Sleep quality, obesity and the risk of multimorbidity among Australian middle-aged and older adults: Evidence from a national longitudinal household survey

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Abstract

Objective: We aim to examine whether sleep quality and obesity are important risk factors for multimorbidity among middle-aged and older adults in Australia.

Methods: We analysed 22,551 person-year observations from the Household, Income and Labour Dynamics in Australia Survey. We used fixed-effects multinomial logistic regression to explore the relationship between sleep quality and obesity with multimorbidity risk.

Results: We found that worsening an individual's sleep quality from good to poor was linked to a 1.65-fold increase in their risk of multimorbidity (relative risk ratio: 1.65, 95% confidence interval: 1.33–2.04). Transitioning from a healthy weight to obesity was associated with a 2.28 times higher risk of developing multimorbidity (relative risk ratio: 2.28, 95% confidence interval: 1.55–3.37). We also found that transitioning from good sleep and healthy weight to poor sleep and obesity resulted in a 3.82-fold increase in their relative risk of multimorbidity (relative risk ratio: 3.82, 95% confidence interval: 2.35–6.19).

Conclusions: The findings highlight the need for public health strategies and health promotion programs to tackle these modifiable risk factors.

Implications for Public Health: A key priority should be funding evidence-based implementation research to identify the most effective ways to deliver the proven interventions for sleep health and weight management across diverse Australian communities.

Key words: Australia, HILDA, multimorbidity, obesity, sleep quality

Introduction

The rapidly ageing population and the rising prevalence of chronic diseases pose one of the greatest challenges to healthcare systems worldwide. Multimorbidity, defined as the coexistence of two or more chronic diseases or ailments in a single individual, is commonly associated with an ageing population.[1,2] Multimorbidity is a major cause of increased mortality,[3] reduced quality of life,[2] increased disability-adjusted life years,[4] increased healthcare usage and costs,[5] compromised functional ability and

Abbreviation

BMI, Body Mass Index; HILDA, Household, Income and Labour Dynamics in Australia Survey; RRR, Relative Risk Ratio; US, United States; UK, United Kingdom.

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increased risk for adverse drug events.[4] While the prevalence of multimorbidity varies across populations, a recent estimate suggests that approximately 42.4% of the global population is affected by this condition.[6] Higher rates of multimorbidity are notably observed among adults, particularly within developed countries.[7] In Australia, an estimated 39% of the adult population aged 50 years or older has multimorbidity,[8] and about 17% have complex multimorbidity.[9] As Australia's population continues to age, a rise in multimorbidity prevalence is anticipated, which could impose an additional economic burden on the healthcare system.[8–10]

Several modifiable risk factors, including sleep quality[11] and obesity[12] are associated with multimorbidity. There is no consensus on the definition of "sleep quality."[13] The term is generally used for numerous sleep-related attributes, including total sleep time, ease of sleep initiation, sleep maintenance and early awakening.[14] Sleep quality is generally associated with physical health, psychological well-being and quality of life.[15] Whilst good sleep quality is vital for good health and vitality,[16] poor sleep quality is associated with multiple chronic diseases, including hypertension, obesity, diabetes and depression.[1,16,17]

Obesity is a major risk factor for several chronic diseases, including diabetes mellitus, chronic kidney disease, cardiovascular diseases, certain cancers, infections and musculoskeletal disorders.[12,18] The prevalence of obesity and its associated disease burden, including mortality, continues to increase worldwide.[18] Evidence suggests that people with obesity have a 1.3 times increased risk of premature death compared with a person with a healthy weight.[19,20]

Despite the growing prevalence and disease burden of multimorbidity, the concept lacks a clear theoretical conceptualisation, contributing to the difficulties in managing and addressing the problem. The Social determinants of health theory[21] has been used to explain the underlying risk factors for multimorbidity.[22,23] Life course theory has also been used to describe various health-related transitions, including multimorbidity.[24] This theory postulates that an individual's developmental stages from birth through adulthood to old age are linked with one another and often determined by specific events and life choices, which are commonly limited by sociocultural and genetic factors.[25] Using the life course theory, several studies have reported that sociodemographic factors and unhealthy lifestyles (e.g. poor sleep quality and unhealthy dietary choices) predispose people to multimorbidity during adulthood and old age.[26,27] For instance, poor sleep quality was associated with increased risk of multimorbidity among Chinese adults aged 45 years and above.[28,29] Additionally, people with obesity worldwide reportedly face a higher risk of multimorbidity,[30,31] which in turn contributes to increased rates of multimorbidity-related mortality.[32]

Whilst there are relatively few available studies on the relationship between obesity and multimorbidity among Australians,[33,34] there is a noticeable absence of previous studies on the influence of sleep quality on multimorbidity in the country. As modifiable risk factors of multimorbidity, both sleep quality and obesity are good targets for reducing the risk of multimorbidity.[29,31] Given the substantial prevalence of multimorbidity,[35] including complex multimorbidity,[9] among Australian adults, strengthening the evidence on the links among poor sleep quality, obesity and increased risk of multimorbidity is crucial. This improved understanding can inform the development of targeted interventions to mitigate the impact of these risk factors on the growing burden of multimorbidity and its associated high mortality in Australia.[36]

Although poor sleep quality[32] and obesity[34] has been independently linked to multimorbidity, little is known about the potential interaction effect of these factors on multimorbidity. Furthermore, a recent longitudinal study indicated that poor sleep quality increases the risk of obesity among adult Australians.[37] Systematic reviews and longitudinal studies also found that the relationship between poor sleep and obesity is bidirectional.[38,39] Therefore, the present study aimed to investigate not only the influence of poor sleep quality and obesity on multimorbidity but also the interaction effect of these factors on the risk of multimorbidity among middle-aged and older adults in Australia. Findings from our study could contribute to enhancing health promotion and lifestyle modification measures that improve sleep quality and encourage healthy weights among adults and older adults in Australia, thereby helping to reduce the prevalence of multimorbidity and its associated disease burden in the country.

Data and methodology

Data source and sample selection

We utilised the Household Income and Labour Dynamics in Australia (HILDA) Survey data to study the link among sleep quality, obesity and multimorbidity. The HILDA Survey, which commenced in 2001, is an annual nationally representative longitudinal study of households that gathers extensive data on Australians' family life, income, labour market activity and employment. Managed by the Melbourne Institute of Applied Economic and Social Research at the University of Melbourne and funded by theAustralian Government Department of Social Services, the survey compiles annual data initially from over 13,000 individuals in more than 7000 households using a multistage sampling technique. Trained interviewers collect data from household members aged 15 years and older, primarily through in-person or telephone interviews, complemented by a self-completion questionnaire.

We utilised data from three waves (waves 13, 17 and 21) of the HILDA Survey, corresponding to data collection years 2013, 2017 and 2021, respectively. These specific waves were selected due to the availability of data on the primary variable of interest, namely sleep quality. Our study population was restricted to participants aged 45 years and older. While the HILDA survey includes data from individuals aged 15 years and above, our study is specifically concerned with the risk factors for multimorbidity, which is more prevalent in middle-aged and older adults. Research indicates that the prevalence of multimorbidity increases significantly with age, with a substantial rise observed from middle age onwards. For example, in Australia, an estimated 39% of the adult population aged 50 years or older has multimorbidity,[8] and about 17% have complex multimorbidity.[9] Therefore, to focus on the age group most relevant to our research question and to ensure a sufficient number of multimorbid cases for robust statistical analysis, we confined our sample to those aged 45 years and above. Furthermore, the analytic sample was restricted to respondents with complete data for the key independent variables (sleep quality and body mass index) and the outcome variable (multimorbidity). Consequently, the final analytic sample comprised 22,551 person-year observations from 10,313 unique individuals. Appendix Figure 1 provides a detailed illustration of the stepwise procedure for determining the analytic sample and managing missing data.

Outcome variable

Multimorbidity was the primary outcome variable of our study, defined as the presence of two or more chronic diseases within an individual. Information regarding chronic or long-term health conditions was sourced from the HILDA Survey, where participants were asked, "Have you ever been advised by a medical practitioner that you have a serious sickness or medical condition?" to determine the presence or absence of such conditions. The survey included 11 non-communicable diseases: cancer, heart disease, circulatory disease, hypertension, type 1 diabetes, type 2 diabetes, asthma, bronchitis, arthritis, anxiety/depression and other mental health conditions. Responses were recorded in a binary format (1 = condition present and 0 = condition absent). Consistent with the previous research, multimorbidity was defined as the presence of at least two of these eleven conditions in the same individual.[33,40,41] A categorical variable was constructed to represent morbidity status with three levels: 0 = no chronic conditions, 1 = one chronic condition and 2 = multimorbidity (two or more chronic conditions).

Primary exposure variables

The present study concentrated on two key health indicators: sleep quality and obesity, which were identified as the primary variables of interest. This emphasis indicates that the research aimed to investigate these specific factors in depth, potentially exploring their individual and combined effects on multimorbidity.

Sleep quality

The HILDA Survey gathered information on the respondents' perceptions of the quality of their sleep by asking, "During the past month, how would you rate your sleep quality overall?" The responses were gathered using a 4-point Likert scale: "very good," "fairly good," "very bad" and "fairly bad"' The sleep quality of the respondents was then reclassified as either good (by combining very good and fairly good) or poor (by combining very bad and fairly bad) sleep quality.

Obesity

The HILDA Survey has collected self-reported information on participants' height and weight. Body mass index (BMI) was calculated by dividing weight (in kilograms) by the square of height (in metres). Based on BMI values and in accordance with World Health Organisation classification standards, respondents were categorised into four groups: underweight (BMI $<$ 18.50), healthy weight (BMI 18.50 to $<$ 25), overweight (BMI 25 to $<$ 30) and obese (BMI $\geq$ 30).[42]

Control variables

We included several covariates based on the previous research to assess the effects of sleep quality and obesity on the acquisition of multimorbidity in Australian middle-aged and older adults.[43–45] These variables were categorised into sociodemographic covariates and health-related behavioural factors. The sociodemographic covariates included age, sex, relationship status, education, annual disposable household income, labour force status, Indigenous status and region of residence. We also accounted for three health-related behavioural factors: smoking status, alcohol consumption and physical activity.

Statistical analyses

To assess the effects of sleep quality and obesity on the likelihood of developing multimorbidity among Australian middle-aged and older adults, we primarily utilised a fixed-effects multinomial logistic regression model. Multinomial logistic regression was chosen to analyse the association between multiple independent variables and a categorical dependent variable with more than two unordered categories. The choice of a fixed-effects specification was driven by the longitudinal nature of the data, allowing for control of time-invariant individual-specific unobserved heterogeneity that could otherwise bias the estimates. To corroborate the primary findings, a random-effects multinomial logistic regression model was also applied as a robustness check.

The results from the statistical models are reported as relative risk ratios (RRRs), along with 95% confidence intervals (CIs) and p values for each predictor variable. Statistical significance was established at a threshold of $p<0.05$. We conducted all statistical analyses using the statistical software STATA (Release 17. College Station, TX: StataCorp LLC).

Results

Table 1 presents the distribution of study participants, their sociodemographic and health-related factors at baseline, the final wave and pooled across all waves. Over half of the respondents were female (53%), with a significant portion aged 60 years and above (52%). Additionally, two-thirds of the sample was unpartnered (65%), 38% had 12 years of schooling or less and more than half were employed (51%). Among the study participants, 98% were non-Indigenous, approximately 63% lived in major cities, 50% had never smoked, 80% consumed alcohol and 36% performed moderate physical activity (pooled data).

Table 1 also presents the distributions of the outcome variable (multimorbidity) and the key variables of interest (sleep quality and BMI). Over 35% of the study participants experienced multimorbidity. Approximately 26% of participants reported poor sleep quality. Furthermore, the findings reveal that more than one-fourth of the respondents (30%) were living with obesity (pooled data). More detailed information on the trends in the distribution of key exposure variables (sleep quality and BMI categories) and the outcome variable (chronic conditions) across the survey waves is presented in Appendix Figure 2, Appendix Figure 3 and Appendix Figure 4, respectively.

Figure 1 illustrates the trends in the rate of chronic conditions by sleep quality across three time points (waves 13, 17 and 21). The figure shows that the rate of multimorbidity is consistently higher among adults reporting poor sleep quality compared to those with good sleep quality. Specifically, the rate of multimorbidity among adults with good sleep quality increased from 29% in 2013 to 33% in 2021. In contrast, the rate of multimorbidity among those with poor sleep quality has remained notably higher throughout the study period, with figures such as 43% in 2013 and 46% in 2021.

Figure 2 presents the distribution of chronic conditions according to BMI categories across the observed study waves. The figure highlights that the rate of multimorbidity is consistently most pronounced among people with obesity. For instance, the rate of multimorbidity among people with obesity was 48% in 2021.

Table 1: Distribution of the analytic sample.

Characteristics	Baseline wave (2013)		Final wave (2021)		Pooled data (2013, 2017 and 2021)	
	N	%	N	%	N	%
Sociodemographic characteristics						
Age						
45–59 years	3,687	50.92	3,413	44.77	10,783	47.82
≥ 60 years	3,554	49.08	4,211	55.23	11,768	52.18
Sex						
Male	3,428	47.34	3,536	46.38	10,590	46.96
Female	3,813	52.66	4,088	53.62	11,961	53.04
Relationship status						
Partnered	2,472	34.14	2,782	36.49	7,967	35.33
Unpartnered	4,769	65.86	4,842	63.51	14,584	64.67
Highest education level completed						
Year 12 and below	3,053	42.16	2,612	34.26	8,606	38.16
Certificate courses	2,457	33.93	2,805	36.79	8,004	35.49
University degrees	1,731	23.91	2,207	28.95	5,941	26.34
Household yearly disposable income						
Quintile 1 (poorest)	1,449	20.01	1,525	20.00	4,511	20.00
Quintile 2	1,449	20.01	1,525	20.00	4,510	20.00
Quintile 3	1,447	19.98	1,526	20.02	4,511	20.00
Quintile 4	1,449	20.01	1,524	19.99	4,509	19.99
Quintile 5 (richest)	1,447	19.98	1,524	19.99	4,510	20.00
Labour force status						
Employed	3,758	51.90	3,825	50.17	11,561	51.27
Unemployed	130	1.80	130	1.71	381	1.69
Not in the labour force	3,353	46.31	3,669	48.12	10,609	47.04
Indigenous status						
Not of indigenous origin	7,112	98.23	7,457	97.82	22,109	98.05
Indigenous origin	128	1.77	166	2.18	439	1.95
Region of residence						
Major city	4,584	63.31	4,820	63.22	14,217	63.04
Regional city	2,547	35.17	2,695	35.35	7,996	35.46
Remote area	110	1.52	109	1.43	338	1.50
Health-related characteristics						
Smoking status						
Never smoked	3,514	48.53	3,865	50.7	11,199	49.66
Ex-smoker	2,714	37.48	2,792	36.62	8,321	36.90
Current smoker	1,013	13.99	967	12.68	3,031	13.44
Alcohol consumption						
Never drunk	739	10.21	722	9.47	2,228	9.88
Ex-drinker	635	8.77	835	10.95	2,217	9.83
Current drinker	5,867	81.02	6,067	79.58	18,106	80.29
Physical activity						
Low	2,557	35.31	2,679	35.14	8,164	36.20
Moderate	2,571	35.51	2,721	35.69	8,026	35.59
High	2,113	29.18	2,224	29.17	6,361	28.21
Outcome variable						
Chronic conditions						
No	2,694	37.20	2,599	34.09	8,054	35.71
Single chronic condition	2,180	30.11	2,216	29.07	6,705	29.73
Multimorbidity	2,367	32.69	2,809	36.84	7,792	34.55
Main exposure variables						
Sleep quality						
Good	5,490	75.82	5,533	72.57	16,660	73.88
Poor	1,751	24.18	2,091	27.43	5,891	26.12
BMI						
Underweight	110	1.52	103	1.35	303	1.34
Healthy weight	2,301	31.78	2,204	28.91	6,900	30.6
Overweight	2,796	38.61	2,866	37.59	8,564	37.98
Obesity	2,034	28.09	2,451	32.15	6,784	30.08

Notes: 1. Distribution was reported for the baseline, final and pooled across all waves. 2. For the pooled data, yearly observations included 22,551 from 10,313 unique respondents.

BMI = body mass index.

Table 2 presents the effects of sleep quality and BMI on the risk of acquiring multimorbidity using the fixed-effects multinomial logistic regression model. Our analysis, which utilises fixed-effects multinomial logistic regression focusing on changes within the same individuals over time, indicated that when an adult transitioned from experiencing good sleep quality to poor sleep quality, their risk of multimorbidity increased by 1.65 times [adjusted RRR (aRRR): 1.65, 95%CI: 1.33–2.04]. Similarly, we discovered that when an individual transitioned from a healthy weight to being obese, their risk of multimorbidity was 2.28 times higher (aRRR: 2.28, 95%CI: 1.55–3.37) compared to when they were at a healthy weight.

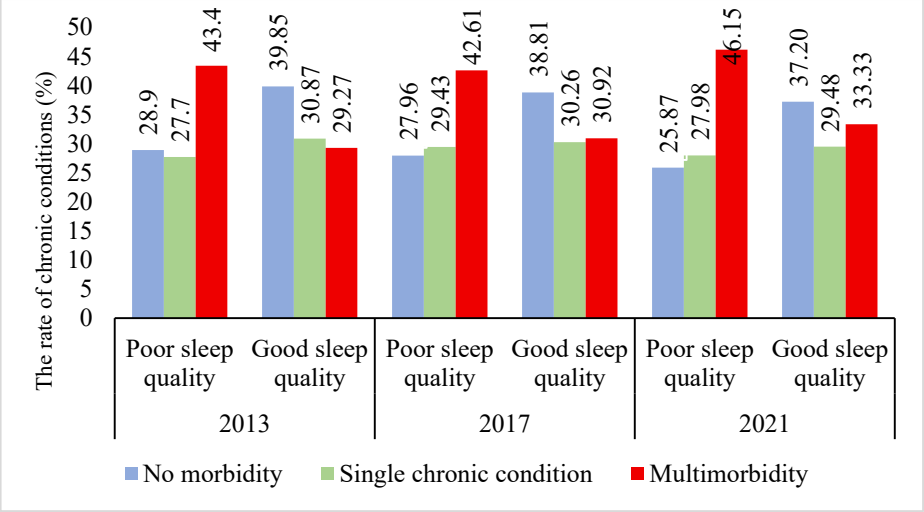
The results from model 2, which examines within-individual changes over time, revealed that when an individual transitioned from having both good sleep quality and a healthy weight to concurrently having poor sleep quality and obesity, their relative risk of experiencing multimorbidity increased 3.82 times (aRRR: 3.82, 95%CI: 2.35–6.19).

Robustness check

Table 3 presents the results of a sensitivity analysis conducted using a random-effects multinomial logistic regression model. The coefficients derived from this model align with those from the primary fixed-effects multinomial logistic regression model, reinforcing the current study's findings. For example, the random-effects model indicated that adults with poor sleep quality faced a 2.82 times higher relative risk of multimorbidity (aRRR: 2.82, 95%CI: 2.45–3.25) compared to those with good sleep quality. Likewise, obesity was linked to a 7.27-fold increase in the relative risk of multimorbidity (aRRR: 7.27, 95%CI: 6.04–8.73) compared to adults with a healthy weight. Furthermore, the interaction analysis in Model 2 indicated that transitioning to both poor sleep quality and obesity simultaneously resulted in a 20.64 times higher relative risk of multimorbidity (aRRR: 20.64, 95%CI: 15.89–26.81) compared to those maintaining good sleep and a healthy weight. This consistency across different modelling techniques and the significant interaction effect underscores the robustness of the results.

To further assess the robustness of our findings, we conducted a fixed-effects multinomial logistic regression analysis stratified by sex, with detailed results presented in Appendix Table 1. This analysis examined the independent and group comparison in the interaction effects between sleep quality and obesity on the risk of multimorbidity separately for males and females. The results indicate

Figure 1: Trends in the rate of chronic conditions by sleep quality.



that a transition to poor sleep quality was associated with an increased risk of multimorbidity in both males (aRRR: 1.62, 95%CI: 1.18–2.23) and females (aRRR: 1.69, 95%CI: 1.26–2.28). Similarly, transitioning from a healthy weight to obesity was associated with a higher risk of multimorbidity in both males (aRRR: 2.00, 95%CI: 1.15–3.47) and females (aRRR: 2.54, 95%CI: 1.45–4.44). The interaction effect of concurrently having poor sleep and obesity also demonstrated a significantly increased relative risk of multimorbidity for both males (aRRR: 2.89, 95%CI: 1.46–5.72) and females (aRRR: 4.68, 95%CI: 2.33–9.41). These sex-stratified results are broadly consistent with our main findings, reinforcing the generalisability of the observed associations across sexes.

To address the concern that the association between poor sleep quality and multimorbidity might be influenced by poor sleep acting as a common symptom of the mental health conditions included in our initial multimorbidity definition, we conducted a further sensitivity analysis. For this purpose, we defined 'physical multimorbidity' by excluding depression and other mental health conditions from the eleven non-communicable diseases used in our primary outcome measure (see Appendix Table 2, Note 1). We then re-ran the fixed-effects multinomial logistic regression models using this "physical multimorbidity" outcome. The detailed results, presented in Appendix Table 2, demonstrate that poor sleep quality remained significantly associated with an increased risk of developing physical multimorbidity. Specifically, a transition from good to poor sleep quality was associated with a 1.58-fold increase in the risk of physical multimorbidity (aRRR: 1.58, 95%CI: 1.27–1.97). This result is comparable to the association found with overall multimorbidity (aRRR: 1.65, 95%CI: 1.33–2.04), suggesting that the detrimental impact of poor sleep quality on accumulating chronic conditions extends beyond its role as a potential symptom of mental health disorders. This consistency enhances the robustness of our

Figure 2: Distribution of chronic conditions by weight status.

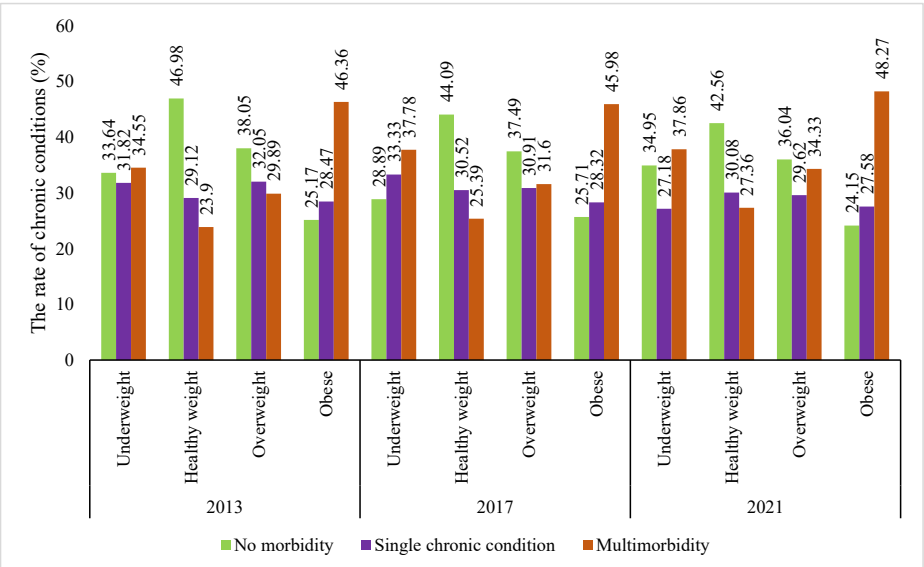


Table 2: Effects of sleep quality and obesity on the risk of multimorbidity: Fixed-effects multinomial logistic regression.

Parameter	Model 1 aRRR (95%CI), *p* value		Model 2 aRRR (95%CI), *p* value	
	Single chronic condition	Multimorbidity	Single chronic condition	Multimorbidity
Sleep quality				
Good (Ref)				
Poor	**1.33 (1.10, 1.59), 0.002**	**1.65 (1.33, 2.04), <0.001**		
BMI				
Underweight	1.12 (0.55, 2.29), 0.753	0.93 (0.38, 2.32), 0.883		
Healthy weight (Ref)				
Overweight	**1.32 (1.04, 1.67), 0.023**	**1.48 (1.11, 1.97), 0.008**		
Obesity	**1.58 (1.14, 2.20), 0.007**	**2.28 (1.55, 3.37), <0.001**		
Group comparison in the interaction effects between sleep quality and BMI				
Good sleep quality and underweight			0.83 (0.36, 1.91), 0.661	0.74 (0.26, 2.13), 0.578
Good sleep quality and healthy weight (Ref)				
Good sleep quality and overweight			**1.31 (1.01, 1.69), 0.038**	**1.36 (1.00, 1.86), 0.052**
Good sleep quality and obese			**1.58 (1.12, 2.25), 0.01**	**2.06 (1.36, 3.10), 0.001**
Poor sleep quality and underweight			2.92 (0.81, 10.54), 0.101	2.43 (0.50, 11.67), 0.269
Poor sleep quality and healthy weight			1.28 (0.94, 1.76), 0.122	1.24 (0.83, 1.84), 0.287
Poor sleep quality and overweight			**1.74 (1.25, 2.42), 0.001**	**2.36 (1.58, 3.51), <0.001**
Poor sleep quality and obese			**2.05 (1.36, 3.10), 0.001**	**3.82 (2.35, 6.19), <0.001**

Note: 1. The regression model was adjusted for age, relationship status, highest education level completed, household yearly disposable income, labour force status, region of residence, smoking status, alcohol consumption and physical activity. 2. Values in bold are statistically significant. 3. Abbreviations: ref = Reference Category; aRRR = Adjusted Relative Risk Ratio;
BMI = Body Mass Index; CI = Confidence Interval.

finding that poor sleep quality is an independent risk factor for multimorbidity.

Discussion

Key findings

We aimed to examine the potential significance of sleep quality and obesity as risk factors for multimorbidity. The findings revealed that individuals with obesity and those experiencing poor sleep quality have a higher relative risk of multimorbidity compared to their peers with a healthy weight or good sleep quality. Additionally, the findings indicated a greater increase in the risk of multimorbidity among individuals with both obesity and poor sleep quality, relative to those with either condition alone, suggesting a significant negative impact of the interaction between poor sleep quality and obesity on the risk of multimorbidity.

Table 3: The association between sleep quality, obesity and the risk of multimorbidity: Random-effects multinomial logistic regression.

Parameter	Model 1 aRRR (95%CI), *p* value		Model 2 aRRR (95%CI), *p* value	
	Single chronic condition	Multimorbidity	Single chronic condition	Multimorbidity
Sleep quality				
Good (Ref)				
Poor	**1.51 (1.35, 1.69), <0.001**	**2.82 (2.45, 3.25), <0.001**		
BMI				
Underweight	1.26 (0.83, 1.92), 0.274	1.23 (0.72, 2.09), 0.457		
Healthy weight (Ref)				
Overweight	**1.39 (1.24, 1.56), <0.001**	**2.24 (1.91, 2.63), <0.001**		
Obesity	**1.99 (1.74, 2.27), <0.001**	**7.27 (6.04, 8.73), <0.001**		
Sleep quality and BMI				
Sleep quality and weight category				
Good sleep quality and underweight			0.89 (0.55, 1.45), 0.638	0.74 (0.39, 1.42), 0.370
Good sleep quality and healthy weight (Ref)				
Good sleep quality and overweight			**1.41 (1.24, 1.60), <0.001**	**2.15 (1.80, 2.57), <0.001**
Good sleep quality and obese			**2.12 (1.82, 2.46), <0.001**	**6.70 (5.45, 8.24), <0.001**
Poor sleep quality and underweight			**6.23 (2.60, 14.93), <0.001**	**11.36 (4.13, 31.30), <0.001**
Poor sleep quality and healthy weight			**1.63 (1.35, 1.98), <0.001**	**2.35 (1.81, 3.04), <0.001**
Poor sleep quality and overweight			**2.16 (1.79, 2.59), <0.001**	**5.85 (4.59, 7.47), <0.001**
Poor sleep quality and obese			**2.72 (2.21, 3.33), <0.001**	**20.64 (15.89, 26.81), <0.001**

Note: 1. The sample size is n = 10,313, with 22,551 person-year observations. 2. Regression model was adjusted for age, sex, relationship status, highest education level completed, household yearly disposable income, labour force status, Indigenous status, region of residence, smoking status, alcohol consumption and physical activity. 3. Values in bold are statistically significant. 4. Abbreviations: ref = reference category; aRRR = adjusted relative risk ratio.
BMI = body mass index; CI = confidence interval.

Poor sleep quality is closely linked to the development of both single and multiple concurrent chronic conditions (multimorbidity). A prospective cohort study in China confirmed this, showing that poor sleep was associated with a higher risk of multimorbidity progression in middle-aged and older adults, with the risk being highest for women and those under 65 years.[46] Another Chinese study also revealed that poor sleep was independently and significantly linked to a greater likelihood of having multimorbidity in adults aged 45 and over.[28] Additionally, the current findings corroborate several previous studies which reported a significant increase in the likelihood of multimorbidity among adults and the elderly population experiencing poor sleep quality[17,47–49] as well as those with obesity.[50,51] According to a systematic review and dose-response meta-analysis, a linear relationship exists between body mass index and the risk of developing multiple chronic conditions. The findings indicate that individuals with obesity face approximately double the risk of multimorbidity compared to those with a normal BMI, and for every 5 kg/m^2 increase in BMI, the risk rises by 35%.[52] A previous prospective cohort study from the USA and Europe identified a clear dose-response relationship between body weight and the risk of developing multiple cardiometabolic diseases, with the risk doubling for overweight individuals and rising to nearly 15-fold for those with severe obesity compared to their healthy weight counterparts.[53] A large-scale observational study has also found that obesity is a significant driver of complex multimorbidity, dramatically increasing the risk of developing four or more chronic diseases by over 12-fold compared to individuals of a healthy weight.[30] Although we found no comparative study on the effects of the interaction between obesity and poor sleep quality on the risk of multimorbidity, our findings support the increased burden of multimorbidity among individuals living with poor sleep quality and obesity.[28]

Existing evidence shows that poor sleep quality increases the risk of obesity,[54] whilst the presence of obesity worsens sleep quality.[55] Perhaps this bidirectional relationship between poor sleep quality and obesity exacerbates the issue of multimorbidity among adults with both conditions. Therefore, in addition to addressing multimorbidity in individuals already affected by poor sleep quality and obesity, greater emphasis on early prevention is vital. Such measures are needed to reduce poor sleep quality and obesity, thereby mitigating their compounding effect on multimorbidity.

Although the underlying pathogenesis of poor sleep quality and the risk for multimorbidity remains unclear, various pathogenetic pathways, including inflammatory and immunologic pathways, have been used to explain this relationship.[56] Persistently poor sleep quality often induces chronic inflammation, which causes multiple diseases in an individual.[56,57] For example, clinical studies have shown that poor sleep quality often contributes to increased secretion of proinflammatory factors such as interleukin-1β (IL-1β), IL-6 and tumour necrosis factor-α, which often instigate chronic inflammatory processes.[58] The resultant chronic inflammation contributes to multiple tissue damages and predisposes individuals to several chronic diseases, including cancers, diabetes, cardiovascular diseases and osteoarthritis.[57,59,60] Meanwhile, a recent study suggested a likelihood of a bidirectional relationship between poor sleep quality and multimorbidity.[48] Whilst the presence of multimorbidity could have a deleterious effect on sleep quality,[61] our findings, based on longitudinal data, provide more credence to the high likelihood of poor sleep quality being a significant predisposing factor for multimorbidity amongst middle-aged and older adults. Similar findings were reported in previous studies in China.[62,63] Therefore, improving sleep quality among the adult population in Australia could contribute towards reducing multimorbidity and its associated disease burden.

The high risk for multimorbidity amongst people with obesity has primarily been attributed to inflammation and abnormal body fat distribution, often associated with obesity.[64,65] Several prospective longitudinal and case–control studies have shown that increased levels and patterns of body fat distribution amongst people with obesity increase the risk of developing chronic diseases, including cancer, diabetes and cardiovascular diseases.[66–70] This phenomenon contributes to the increased likelihood of multimorbidity amongst people with obesity, as found in the present study. A study conducted among Canadian adults found that people with obesity have a twofold higher risk of multimorbidity than their healthy weight counterparts.[50] Similarly, a Serbian study found that class III obesity (morbid obesity) is associated with a 7-fold and 9.5-fold likelihood for multimorbidity among adult men and women, respectively, compared to their counterparts with a healthy weight.[51] These findings emphasise the importance of enhanced weight control measures to reduce the risk of obesity among adults and minimise their risk of multimorbidity.

Policy implications

Our findings confirm that poor sleep quality and obesity are significant, interacting risk factors for multimorbidity. These findings have important policy implications that go beyond traditional awareness campaigns. While effective clinical interventions for managing a healthy weight and improving sleep quality exist, successfully translating and maintaining these in community settings remains a major challenge. Knowledge of health risks alone is often insufficient to cause lasting behavioural change. Therefore, a key policy priority should be to fund and support evidence-based implementation research. This research is urgently needed to determine how best to deliver proven interventions for weight management and sleep health on a large scale across diverse Australian communities. To be effective, such research must be community-led and actively involve consumers in designing implementation strategies. This approach helps ensure interventions are acceptable, equitable and tailored to the needs of the population, increasing the chances of real-world uptake and impact. By focusing on how to implement what is already known to work, policymakers can better address the intertwined risks of poor sleep and obesity highlighted in this study, ultimately helping to reduce the rising rates of multimorbidity and its costs.

Educating individuals about proper sleep habits and healthy weight choices through ongoing media campaigns led by health professionals may substantially reduce poor sleep quality and obesity, along with their associated multimorbidity. Furthermore, limiting unhealthy meals, encouraging physical exercise, reducing screen time and television viewing and alleviating mental stress can enhance both sleep quality and a healthy weight. Additionally, monitoring BMI in various healthcare settings, including primary care, may facilitate the early diagnosis of individuals at risk of obesity. This could enable the prompt implementation of necessary interventions, such as dietary and weight management programs, to minimise the risk of obesity and its related chronic diseases.

Strengths and limitations

Our study has several strengths. First, we utilised nationally representative longitudinal population-based datasets. Second, we controlled for a wide range of time-varying and time-invariant confounders. Third, we report both within-person and between-person differences in the relationship between sleep quality, obesity and the risk of multimorbidity.

Despite these strengths, our study also had some limitations. First, since observational data were used, the findings established only associations rather than causality among the risk of multimorbidity, poor sleep quality and obesity. Second, all participant data, including the presence and number of chronic conditions, sleep quality and obesity, were self-reported, which increased the possibility of recall and social desirability biases. Therefore, to improve the validity and reliability of research findings, future studies should prioritise using objective measures for multimorbidity, sleep quality and obesity.

Conclusion

Our study reveals that adults living with obesity and poor sleep quality exhibit a higher prevalence of multimorbidity. Employing fixed-effects multinomial logistic regression models, the adjusted relative-risk ratios demonstrate a higher prevalence of multimorbidity among adults with poor sleep quality and obesity than their counterparts with good sleep quality and a healthy weight. To ensure the robustness of the results, random-effects multinomial logistic regression models were also utilised, yielding similar findings. The results of our study have significant implications for Australia's healthcare sector. We found that poor sleep quality and obesity are key factors in acquiring multimorbidity. Therefore, health promotion programs and strategies should be implemented to address these issues. Health education programs should also be introduced to promote the benefits of good sleep and the causes of obesity. These programs can educate people, particularly teenagers, on the recommended hours of sleep, present evidence on sleep disorders and excessive weight and explain their symptoms and adverse health effects to prevent multimorbidity.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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Ethics approval and consent to participate

The HILDA Survey commenced in 2001 and has been conducted annually following the University of Melbourne's ethical guidelines. The Human Research Ethics Committee of the University of Melbourne has approved this research project. The ethics ID number of the research project (HILDA Survey) is 1647030. The HILDA Survey is conducted under a new human research ethics approval (Project ID 31363, approved February 2025) received from The University of Melbourne. This paper uses unit record data from the HILDA conducted by the Australian Government Department of Social Services. This study did not require ethical approval as the analysis used only de-identified existing unit record data from the HILDA Survey.

Informed consent to participate in the HILDA Survey was gained through the use of an information letter to all potential respondents. This letter described the voluntary nature of participation in The Survey and outlined that informed consent would be implied when participants agreed to be interviewed. Further, more detailed information about the purposes of the HILDA was sent after the interview to Wave 1 respondents (and any new sample members at later waves), along with further information about the way the data are being held, what is being done with the data, and how individuals can, on request (but after undergoing a range of security checks), access that information.

Author contributions

S.A.K., K.A., A.A.M. Conceptualisation.

S.A.K., R.B., A.A.M. Formal analysis.

S.A.K., K.A., R.B., A.M., A.A.S., B.O.A., A.A.M. Methodology.

S.A.K., K.A., R.B., A.M., A.A.S., B.O.A., A.A.M. Writing – original draft.

S.A.K., K.A., R.B., A.M., A.A.S., B.O.A., A.A.M. Writing – review & editing.

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Data availability statement

There are two versions of the HILDA data: the General Release and the Restricted Release. This study utilised restricted release data from the Household, Income and Labour Dynamics in Australia (HILDA) Survey. Funded by theAustralian Government Department of Social Services (DSS), the Survey is managed by the Melbourne Institute of Applied Economic and Social Research at the University of Melbourne. Access to the complete HILDA dataset is limited and requires specific approval as it contains sensitive personal information. To apply for access to any of the DSS Longitudinal Studies datasets, first, all applicants and collaborators who need to

view unit record data must complete and sign a once only Confidentiality Deed Poll and email the scanned, signed copy to DSS (DataAccess@dss.gov.au) and ADA (ada@ada.edu.au). Electronic signatures are currently accepted. Detailed information regarding data access procedures and requirements can be found at https://dataverse.ada.edu.au/dataverse.xhtml?alias=hilda.

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Appendix A Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.anzjph.2025.100280.