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Neighbourhood Socio-Economic Circumstances, Place of Residence and Obesity amongst Australian Adults: A Longitudinal Regression Analysis Using 14 Annual Waves of the HILDA Cohort

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Abstract: The prevalence of overweight and obesity is rising dramatically worldwide, including in Australia. Therefore, the necessity of identifying the risk factors of overweight and obesity is pivotal. The main objective of this study is to investigate the influence of neighbourhood socio-economic circumstances and place of residence on obesity amongst Australian adults. This study has used nationally representative panel data on 183,183 person-year observations from 26,032 unique Australian adults from the Household, Income, and Labour Dynamics in Australia (HILDA). Random-effects logistic regression technique was employed to examine the relationships. The prevalence of overweight and obesity has been found at approximately 34% and 24%, respectively. The most striking result to emerge from the analyses is that adults living in the most socio-economic disadvantaged area were 2.04 times (AOR: 2.04, 95% CI: 1.57–2.65) and adults from regional cities of Australia were 1.71 times (AOR: 1.71, 95% CI: 1.34–2.19) more prone to be obese compared to their healthy counterparts. The prevalence of overweight and obesity is very high among Australian adults, especially those living in disadvantaged neighbourhoods and the regional cities. Unhealthy levels of BMI have costly impacts on the individual, the economy, and the health care system. Therefore, this study emphasises effective weight control strategies that can potentially tackle the obesity epidemic in Australia.

Keywords: obesity; neighbourhood socio-economic circumstances; place of residence; random-effects logistic regression; Australia

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1. Introduction

Globally, obesity is an epidemic concern that imposes substantial health challenges. The prevalence of obesity has risen worldwide substantially irrespective of gender, among men (3% to 11%) and women (6% to 15%) over the last four decades [1]. In 2016, a global estimation reported that around 39% of the world population was overweight, of which 13% suffered from obesity [2]. Besides, more than one in two people in the Organisation for Economic Co-operation and Development (OECD) countries live with higher BMI, i.e., overweight or obesity [3]. The prevalence of obesity nearly doubled from 1980 to 2000 in Australia [4]. A recent study revealed that almost 26% of Australian adults aged 15 years and over were obese in 2019 [5]. Besides, it is predicted that the obesity rate in Australia might increase by 65% within 2025 [6].

The high and growing trends of overweight and obesity is a serious public health concern in Australia since it is associated with chronic diseases [7], disability [8], and poor self-rated physical and mental health outcomes [9]. Besides, there is evidence that obesity has an adverse and statistically significant effect on labour market outcomes in the Australian adult population in terms of job discrimination [10], job dissatisfaction [11], absenteeism [12], and presenteeism [13] in the workplace. Moreover, obesity is accountable for immense economic loss nationally because it adversely affects a country's resources through the associated inverse health impacts [14]. It increases the risk of permanent and non-permanent work leave, low productivity, disability, and premature death [15]. Further, the probability of developing non-communicable diseases, such as cardiovascular disease, diabetes, asthma, arthritis, and depression, escalates because of overweight and obesity. Additionally, maternal obesity has been found positively associated with fetal and neonatal deaths [16]. Many of these non-communicable diseases could be prevented if healthy weight status could be maintained as obesity is highly preventable [2]. Interestingly, health-promoting behaviour in the lifestyle influences the weight status [17]. This circumstance induces a wide range of future research that will identify behavioural factors of obesity.

Earlier studies conducted in Australia focused on overweight and obesity trends that covered only specific dimensions. For example, prediction of higher BMI trends [6,18,19], costs of obesity [20], prevalence and factors of child obesity [21,22], and modelling for obesity prevention [23,24] are the most prominent. However, some cross-sectional studies executed outside of Australia determined the risk indicators of obesity [25–28]. These studies outlined that age [26,27], gender [26,27], marital status [26,28], residence [27,28], education [26,28], alcohol intake [28], physical activity [26], and ethnicity [26] are significant risk factors of overweight and obesity.

In the existing evidence, no study exclusively covers the influence of location, socio-economic circumstances, and behavioural parameters on weight status among Australian adults. Besides, identifying risk factors of pre-obesity and obesity based on longitudinal data assists a more precise approach, but previous efforts in this regard are lacking. Yet, a recent study conducted on longitudinal data found that ethnicity, residence, education, and age significantly impact weight status among Chinese adults [29]. However, that study ignores some important behavioural factors along with socio-economic areas.

Due to the lack of evidence that solves these problems, this study endeavours to determine the significance of location associated with obesity in Australia utilising longitudinal data. The present study aims to delineate up-to-date prevalence and examine the influence of location on weight status after adjusting and lifestyle factors. To attain the objective, this study systematically searches the answer to the following research question: Do neighbourhood socio-economic circumstances and place of residence impact an adult's weight status after controlling other risk factors? Evidence on these might help designing multidimensional health programs that will control adults' weight status and prevent higher BMI problems in Australia.

2. Methods

2.1. Data Sources

This study was conducted through 14 waves (waves 6 to 19) from the Household, Income, and Labour Dynamics in Australia (HILDA) survey spanning 2006 to 2019. It is a nationally representative household-based longitudinal survey of Australia covering a wide range of information about family, income, and the labour market. The survey was initiated with a large household sample in 2001 through a multistage sampling approach and re-sampled in 2011. The primary sampling unit, collection districts, was sampled by probability proportional to size. In the survey, adults aged $\geq$15 years have attended the face-to-face interviews and provided data by filling self-completed questionnaires. More about the data collection methodology has been mentioned elsewhere [30].

2.2. Sample Size

Figure 1 displays the steps for obtaining the final analytic data. Individual data points were excluded using the following criteria: pregnant women during the survey, missing data on body mass index (BMI) and primary exposures (neighbourhood socio-economic circumstances and place of residence). Utilising the exclusion criteria, this study included 183,183 yearly observations from 26,032 unique adults for the sub-sample analyses.

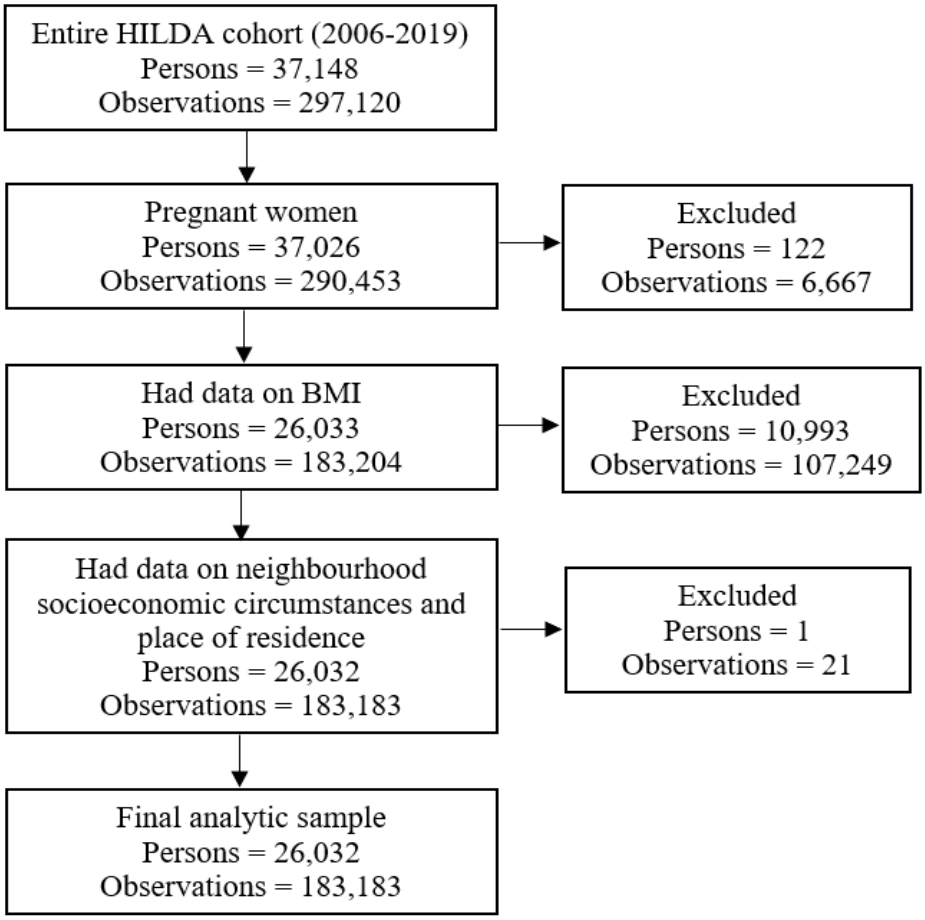


Figure 1. Sample selection procedure.

2.3. Outcome Measurement

Body mass index (BMI) is the primary outcome variable of the present study. It was calculated using self-reported height and weight using the following formula: weight (in kilograms) divided by height (in metres squared). For the analysis purpose, BMI was categorised into four groups following World Health Organization recommended BMI cut-off points: <18.50 (underweight), 18.50–24.99 (normal/healthy weight), 25.00–29.99 (overweight), and ≥30 (obese) [2]. Overweight and obesity prevalence were calculated for the population aged 15 years and over living in Australia from 2006–2019.

2.4. Exposure Variables

The key exposures of the present study are neighbourhood socio-economic circumstances and place of residence. This study used the Index of Economic Resources as the proxy of neighbourhood socio-economic circumstances that was derived from Socio-economic Indexes for Areas (SEIFA). The SEIFA measure estimates the definite value and ranks it from socio-economic disadvantaged to advantaged areas [31]. Financial variables, mainly income and wealth, are considered in this regard to determine relative socio-economic advantage and disadvantage [31]. Thus, low index scores indicate most or

more disadvantaged areas, and high index scores indicate more or most advantaged areas. More specifically, a low index score suggests that an individual living in a particular place has a comparative lack of access to economic resources and vice versa.

The other exposure, place of residence, was categorised as major cities of Australia, regional cities (inner regional Australia and outer regional Australia), and remote areas (remote or very remote areas of Australia).

2.5. Explanatory Variables

Authors selected risk factors associated with overweight and obesity based on existing evidence [5,25,26,28,32,33]. Demographic variables include age (15–24, 25–34, 35–44, 45–54, 55–64, and $\geq$65 years); gender (male and female); marital status (cohabitating and non-cohabitating) and ethnic origin (not of Indigenous origin; and Aboriginal, or Torres Strait Islander or both). Socio-economic variables include education (year 12 and below, professional qualifications, and university qualifications), household yearly disposable income (Quantile 1 [lowest], Quantile 2, Quantile 3, Quantile 4, and Quantile 5 [highest]), and labour force status (employed, unemployed, and not in the labour force).

Behavioural variables were smoking status (never smoked, ex-smoker, and current smoker), alcohol consumption (never drank, ex-drinker, only rarely to 4 days per week, and over four days per week), and physical activity (below the recommended level and recommended level).

2.6. Statistical Analyses

The study outlined participants' characteristics in frequency (n) and percentages (%). Following this, the Chi-square test was deployed to examine the bivariate relationship between obesity and particular covariates (results were not reported). Finally, the study adopted the longitudinal random-effects logistic regression technique to identify the between-person effects in the relationship between neighbourhood socio-economic circumstance and place of residence with overweight and obesity. Central to the analyses reported in this study is the estimation of the random-effects logistic regression model in the following format:

$$BMI_i = \alpha + BX_i + \varepsilon_i$$

Here, *BMI* is a categorical variable wherein healthy weight individual is the reference group, and overweight and obese adults are the counterparts. X is a vector of explanatory variables that might influence the weight status of the adults. This study includes neighbourhood socio-economic circumstances, place of residence, age, gender, civil status, education, household yearly disposable income, ethnicity, smoking status, alcohol consumption, and physical activity as explanatory variables. Covariates having a p-value of $\leq$0.05 in the bivariate logistic regression were entered into the longitudinal random-effects logistic regression model. Finally, the adjusted odds ratio (AOR) was reported to interpret the findings of the study. STATA version 17.0 (Stata SE 17, College Station, TX: StataCorp LLC, USA) was used to accomplish the analysis of this study.

3. Results

The characteristics of the study participants in the baseline and final waves and the pooled characteristics of all waves are demonstrated in Table 1. The results report Australian adults' obesity, economic resources and residence, and socio-economic and lifestyle characteristics of the 183,183 yearly observations from 26,032 unique respondents. The proportion of obese people reported in the baseline and final waves were around 21% and 27%, respectively. Table 1 also demonstrates that of the pooled sample of all waves, there was an equal distribution in all age groups, more than half were female (53%), almost 59% were cohabitating, approximately one-fourth had university qualifications (25%), nearly two-thirds were employed (64%), most were not of indigenous origin (97%) and were living in major cities (66%). Of the lifestyle characteristics, 18% were current

smokers, 15% drank alcohol over four days a week, and 66% performed physical activity below the recommended level.

Table 1. Distribution of the analytic sample: baseline, final and pooled across all waves (person = 26,032, observation = 183,183).

Characteristics	Baseline Wave (2006)		Final Wave (2019)		Pooled in All Waves (2006 to 2019)	
	n	%	*n*	%	*n*	%
Outcome variable						
BMI						
Underweight	342	3.17	350	2.34	4870	2.66
Healthy weight	4588	42.56	5509	36.82	72,573	39.62
Overweight	3615	33.53	5067	33.87	62,299	34.01
Obesity	2235	20.73	4036	26.98	43,441	23.71
Exposures and covariates						
Index of economic resources						
Q1 (least advantaged)	3147	29.19	4201	28.08	53,022	28.94
Q2	2168	20.11	3026	20.22	36,212	19.77
Q3	2294	21.28	3100	20.72	37,995	20.74
Q4	1213	11.25	1571	10.5	19,769	10.79
Q5 (most advantaged)	1958	18.16	3064	20.48	36,185	19.75
Place of residence						
Major cities	6939	64.37	9936	66.41	121,289	66.21
Regional cities	3669	34.04	4846	32.39	59,316	32.38
Remote areas	172	1.6	180	1.2	2578	1.41
Age groups						
15–24 years	1888	17.51	2200	14.7	30,503	16.65
25–34 years	1536	14.25	2671	17.85	28,590	15.61
35–44 years	2085	19.34	2186	14.61	29,528	16.12
45–54 years	2006	18.61	2336	15.61	32,507	17.75
55–64 years	1499	13.91	2435	16.27	28,310	15.45
≥65 years	1766	16.38	3134	20.95	33,745	18.42
Gender						
Male	5115	47.45	7139	47.71	86,912	47.45
Female	5665	52.55	7823	52.29	96,271	52.55
Civil Status						
Cohabitating	6324	58.7	8871	59.29	108,220	59.08
Non-cohabitating	4456	41.3	6091	40.71	74,963	40.92
Education						
Year 12 and below	5455	50.6	5772	38.58	80,467	43.93
Professional qualifications	3030	28.11	4955	33.12	56,853	31.04
University qualifications	2295	21.29	4235	28.31	45,863	25.04
Household yearly disposable income quintile						
Quintile 1 (lowest)	2156	20.00	2995	20.02	36,641	20.00
Quintile 2	2157	20.01	2991	19.99	36,634	20.00
Quintile 3	2155	19.99	2993	20.00	36,637	20.00
Quintile 4	2157	20.01	2994	20.01	36,635	20.00
Quintile 5 (highest)	2155	19.99	2989	19.98	36,636	20.00
Labour force status						
Employed	7007	65	9536	63.73	117,202	63.98
Unemployed	338	3.14	565	3.78	6567	3.58
Not in the labour force	3435	31.86	4861	32.49	59,414	32.43
Indigenous status						
Non-indigenous	10,533	97.71	14,431	96.45	178,009	97.18
Aboriginal or Torres Strait Islander	247	2.29	531	3.55	5174	2.82

Table 1. *Cont.*

Characteristics	Baseline Wave (2006)		Final Wave (2019)		Pooled in All Waves (2006 to 2019)	
	n	%	*n*	%	*n*	%
Smoking status						
Never smoked	5576	51.73	8444	56.44	99,583	54.36
Ex-smoker	2955	27.41	4114	27.50	50,659	27.65
Current smoker	2249	20.86	2404	16.07	32,941	17.98
Alcohol consumption						
Never drank	1131	10.49	1688	11.28	20,116	10.98
Ex-drinker	655	6.08	1281	8.56	13,532	7.39
Only rarely to 4 days/week	7163	66.45	9999	66.83	122,279	66.75
4+ days/week	1831	16.99	1994	13.33	27,256	14.88
Physical activity (≥30 min)						
Below the recommended level	7042	65.32	9867	65.95	120,950	66.03
Recommended level	3738	34.68	5095	34.05	62,233	33.97

Figure 2 illustrates the distribution of weight status by neighbourhood socio-economic circumstances. The highest (27%) and second-highest (25%) prevalence of obesity were among the most deprived quartiles, Q1 and Q2, respectively. In reverse, healthy weight adults were more prevalent among more affluent populations, 40% in Q4 and 42% in Q5 socio-economic groups.

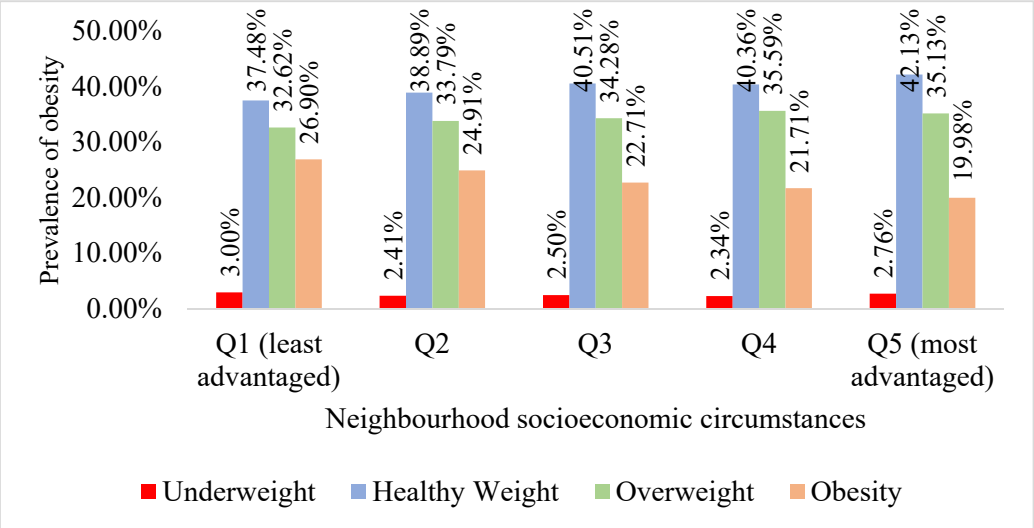


Figure 2. Distribution of weight status by neighbourhood socio-economic circumstances, 26,032 persons, 183,183 observations.

Figure 3 also presents the distribution of obesity status by place of residence. The prevalence of both overweight and obesity was found higher among inhabitants living in regional cities and remote areas than the residents of major cities. The highest prevalence of obesity (27%) was among peoples of regional cities, while the highest prevalence of overweight was (36%) observed among the residents of remote areas.

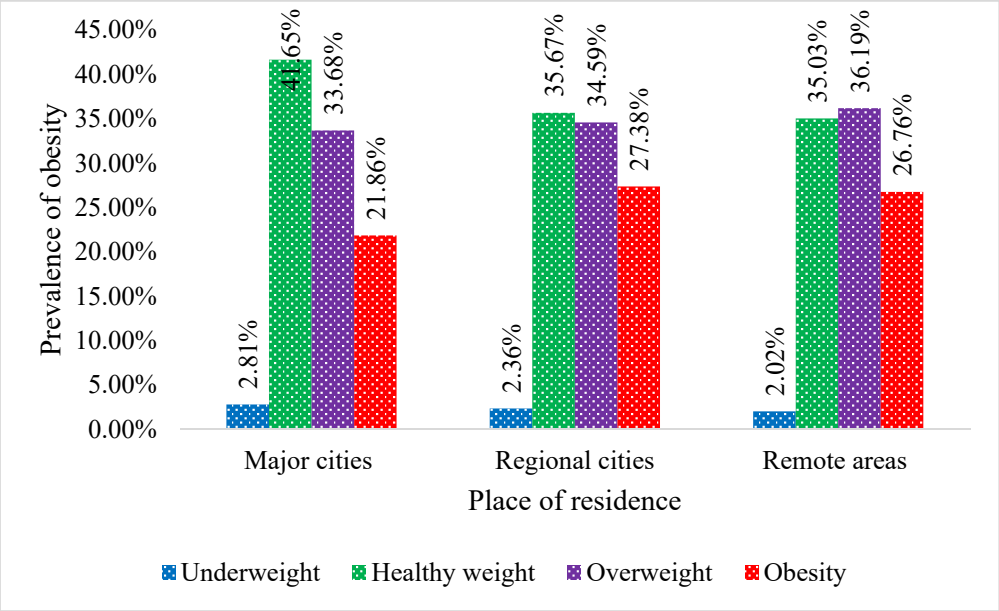


Figure 3. Distribution of weight status by place of residence, 26,032 persons, 183,183 observations.

Table 2 presents the multivariate models that explored the association between neighbourhood socio-economic circumstances, place of residence, and obesity after adjusting for confounders. The results showed that compared to the respondents of affluent socio-economic status (Q5), the odds of being obese were higher among the participant of less affluent or most deprived groups, that is, the adults belonged to Q3, Q2 and Q1 of the socio-economic groups. The probability of being obese was 2.04 times higher (OR: 2.04, 95% CI: 1.57–2.65) among the participants of the most deprived adults (Q1), compared to the wealthiest adults (Q5) in the Australian society. The results from the random-effects logistic models also represent that the odds of being obese were 1.71 times higher (OR: 1.71, 95% CI: 1.34–2.19) among the participants inhabiting the regional cities compared to the inhabitants of major cities.

Table 2. Adjusted random-effect logistic regression results for the between-person difference in obesity due to neighbourhood socio-economic circumstances and place of residence.

Exposures	Model 1 [a]	Model 2 [b]
	Overweight Versus Healthy Weight	Obesity Versus Healthy Weight
	AOR (95% CI), *p*-Value	AOR (95% CI), *p*-Value
Index of economic resources		
Q1 (least advantaged)	1.04 (0.95–1.14), 0.43	**2.04 (1.57–2.65), <0.001**
Q2	0.95 (0.86–1.05), 0.34	**1.51 (1.15–1.98), 0.01**
Q3	0.99 (0.90–1.10), 0.91	**1.41 (1.08–1.85), 0.01**
Q4	1.03 (0.91–1.16), 0.64	1.14 (0.82–1.58), 0.43
Q5 (most advantaged) (ref)		
Place of residence		
Major cities (ref)		
Regional cities	**1.15 (1.06–1.26), 0.01**	**1.71 (1.34–2.19), <0.001**
Remote areas	1.10 (0.83–1.45), 0.66	1.61 (0.71–3.66), 0.25

[a] and [b] Model 1 and 2: adjusted for age, gender, civil status, education, household yearly disposable income, labour force status, indigenous status, smoking status, alcohol consumption, and physical activity. Abbreviations: AOR, adjusted odds ratio; ref, reference. Values in bold are statistically significant at 5% level of significance.

4. Discussion

The current study demonstrates the prevalence of overweight and obesity and its association with the neighbourhood socio-economic circumstances and place of residence among Australian adults. This study has been undertaken through the longitudinal random-effect logistic regression technique and the most recently available longitudinal data from the HILDA survey. This study found that the prevalence of overweight and obesity is very high among Australian adults, especially those living in disadvantaged neighbourhoods and the regional cities. The results also showed that neighbourhood socio-economic circumstances and place of residence are significantly associated with obesity.

The present study found that disadvantaged neighbourhood is a statistically significant risk factor of being obese. It indicates that adults from most disadvantaged neighbourhoods are more likely to be obese than their peers living in the most advantaged areas. This finding is consistent with existing evidence on the association between disadvantaged neighbourhoods and obesity [32,34]. Many studies have also reported that the prevalence of higher BMI is extensive amongst low-income groups in developed countries [32,35–37]. The possible reason for the socio-economic disparity in weight status is that low-income people usually reside in disadvantaged areas and cannot afford healthier diets. Besides, people from disadvantaged neighbourhoods generally lead an unhealthy lifestyle, such as eating non-nutrient and energy deficient foods [38]. Another possible reason could be that people from disadvantaged neighbourhoods perform lower levels of physical activity [32].

Place of residence is another crucial variable that is associated with increased levels of obesity. In this study, adults residing in regional (inner and outer) or remote areas had a higher risk of being overweight or obese compared to adults living in major cities in Australia. This finding aligns with previous evidence suggesting that adults living in regional and rural areas are more likely to be obese [5,39]. An earlier study from developing countries contexts also reported that place of residence is positively associated with obesity [40]. Higher BMI among adults in rural or remote territories might be due to deprivation related to education, income, and health services [5,41].

The present study findings emphasised diverse strategies to control the rapidly growing overweight and obesity prevalence in Australia. This study suggests forming healthier places to ensure healthy weight status for adults living in socioeconomically disadvantaged, rural, and remote areas. The current study also emphasises implementing a primary care program to reduce weight gain risk by increasing activity levels and consuming healthy diets (increasing fruit and vegetable intake and minimising alcohol consumption). These suggestions are identical with the goals of the Australian Health and Wellbeing Strategic Framework 2017–2026, which has also recommended constructing a healthy environment for individuals to stay healthy.

This study contributes to the literature in several ways. This study first outlined the distribution of Australia's adult overweight and obesity across different neighbourhoods and place of residence. The study's major strength is that it offered an assembled update on the impact of neighbourhood socio-economic circumstances and place of residence on higher BMI in Australian adults after adjusting for demographic, socio-economic circumstances, and health-related behaviour. Further, this study used the most recent available data from an extensive, nationally representative longitudinal survey (Wave 6–19 of the HILDA survey) to determine the association.

This study has some drawbacks that should be mentioned. Firstly, this study has used self-reported BMI, which may underestimate or overestimate the results. Secondly, causality cannot be drawn since this study performed analyses on unbalanced longitudinal data. Thirdly, the actual distribution of overweight and obesity might be underestimated in the total population since a large portion of the study participants were from major cities. However, the study findings are in line with other survey findings of Australia.

5. Conclusions

This study revealed the prevalence of overweight and obesity by the respondents' neighbourhoods socio-economic circumstances and type of residence, along with the respective contribution of these risk factors to individuals exposed to weight gain. The results showed that the prevalence of overweight and obesity is higher among adults living in regional cities or remote areas and people living in disadvantaged neighbourhoods. The high prevalence of obesity imposes a substantial cost to the individuals involved and the Australian healthcare system. Increased prevalence of overweight and obesity may worsen if no policy interventions can be implemented to reverse the trend and overcome the situation. Implementing strategies and interventions to reduce the prevalence of overweight and obesity requires evidence to make it fruitful. This study may provide evidence to health system decision-makers in Australia to identify the "hot spots" and the related risk factors of overweight and obesity. The authors suggest that interventions should be tailored to consider the needs of socioeconomically and geographically disadvantaged adults who are at the most significant risk of excessive weight gain. The authors envisage that the study findings 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 future in Australian society.

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Institutional Review Board Statement: The HILDA survey commenced in 2001 and since then has been conducted annually following the University of Melbourne's ethical guidelines. This research project has been approved by the Human Research Ethics Committee of The University of Melbourne. The ethics ID number of the research project (HILDA Survey) is 1647030. This paper uses unit record data from the HILDA conducted by the Australian Government Department of Social Services (DSS). This study did not require ethical approval as the analysis used only de-identified existing unit record data from the HILDA survey.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: 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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Conflicts of Interest: The authors declare that they have no conflict of interest.

Abbreviations

BMI	Body Mass Index
OR	Odds Ratio
CI	Confidence Interval
HILDA	Household, Income and Labour Dynamics in Australia
SEIFA	Socio-Economic Indexes for Areas

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