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Sleep duration, sleep quality and the risk of being obese: Evidence from the Australian panel survey

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ABSTRACT

Background: Sleep difficulty is an unmet public health concern affecting a vast proportion of the world's population. Poor sleep duration (short or long sleep length) and quality affect more than half of older people. Sleep difficulty is associated with negative health outcomes such as obesity and reduced longevity. We aimed to assess whether poor sleep duration and quality are significant risk factors for obesity in adults aged 15 and over in Australia by examining a nationally representative panel data.
Methods: We used three waves (waves 13, 17, and 21) of the nationally representative Household, Income and Labour Dynamics in Australia (HILDA) survey data. The study applied generalized estimating equations (GEE) logistic regression model to assess the relationship between sleep duration and quality with obesity.
Results: The study found that the odds of being obese was significantly higher amongst the study participants with poor sleep duration (adjusted odds ratio [aOR]: 1.24, 95% confidence interval [CI]: 1.16−1.32) and poor sleep quality (aOR: 1.29, 95% CI: 1.02−1.38) compared with their counterparts who had good sleep duration and quality, respectively.
Conclusion: Having short or long sleep at night and poor sleep quality are associated with an increased risk of obesity. Obesity poses a significant threat to the health of Australian adults. Enacting policies that raise public awareness of the significance of good sleep hygiene and encouraging healthy sleeping habits should be considered to address the alarming rise in the obesity rate.

1. Introduction

Once considered a health condition for affluent and high-income countries, obesity has become a serious public health concern worldwide. According to the World Health Organisation (WHO), obesity can be defined as a body mass index (BMI) of 30 or more [1]. Evidence shows that the prevalence of obesity has tripled within the last four decades, with 13% of the world's total population classified as obese [2]. In Australia, evidence from the 2014/15 national health survey revealed that 27.9% of the Australian adult population were obese, with more males (28.4%) suffering from obesity than females (27.4%) [3]. This high prevalence of obesity in Australia has significant ramifications because a BMI exceeding 35 kg/m confers acute health concerns, and healthcare expenses increase sharply above that point [4,5].

The importance of controlling obesity in any population cannot

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be understated. Obesity is strongly associated with the development of chronic health conditions including cardiovascular diseases [6], depression [7], different types of cancer [8], kidney disease [9], non-alcoholic fatty liver disease [10], osteoarthritis [11] and type 2 diabetes [12]. Furthermore, obesity has been found to exacerbate the risk of mortality amongst individuals with other health conditions [13]. In Australia, about 7% of the burden of disease is associated with obesity [14].

Beyond the health consequences of obesity, its financial and economic burden is overwhelming. For instance, a recent study posited that healthcare expenses increase sharply when most of the population has a BMI of over 35 [5]. A study conducted in Australia revealed that the annual direct healthcare cost of an obese individual (A$2501) is much higher than that of healthy-weight peers (A$1998) [15]. A recent report also showed that between 2011 and 2012, the estimated cost of obesity to the Australian economy was A$8.6 billion [14]. Moreover, the time lost due to obesity has significant ramifications on productivity losses through presenteeism and absenteeism in the workplace [16,17]. The health and economic consequences of obesity justify advancing empirical research to better understand the risk factors of adult obesity in Australia.

Previous studies have identified a number of risk factors for obesity. Some established factors associated with the risk of obesity include being a male [18], having low educational attainment [19], alcohol consumption [20], living in urban areas [21] and sedentary lifestyles [22]. Beyond these determinants, there is a growing interest in how sleep contributes to the risk of obesity among adults [23]. Short sleep duration and poor sleep quality are associated with significant preventable morbidity and mortality [24].

Both short (<7 h) and long (>9 h) sleep duration are positively associated with a high risk of diabetes, hypertension and cardiovascular diseases among adults in the United States [25]. A longitudinal study has also shown that poor sleep quality is significantly associated with a high risk of depression [26]. Beyond the adverse health effects associated with poor sleep quality and short sleep duration, there is a growing interest in the role of sleep duration and sleep quality on the risk of obesity among adults [27–29].

In a narrative review, the results revealed that individuals who sleep less than 7 h are more likely to experience obesity than their counterparts [27]. Individuals with poor sleep quality are 1.10 times more likely to be obese [30]. Another study conducted in Italy showed that sleep duration and sleep quality are significantly positively associated with obesity [31]. The relationship between sleep duration, sleep quality, and the risk of being obese can be explained from the perspective that the circadian rhythm is significantly altered by the short duration of sleep and poor sleep quality, thereby resulting in negative changes in metabolic, inflammatory, neuroendocrine and antioxidant biomarkers [30]. Moreover, individuals with short sleep durations have been found to have an increased appetite for high-calorie and high-carbohydrate foods and poor eating outside habits that exacerbate their risk of obesity [31].

Despite the empirical evidence on the association between sleep and obesity, most studies followed cross-sectional designs. Longitudinal studies are necessary to track and measure changes in sleep duration, sleep quality and obesity over a certain period of time. Moreover, to the best of our knowledge, no study in Australia has investigated this phenomenon. Hence, there is a significant literature gap and a limited understanding of the dynamics of poor sleep duration, quality and obesity risk. Therefore, we investigated whether sleep duration and sleep quality are associated with the risk of being obese by utilizing Australian longitudinal data.

2. Methods

2.1. Data source

The empirical analysis of this study was conducted using unit-record data from the Household, Income and Labour Dynamics in Australia (HILDA) survey. The survey is one of the largest household panel surveys in the world, launched in 2001. It is designed and managed by the Melbourne Institute of Applied Economic and Social Research with funding from the Department of Social Services of the Australian Government. The survey assembles annual data from over 13,000 individuals within over 7000 households using a multistage sampling procedure. The survey collects information on participants' socio-demographic, economic, lifestyle, labour market activity and health-related issues. The survey collects information from household members aged 15 years or over using a combination of self-completed questionnaires and in-person and telephone interviews conducted by professional interviewers. The reason for using the HILDA dataset in this research is that it contains self-reported information on sleep duration, sleep quality, weight status, physical activity and several chronic diseases. Besides, the dataset contains extensive information on socio-demographic and lifestyle factors, such as age, gender, education, civil status, labour force participation, ethnicity, smoking and alcohol intake at different periods. The details of the HILDA survey design can be found elsewhere [32–34].

2.2. Analytic sample and missing data

The research respondents were selected from three waves of the HILDA survey, and information was collected in 2013 (wave 13), 2017 (wave 17), and 2021 (wave 21). Data on the main variables of interest (sleep duration and sleep quality) were not available in every wave of the survey. Consequently, this study utilised data gathered in waves 13, 17, and 21 when these variables were collected. Fig. 1 presents the procedure for finding the analytic sample. The total HILDA sample of the study (waves 13, 17, and 21) consisted of 69,175 person-year observations from 30,088 unique respondents. We kept data for adult respondents who completed the self-completion questionnaire. In addition, the data were confined to respondents having complete data on the main variables of interest (sleep duration and sleep quality) and the outcome variable (BMI). The final analytic sample consisted of 44,277 yearly observations from 20,576 unique participants.

2.3. Outcome variable

Obesity status was the main outcome variable of the present study, which was measured through an internationally standardized BMI scale. The HILDA survey calculated the respondents' BMI by using their self-reported weight and height following the formula weight (in kilograms) divided by height (in meters) squared. To define a participant's obesity status, BMI was categorised into underweight (BMI <18.50), healthy weight (BMI 18.50 to < 25), overweight (BMI 25 to < 30) and obese (BMI $\geq$ 30) following the WHO cut-off points [2].

3. Exposure variables

3.1. Sleep duration

The HILDA survey captures information on participants' hours of sleep per week, which is a constructed variable. The survey separately calculated the weekly sleep duration of the employed and unemployed participants. For the unemployed, the calculation was

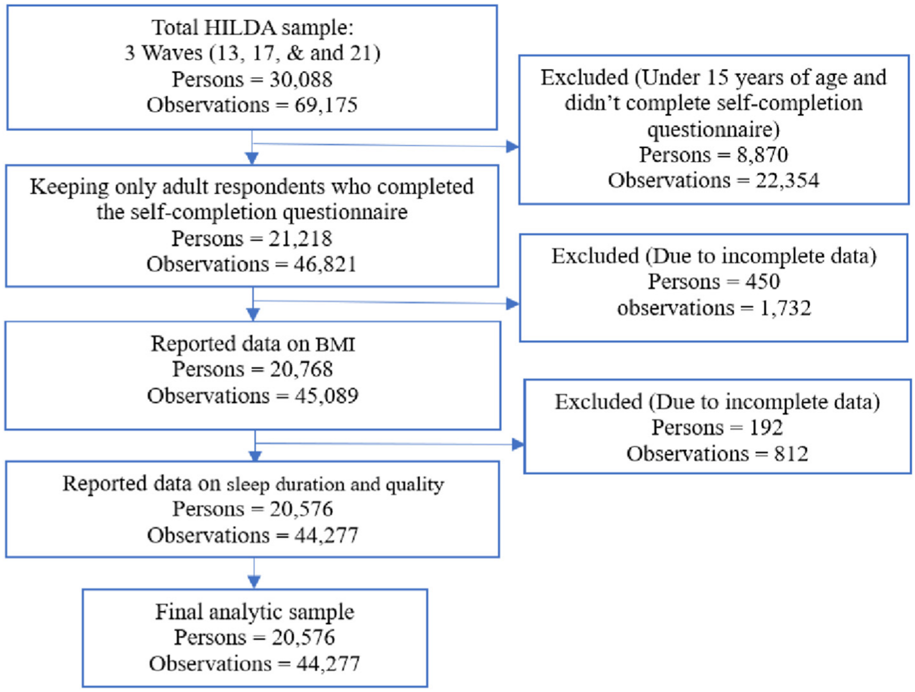

Fig. 1. Participants flow into the analytic sample and missing data.

5*weekday sleep + 2*weekend + naps. For the employed, the calculation was 5*workday sleep + 2*non-workday + naps. For employed persons, the number of work nights was based on days worked in the main job (and not all jobs). We dichotomised the sleep duration of respondents into two categories: poor (less than 7 h or more than 9 h of sleep) and good (7–9 h of sleep).

3.2. Sleep quality

The sleep quality variable was derived from participants' responses to the following question: 'Overall, how would you rank your sleep during the previous month?' The survey gave four options: 'very good', 'fairly good', 'very bad' and 'fairly bad' to the participants to gather information on their sleep quality. For the analysis, we dichotomised the responses: poor (combining 'very bad' and 'fairly bad') and good ('very good' and 'fairly good').

3.3. Control variables

This study controlled a wide range of socio-demographic and health-related characteristics that could also explain an individual's obesity status following previous research [27,35,36]. The socio-demographic covariates were age (15–29, 30–39, 40–49, 50–59 and 60 or above years), gender (male and female), relationship status (unpartnered and partnered), education (year 12 and below, certificate courses and university degrees), annual household disposable income (quintile 1 [poorest] to 5 [richest]), labour force status (employed, unemployed and not in the labour force), indigenous status (not of indigenous origin and of indigenous origin) and region of residence (major city, regional city and remote area). This study also included several health-related behavioural characteristics that comprised smoking status (never smoked, ex-smoker and current smoker), alcohol consumption (never drunk, ex-drinker and current drinker), physical activity (low, moderate and high) and the number of chronic diseases (0 [no morbidity], 1 [single morbidity] and ≥2 [multimorbidity]).

3.4. Estimation strategy

We constructed an unbalanced panel data consisting of 44,277 person-year observations by connecting the records of 20,576 de-identified participants. Descriptive statistics of the study respondents were presented as frequency (n) and percentages (%) with 95% confidence intervals (CIs). This study applied generalized estimating equations (GEE) logistic regression model to examine the association between sleep duration and quality with the risk of being obese over time. GEE is a statistical technique applied to examine longitudinal or clustered data. It is frequently used with binary or count data. GEE extends the Generalized Linear Model (GLM) framework by incorporating a working correlation matrix that accounts for the within-cluster or within-subject correlation. The technique measures the population-averaged effects by iteratively solving estimating equations. The following equation represents GEE.

$$g\,(E\,(Y_{mn})) = X_{mn}\alpha + Z_{mn}d$$

Where, $g\,(.)$ is the link function that relates the expected value of the response variable to the linear predictors. $E\,(Y_{mn})$ signifies the expected value of the response variable for observation m in cluster n. X_{mn} is the matrix of covariates (fixed effects) for observation m in cluster n. α denotes the vector of fixed-effect coefficients to be estimated. Z_{mn} is the matrix of covariates (random effects) for observation m in cluster n. d represents the vector of random-effect coefficients to be estimated.

GEE is predicated on the specification of a working correlation matrix, denoted by Σ, which captures the within-cluster or within-subject correlation structure. The working correlation matrix takes into account the interdependence of observations within the same cluster. GEE calculates the population-averaged effects by solving the following estimation equations iteratively.

$$\sum_{n=1}^{i}\sum_{m=1}^{jn} W_{mn}^{T}\left(Y_{mn}-g^{-1}\left(X_{mn}\alpha\right)\right)X_{mn}-0$$

Where, W_{mn} represents a working matrix derived from the working correlation matrix $\sum$, i is the number of clusters or subjects, and jn is the number of observations in cluster n.

These estimating equations are solved iteratively until convergence, which yields estimates for both the fixed-effect coefficients (α) and the working correlation matrix ($\sum$).

GEE has several advantages. It is robust to misspecification of the working correlation structure, estimates population-averaged effects and provides flexibility in modelling longitudinal or clustered data. These qualities make GEE suitable for situations with unknown or challenging correlation specifications and complex data structures [37]. GEE has limitations in terms of efficiency loss compared to specialized methods when the true correlation structure is well-specified, and interpretation challenges arise due to the population-averaged nature of the estimates. Additionally, GEE requires a large sample size for accurate estimation, and its performance should be assessed carefully in situations with limited data to avoid biased estimates and unreliable inference [38].

We controlled a number of time-varying and time-invariant confounders in the regression model. The results of the regression modelling were presented using the adjusted odds ratio (aOR). In this investigation, an explanatory variable was considered significant if the p-value was less than 0.05. We performed all the analyses using Stata Statistical Software: Release 17. College Station, TX: StataCorp LLC.

4. Results

The distribution of the analytic sample regarding socio-demographic and health-related characteristics at the baseline, final timepoint and pooled data is presented in Table 1. Table 1 indicates that over a quarter of respondents (26%) were aged 60 years or above. Amongst the study sample, more than half were female (53%), over three-fifths were unpartnered (60%), more than one-fourth held university degrees (28%) and nearly two-thirds were employed (64%). The results also indicated that 97% were not of Indigenous origin, 67% lived in major cities, 56% never smoked, 81% drank alcohol, 36% engaged in high physical activity and 52% had no morbidity (pooled data).

Table 2 displays the distributions of the outcome variable (BMI) and two main variables of interest (sleep duration and sleep quality) at the baseline (2013), final timepoint (2021) and pooled across all waves. Amongst survey participants, nearly two-third slept 7–9 h daily (62%), and approximately one-fourth had good quality sleep (73%). Over 50% of the study participants were either overweight (34%) or obese (26%) (pooled data).

Fig. 2 represents the proportion of weight category of the study participants over the recent nine years. The figure shows that the proportion of obese Australian adults has been increasing in the study period. In 2021, 28.71% of Australians were obese, compared to 25.79% in 2017, and 23.50% in 2013.

Fig. 3 displays the proportion of poor sleep length and quality in Australian adult population. The figure indicates that the proportion of poor sleep length was greater than 35% across all study years. The figure also indicates that 25%–30% of Australian adults were suffering from poor sleep quality. It is observed that the proportion of poor sleep length and quality were 36.35% and 28.60%, respectively, in 2021.

Fig. 4 displays the proportion of poor sleep duration according to their BMI. The figure shows that the rate of poor sleep duration was highly concentrated in obese adults in all the studied waves.

Table 1
Sample characteristics at baseline, final timepoint, and pooled data.

Variables	Baseline (Wave 13)		Final timepoint (Wave 21)		Pooled data (Waves 13, 17 & 21)	
	n	%	n	%	n	%
Socio-demographic characteristics						
Age						
15–29 years	3818	26.38	3324	22.73	10,965	24.76
30–39 years	2230	15.41	2713	18.55	7471	16.87
40–49 years	2442	16.88	2119	14.49	6958	15.71
50–59 years	2449	16.92	2284	15.62	7187	16.23
≥ 60 years	3532	24.41	4183	28.61	11,696	26.42
Gender						
Male	6821	47.14	6768	46.28	20,785	46.94
Female	7650	52.86	7855	53.72	23,492	53.06
Relationship status						
Partnered	5709	39.45	5784	39.55	17,475	39.47
Unpartnered	8762	60.55	8839	60.45	26,802	60.53
Highest education level completed						
Year 12 and below	6234	43.08	5341	36.52	17,523	39.58
Certificate courses	4539	31.37	4818	32.95	14,401	32.52
University degrees	3698	25.55	4464	30.53	12,353	27.9
Household yearly disposable income						
Quintile 1 (Poorest)	2896	20	2928	20.02	8857	20
Quintile 2 (Poorer)	2894	20	2923	19.99	8855	20
Quintile 3 (Middle)	2893	19.99	2925	20	8856	20
Quintile 4 (Richer)	2894	20	2923	19.99	8857	20
Quintile 5 (Richest)	2894	20	2924	20	8852	19.99
Labor force status						
Employed	9159	63.29	9344	63.9	28,266	63.84
Unemployed	574	3.97	456	3.12	1588	3.59
Not in the labour force	4738	32.74	4823	32.98	14,423	32.57
Indigenous status						
Not of Indigenous origin	14,033	96.97	14,119	96.55	42,860	96.8
Indigenous origin	438	3.03	504	3.45	1417	3.2
Region of residence						
Major city	9762	67.46	9626	65.83	29,467	66.55
Regional city	4516	31.21	4816	32.93	14,231	32.14
Remote area	193	1.33	181	1.24	579	1.31
Health-related characteristics						
Smoking status						
Never smoked	7913	54.68	8395	57.41	24,862	56.15
Ex-smoker	4028	27.83	4085	27.94	12,249	27.66
Current smoker	2530	17.48	2143	14.65	7166	16.18
Alcohol consumption						
Never drunk	1613	11.15	1482	10.13	4727	10.68
Ex-drinker	1136	7.85	1434	9.81	3899	8.81
Current drinker	11,722	81	11,707	80.06	35,651	80.52
Physical activity						
Low	4376	30.24	4316	29.52	13,690	30.92
Moderate	4865	33.62	4737	32.39	14,720	33.25
High	5230	36.14	5570	38.09	15,867	35.84
Number of chronic diseases						
0 (No morbidity)	7943	54.89	7140	48.83	23,052	52.06
1 (Single morbidity)	3702	25.58	3924	26.83	11,593	26.18
2 (Multimorbidity)	2826	19.53	3559	24.34	9632	21.75

Notes: 1. In the pooled data, a total of 44,277 yearly observations were considered from 20,576 unique persons. 2. The study used a 'modified OECD' equivalence scale to measure equivalised household annual disposable income and then categorised it into quintiles. 3. Eleven diseases were considered to create the variable 'number of chronic diseases'.

For example, the proportion of adults with poor sleep duration is 43% among the obese, followed by 35% among the overweight, 33% among the underweight and 32% among those with a healthy weight.

Fig. 5 displays the proportion of poor sleep quality of the study participants based on their weight status. The proportion of poor sleep quality amongst obese adults is 36%, followed by underweight (31%), and overweight (27%) in 2021.

Table 3 shows the association between poor sleep (transition to short or long sleep duration from 7 to 9 h of 'normal' sleep), poor

Table 2
Descriptive statistics: outcome and main variables of interests.

Variables	Baseline (Wave 13)		Final timepoint (Wave 21)		Pooled data (Waves 13, 17, & 21)	
	n	%	n	%	n	%
Outcome variable						
BMI						
Underweight	403	2.78	315	2.15	1069	2.41
Healthy weight	5757	39.78	5145	35.18	16,637	37.57
Overweight	4910	33.93	4965	33.95	15,057	34.01
Obese	3401	23.5	4198	28.71	11,514	26.0
Main variables of interest						
Sleep duration						
Good (7–9 h)	8941	61.79	9308	63.65	27,541	62.2
Poor (<7 h or >9 h)	5530	38.21	5315	36.35	16,736	37.8
Sleep quality						
Good	10,894	75.28	10,441	71.4	32,319	72.99
Poor	3577	24.72	4182	28.6	11,958	27.01

Note: In the pooled data, a total of 44,277 yearly observations were considered from 20,576 unique persons.

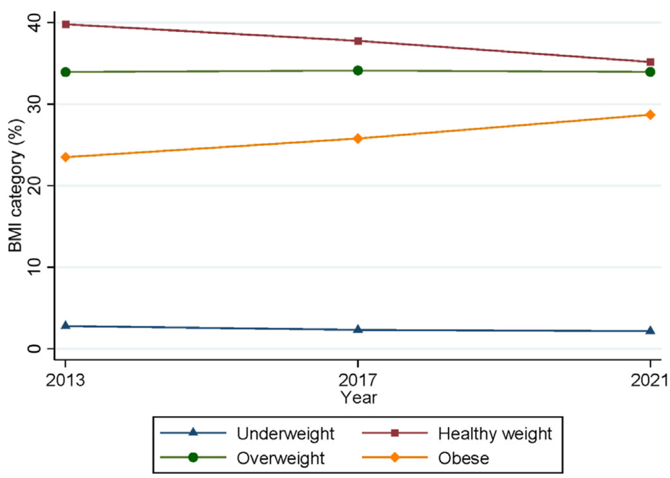

Fig. 2. Trend in the proportion of obesity.

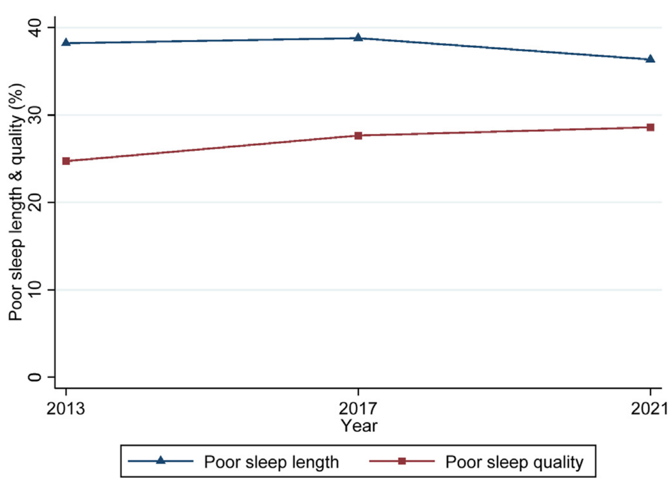

Fig. 3. Trend in the proportion of poor sleep duration and poor sleep quality.

sleep quality, and the risk of being obese through the generalized estimating equations (GEE) logistic regression model. The results showed that the odds of being obese was 1.24 times (aOR: 1.24; 95%

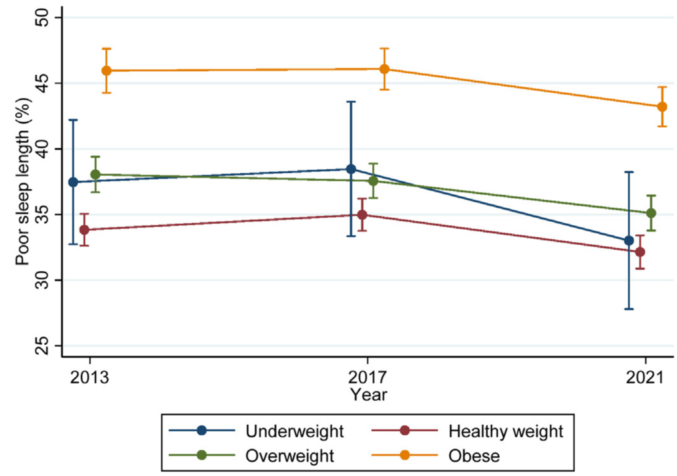

Fig. 4. Proportion of poor sleep duration by BMI.

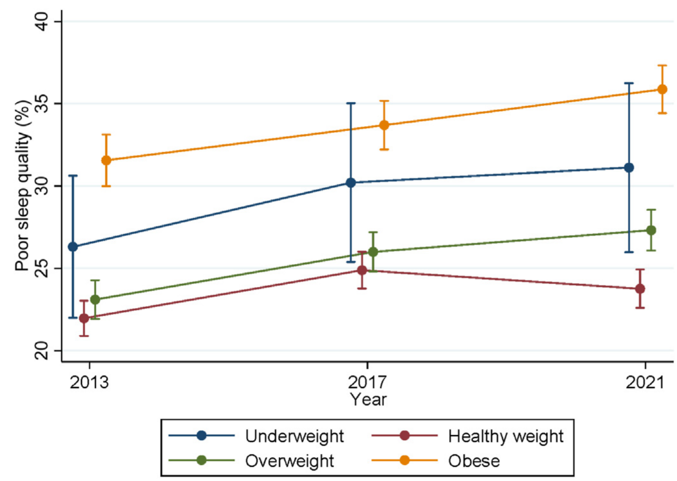

Fig. 5. Proportion of poor sleep quality by BMI.

CI: 1.16–1.32) higher amongst individuals who had poor sleep (<7 h or >9 h of sleep) compared with peers with good sleep (7–9 h). The results also showed that individuals with poor sleep quality had a 1.10 times higher odds (aOR: 1.29; 95% CI: 1.20–1.38) of being obese than their counterparts who had good sleep quality (Model 2).

5. Discussion

Obesity is one of the double burdens of malnutrition afflicting many nations, including Australia. Poor sleep duration and quality promote hormonal imbalance, which leads to obesity through overeating and consuming foods rich in calories. Therefore, it is essential to comprehend the connection between sleep length, sleep quality, and obesity. We aimed to evaluate the association between poor sleep duration and quality with the risk of being obese using longitudinal data. GEE logistic regression model was employed in this study to determine the association between sleep duration and sleep quality with obesity. We found that both poor sleep duration and quality were associated with an elevated risk of obesity among Australian adults.

We found that the risk of being obese was significantly higher amongst individuals with poor sleep duration (<7 h or >9 h) compared with those who had the recommended (7–9 h) sleep length. A previous study of Australian older adults also found that

Table 3
Relationship between sleep duration and sleep quality with the risk of being obese: generalized estimating equations (GEE) logistic regression model.

Parameter	Model 1: Overweight versus Healthy Weight	Model 2: Obesity Versus Healthy Weight
	aOR (95% CI)	aOR (95% CI)
Sleep duration		
Good (7–9 h) (ref)		
Poor (<7 h or >9 h)	1.06 [1.00–1.12]	1.24*** [1.16–1.32]
Sleep quality		
Good (ref)		
Poor	1.09** [1.02–1.16]	1.29*** [1.20–1.38]
Socio-demographic characteristics		
Age		
15–29 years (ref)		
30–39 years	1.64*** [1.51–1.78]	1.79*** [1.62–1.98]
40–49 years	1.95*** [1.78–2.14]	2.33*** [2.08–2.59]
50–59 years	2.12*** [1.93–2.33]	2.12*** [1.89–2.36]
≥60 years	2.17*** [1.97–2.39]	1.46*** [1.30–1.64]
Gender		
Male (ref)		
Female	0.54*** [0.50–0.57]	0.80*** [0.74–0.87]
Relationship status		
Partnered (ref)		
Unpartnered	1.22*** [1.15–1.30]	1.18*** [1.09–1.27]
Highest education level completed		
Year 12 and below (ref)		
Certificate courses	1.14*** [1.06–1.23]	1.11* [1.02–1.21]
University degrees	0.90** [0.83–0.97]	0.58*** [0.52–0.64]
Household yearly disposable income		
Quintile 1 (Poorest)	0.95 [0.86–1.04]	1.08 [0.97–1.21]
Quintile 2 (Poorer)	0.98 [0.90–1.07]	1.12* [1.01–1.24]
Quintile 3 (Middle)	1.01 [0.93–1.09]	1.13* [1.03–1.25]
Quintile 4 (Richer)	1.08* [1.00–1.17]	1.14** [1.04–1.25]
Quintile 5 (Richest) (ref)		
Labour force status		
Employed (ref)		
Unemployed	0.85* [0.74–0.98]	0.96 [0.82–1.12]
Not in the labour force	0.79*** [0.73–0.85]	0.78*** [0.72–0.85]
Indigenous status		
Not of indigenous origin (ref)		
Indigenous origin	1.29** [1.09–1.53]	1.64*** [1.35–2.00]
Region of residence		
Major city (ref)		
Regional city	1.21*** [1.13–1.29]	1.45*** [1.34–1.56]
Remote area	1.30* [1.02–1.66]	1.65*** [1.24–2.19]
Health-related characteristics		
Smoking status		
Never smoked (ref)		
Ex-smoker	1.24*** [1.15–1.33]	1.41*** [1.29–1.54]
Current smoker	0.89** [0.81–0.96]	0.91 [0.82–1.01]
Alcohol consumption		
Never drank (ref)		
Ex-drinker	1.15* [1.01–1.30]	1.22** [1.06–1.40]
Current drinker	1.24*** [1.13–1.37]	1.14* [1.02–1.28]

(*continued on next page*)

Table 3 (*continued*)

Parameter	Model 1: Overweight versus Healthy Weight	Model 2: Obesity Versus Healthy Weight
	aOR (95% CI)	aOR (95% CI)
Physical activity		
Low (ref)		
Moderate	0.83*** [0.78–0.89]	0.69*** [0.63–0.74]
High	0.79*** [0.74–0.85]	0.53*** [0.49–0.57]
Number of chronic diseases		
0 (No morbidity) (ref)		
1 (Single morbidity)	1.26*** [1.18–1.34]	1.72*** [1.60–1.86]
2 (Multimorbidity)	1.61*** [1.48–1.75]	3.32*** [3.03–3.65]
Observations	$n_{observations}$ = 31,694 $n_{individuals}$ = 16,192	$n_{observations}$ = 28,151 $n_{individuals}$ = 15,748

Notes: 1. 95% confidence intervals are reported in parentheses. 2. * indicates significance at the 5% level, ** indicates significance at the 1% level, *** indicates significance at the 0.1% level. 3. Abbreviations: aOR = Adjusted Odds Ratio; Ref = reference category; h = hours. 4. values are rounded off to two decimal places.

both short and long sleep lengths increase the risk of obesity in those aged 55–64 years, but not in those aged over 64 [39]. Two prior studies on US adults revealed that short sleep length (<7 h) is associated with a high risk of obesity [25,40]. Similarly, a prospective study conducted on Japanese workers found that both short (<6 h) and long (9 or more hours) sleep durations are associated with weight gain [41].

Our findings also confirm the hypothesis that there is a strong correlation between sleep quality and obesity in the Australian adult population. This was obvious in the findings that individuals who had poor sleep quality were more likely to become obese than those with good sleep quality. Our findings corroborated the results of a recent systematic review that poor sleep quality (regardless of sleep duration) considerably increases the risk of being obese [42]. Our findings were consistent with an Italian study which reported that short sleep duration and poor sleep quality are significantly associated with a high risk of obesity [31]. In addition, some prior studies established causal relationships between sleep and adiposity using Mendelian randomisation [43–45].

One of the possible reasons behind this finding is that poor sleep duration and sleep quality distort the circadian rhythm of the human body [46]. This distortion affects the metabolism, boosting the secretion of hormones and exacerbating the risk of being obese [47]. Sleep deprivation resulting from poor sleep duration and quality lowers appetite-suppressing blood leptin levels and raises appetite-promoting blood ghrelin levels [48]. From a behavioural perspective, the likelihood of unhealthy dietary habits such as consuming sugar-sweetened beverages and calorie-rich fast food is high amongst individuals who have poor sleep duration and quality, thereby increasing their risk of obesity [31]. Another plausible explanation for the observed relationship could be that poor sleep duration and quality may result in significantly reduced physical activity [27]. Physical inactivity arising from poor sleep quality and duration can make weight management difficult for adults, placing them at risk of being obese.

Our findings may have significant policy implications for the prevention of obesity. Interventions that improve sleep hygiene and promote healthy sleeping patterns may be an effective obesity prevention strategy. Healthy sleeping patterns should be targeted through behavioural interventions to prevent obesity. We found evidence that persons with higher educational attainment had a reduced chance of being obese compared with those with a lower educational attainment. Consequently, health and wellness promotion activities may serve as a preventative measure against obesity through lifestyle modifications such as adopting a healthier diet and engaging in more physical activity. We also found evidence that moderate to high engagement in physical activities was a significant protective factor against obesity. This result was corroborated by related studies that established a significant relationship between high engagement in physical activities and low risk of obesity [19,22]. The result was similar to a related study conducted among adults in Queensland, Australia, that showed a statistically significant negative association between engagement in physical activities and the risk of obesity [49]. This protective effect of physical activity on the risk of obesity could be due to the fact that obesity is triggered by a calorie surplus [49]; being physically active facilitates high daily energy expenditure [50]. Therefore, policies to encourage physical activities might serve as a protective factor against obesity. Moreover, strategies to increase awareness and adherence to continuous positive airway pressure for adults with obstructive sleep apnea might be useful.

Our study contributes to the existing body of knowledge regarding the effect of sleep duration and sleep quality on obesity risk in a number of ways. Our study's original contribution lies in the use of robust methods and reliable longitudinal data to demonstrate that poor sleep duration and sleep quality are associated with an elevated risk of obesity in Australian adults. We followed a retrospective longitudinal study design and fitted a population-averaged model to draw inferences. Prior studies on this topic draw conclusions following a cross-sectional study design. In our analyses, we considered both sleep length and quality to determine the relationship between sleep health and the risk of being obese. Previous studies mostly considered sleep duration whilst examining this relationship. We used a large sample size from a nationally representative dataset that allowed us to provide more precise and unbiased estimates. We also controlled for a large number of covariates that could have confounded the relationship between sleep duration, sleep quality, and risk of obesity. However, this study had some drawbacks that must be mentioned. We used self-reported data on BMI, sleep duration, sleep quality and other covariates that might underestimate or overestimate the relationships between sleep and obesity. For example, people tend to underreport their weight and overestimate their height, resulting in an estimate of BMI that is lower than the real value [51,52]. Another possible drawback of our study could be that our findings are based on the Australian population and may only be applicable to populations in other Western countries.

6. Conclusion

We found that individuals who had poor sleep duration and poor sleep quality were exposed to a higher risk of being obese compared with their counterparts who had good sleep duration and good sleep quality. Similar to many other Western economies, Australia is currently experiencing substantial rises in adult obesity; hence, the findings of this study have significant implications. The findings of this study may aid policymakers in developing effective health interventions to reduce the current rate of overweight and obesity in the population, thereby reducing its economic and health burdens. As a preventative measure to combat obesity, both the recommended hours and quality of sleep are crucial factors to consider.

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.

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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CRediT authorship contribution statement

Syed Afroz Keramat: Conceptualization, Formal analysis, Methodology, Writing – review & editing. **Khorshed Alam:** Conceptualization, Writing – review & editing. **Rabeya Basri:** Conceptualization, Formal analysis, Methodology, Writing – original draft. **Farzana Siddika:** Formal analysis, Methodology, Writing – original draft. **Zubayer Hassan Siddiqui:** Formal analysis, Methodology, Writing – original draft. **Joshua Okyere:** Writing – original draft, Writing – review & editing. **Abdul-Aziz Seidu:** Writing – original draft, Writing – review & editing. **Bright Opoku Ahinkorah:** Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no conflicts of interest.

Abbreviations

BMI	Body Mass Index
H	Hours
HILDA	Household, Income and Labour Dynamics in Australia Survey
US	United States

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