumption to reduce the risk of noncommunicable diseases [WWW Document]. URL https://www.who.int/elena/titles/fruit_vegetables_ncds/en/ (accessed 5.13.19).

Yoon, C.-G., Kang, M.-Y., Bae, K.-J., Yoon, J.-H., 2016. Do Working Hours and Type of Work Affect Obesity in South Korean Female Workers? Analysis of the Korean Community Health Survey. J. Women's Heal. 25, 173–180. https://doi.org/10.1089/jwh.2014.5161

Zerah, F., Harf, A., Perlemuter, L., Lorino, H., Lorino, A.M., Atlan, G., 1993. Effects of obesity on respiratory resistance. Chest 103, 1470–1476. https://doi.org/10.1378/chest.103.5.1470

Zhang, L., Lix, L.M., Ayilara, O., Sawatzky, R., Bohm, E.R., 2018. The effect of multimorbidity on changes in health-related quality of life following hip and knee arthroplasty. Bone Joint J. 100-B, 1168–1174. https://doi.org/10.1302/0301-620X.100B9.BJJ-2017-1372.R1

Zhu, Y., Wang, Q., Pang, G., Lin, L., Origasa, H., Wang, Y., Di, J., Shi, M., Fan, C., Shi, H., 2015. Association between Body Mass Index and Health-Related Quality of Life: The "Obesity Paradox" in 21,218 Adults of the Chinese General Population. PLoS One 10, e0130613. https://doi.org/10.1371/journal.pone.0130613

Zizza, C., Herring, A.H., Stevens, J., Popkin, B.M., 2004. Length of hospital stays among obese individuals. Am. J. Public Health 94, 1587–1591. https://doi.org/10.2105/AJPH.94.9.1587

Zoico, E., Di Francesco, V., Guralnik, J.M., Mazzali, G., Bortolani, A., Guariento, S., Sergi, G., Bosello, O., Zamboni, M., 2004. Physical disability and muscular strength in relation to obesity and different body composition indexes in a sample of healthy elderly women. Int. J. Obes. 28, 234–241. https://doi.org/10.1038/sj.ijo.0802552

Appendix A (Study 1)

Table 1: Person-year observations across study years

Year	Waves	N	Weighted population size	%	Cumulative %
2006	6	11,716	15,115,558	5.87	5.87
2007	7	11,381	15,452,496	5.70	11.57
2008	8	11,194	15,768,595	5.61	17.17
2009	9	11,563	16,139,759	5.79	22.96
2010	10	12,052	16,442,982	6.04	29.00
2011	11	15,366	16,711,584	7.70	36.70
2012	12	15,389	17,013,844	7.71	44.40
2013	13	15,360	17,332,799	7.69	52.10
2014	14	15,595	17,559,353	7.81	59.91
2015	15	15,513	17,855,647	7.77	67.67
2016	16	16,253	18,180,579	8.14	75.81
2017	17	16,194	18,540,853	8.11	83.92
2018	18	15,949	18,860,088	7.99	91.91
2019	19	16,150	19,109,375	8.09	100
	Total	199,675		100	100

Table 2: Missing observation analysis

Variable	Missing	Available	% missing
BMI	10,122	189,553	5.34%
Remoteness	21	199,654	0.01%
Civil status	8	199,667	0.00%
Ethnicity	76	199,599	0.04%
Education	94	199,581	0.05%
Smoking status	2,324	197,351	1.18%
Alcohol consumption	2,412	197,263	1.22%