Preventive Medicine Reports 28 (2022) 101823

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

Morbid obesity, multiple long-term conditions, and health-related quality of life among Australian adults: Estimates from three waves of a longitudinal household survey

Syed Afroz Keramat [a,b,c], Khorshed Alam [b,c], Byron Keating [d], Bright Opoku Ahinkorah [e], Richard Gyan Aboagye [f], Abdul-Aziz Seidu [g], Nandeeta Samad [h], Monidipa Saha [i], Jeff Gow [b,j], Stuart J.H. Biddle [c], Tracy Comans [a]

[a] Centre for Health Services Research, Faculty of Medicine, The University of Queensland, Brisbane, QLD, Australia
[b] School of Business, University of Southern Queensland, Australia
[c] Centre for Health Research, University of Southern Queensland, Australia
[d] Faculty of Business & Law, Queensland University of Technology, Australia
[e] School of Public Health, University of Technology Sydney, Sydney, Australia
[f] School of Public Health, University of Health and Allied Sciences, Ho, Ghana
[g] Department of Population and Health, University of Cape Coast, Cape Coast, Ghana
[h] Department of Public Health, North South University, Dhaka, Bangladesh
[i] Department of Public Health, American International University-Bangladesh (AIUB), Dhaka, Bangladesh
[j] School of Accounting, Economics, and Finance, University of KwaZulu-Natal, South Africa

ARTICLE INFO

Keywords:
Health-related quality of life
MCS
Morbid obesity
Multiple long-term conditions
PCS
SF-36
SF-6D

ABSTRACT

This study aims to investigate the impact of morbid obesity and multiple long-term conditions (MLTCs) on health-related quality of life (HRQoL). Data for this study were sourced from three waves (waves 9, 13 and 17) of the Household, Income and Labour Dynamics in Australia (HILDA) survey. The paper analyses 37,887 person-year observations from 19,387 individuals during the period 2009–2017. The longitudinal random-effects Tobit model was fitted to examine the association between morbid obesity, MLTCs and HRQoL. This study found that morbid obesity and MLTCs were both negatively associated with HRQoL as measured through physical component summary (PCS), mental component summary (MCS), and the short-form six-dimension utility index (SF-6D) of the 36-item Short-Form Health Survey (SF-36). Morbidly obese scored lower points on the PCS ($\beta = -5.05$, 95% CI: −5.73, −4.37), MCS ($\beta = -1.03$, 95% CI: −1.84, −0.23), and in the SF-6D utility index ($\beta = -0.045$, 95% CI: −0.054, −0.036) compared to their healthy weight counterparts. Similar findings were observed for individuals with MLTCs, with lower scores for the PCS ($\beta = -4.79$, 95% CI: −5.20, −4.38), MCS ($\beta = -4.95$, 95% CI: −5.43, −4.48), and SF-6D utility ($\beta = -0.071$, 95% CI: −0.076, −0.066). Additionally, multiplicative interaction between morbid obesity and MLTCs was observed to modestly exacerbated the negative effect of morbid obesity on PCS scores ($\beta = -1.69$, 95% CI: −2.74, −0.64). The interaction effect, on the other hand, significantly lessen the unfavourable effect of morbid obesity on the MCS score ($\beta = 1.34$, 95% CI: 0.10, 2.58). The findings of this study will be useful for future cost-effectiveness analyses and measuring the burden of diseases since it provides information on the disutility associated with morbid obesity and MLTCs.

1. Introduction

Both obesity and multiple long-term conditions (MLTCs) have developed as serious public health problems in Australia. Between 1995 and 2015, Australia's obesity rate climbed from 18.5 to 27.9% (Hayes et al., 2017), accounting for 8.4% of Australia's total disease burden (Australian Institute of Health and Welfare, 2020). Over a quarter of Australian adults (26%) were classified as obese in 2019 (Keramat et al.,

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

https://doi.org/10.1016/j.pmedr.2022.101823
Received 14 November 2021; Received in revised form 31 March 2022; Accepted 9 May 2022
Available online 12 May 2022

2021), and by 2025, the prevalence of adult obesity is expected to reach 35% (Hayes et al., 2017). Defined as the presence of two or more chronic diseases in a single person (National Institute for Health Research, 2021), MLTCs have also emerged as a severe public health concern worldwide (Fortin et al., 2007). In 2017–2018, approximately 20% of Australian adults had MLTCs, accounting for about 66% of the disease burden (including fatal and non-fatal) in Australia (Australian Institute of Health and Welfare, 2020).

Obesity and MLTCs have been adversely affecting health-related quality of life (HRQoL). Quality of life broadly refers to the extent to which an individual can function successfully in daily life and is commonly captured with reference to their perceived physical, emotional, and social well-being (Klassen et al., 2017). HRQoL has emerged as an important public health goal and a valuable complement to traditional measures such as morbidity and mortality as it can guide policy and provide an early warning indicator of a nation's health system (Perales et al., 2014). Obesity is associated with reduced HRQoL and increased comorbidity and mortality (Busutil et al., 2017; Kortt and Dollery, 2011; Schelbert, 2009; Ul-Haq et al., 2012; Zhu et al., 2015), with morbidly obese persons having a threefold risk of experiencing poor HRQoL than normal-weight adults (Serrano-Aguilar et al., 2009). The health burden among individuals with a higher body mass index (BMI) is becoming concerning, especially those with co-occurring chronic conditions (Schienkiewitz et al., 2012; Guh et al., 2009).

The relationship between BMI and HRQoL has been investigated in several population-based studies, confirming a negative association between BMI and perceived quality of life, with a higher risk of poorer HRQoL frequently observed in overweight and obese persons (Busutil et al., 2017; Audureau et al., 2016; Jia and Lubetkin, 2005; Kolotkin et al., 2001; Renzaho et al., 2010; Song et al., 2015). According to the findings of a study conducted in the UK, for instance, an increasing level of BMI is associated with a statistically significant deterioration in the quality of life (Stephenson et al., 2021). There is additional evidence that persons with morbid obesity (i.e., a body mass index of 40 or over) are likely to have the worse health utility scores within a population (Slagter et al., 2015). Other studies have also identified a statistically significant inverse connection between morbid obesity and HRQoL as measured by the SF-12 or the EQ-5D (Busutil et al., 2017; Jia and Lubetkin, 2005; Tamura et al., 2017).

There has also been a persistent negative association between the presence of comorbid chronic disease and quality of life. A number of empirical studies have shown that poor HRQoL is more common among those who have comorbid or multimorbid disorders (Tyack et al., 2018; Zhang et al., 2018; Busetto et al., 2012). It is noteworthy that among individuals who reported poor HRQoL, the greatest burden was found among those with multiple chronic conditions (Lima et al., 2009). Despite these observations, there is a relative dearth of longitudinal research exploring the links between morbid obesity, MLTCs, and HRQoL. The existing research has mostly concentrated on the relationships between obesity and quality of life without accounting for different classes of obesity or considering the individual or combined impact of specific chronic conditions. Earlier investigations have also neglected the adjusted effects of morbid obesity and MLTCs. Additionally, prior research has tended to examine the associations between morbid obesity, MLTCs, and HRQoL in a condition-specific sample rather than a general population.

Considering these limitations, the current body of knowledge could benefit from research to shed light on the relationship between morbid obesity, MLTCs and HRQoL. This article responds by examining the relationships among morbid obesity, MLTCs, and HRQoL in a population-based sample in Australia. These findings have the potential to highlight new and previously unknown aspects of the link between morbid obesity, MLTCs, and health-related quality of life. The findings of this study will also aid future economic evaluations and the burden of diseases by elucidating the utility value associated with morbid obesity and MLTCs. Finally, by clarifying the impact of morbid obesity and MLTCs on HRQoL, it is hoped that the findings of this research will also aid policy-makers to better respond to this pervasive problem.

2. Methodology

2.1. Data source and sample selection

The data for the current study were sourced from the Household, Income and Labour Dynamics in Australia (HILDA) survey, a nationally representative longitudinal study of the Australian population. The survey collects information annually on some key aspects of life, such as wealth, labour market outcomes, household and family relationships, fertility, health and education. The survey was started in 2001, and a multistage sampling approach was used to select an initial sample of households. Individuals aged 15 years or older residing in each household were included in the sample. The survey follows the lives of more than 17,000 Australian adults annually. An in-depth discussion of the survey's objectives, sampling design, and data gathering method may be found elsewhere (Watson, 2021).

This study analysed three waves of data from the HILDA survey: wave 9 (2009), wave 13 (2013), and wave 17 (2017), spanning nine years. The primary reason for picking these three waves is that only these waves contained data on chronic diseases. Missing observations on the outcome (dimensions of HRQoL) and main variables of interest (BMI and MLTCs) were excluded for the subsample analyses. Additionally, this study excluded pregnant women's observations to reduce bias. This study established an unbalanced panel with 37,887 person-year observations from 19,387 unique respondents after adjusting the exclusion criteria. The sample selection technique and analysis of missing observations are detailed in Fig. 1.

2.2. Outcome measures

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

A related instrument that is widely used in economic evaluations as a measure of HRQoL is SF-6D. The SF-6D allows to obtain quality adjusted life years (QALYs) from the SF-36. The value of SF-6D ranges from 0.29 to 1. The value 1 indicates full health, and 0.29 shows the worst health state (equivalent to death).

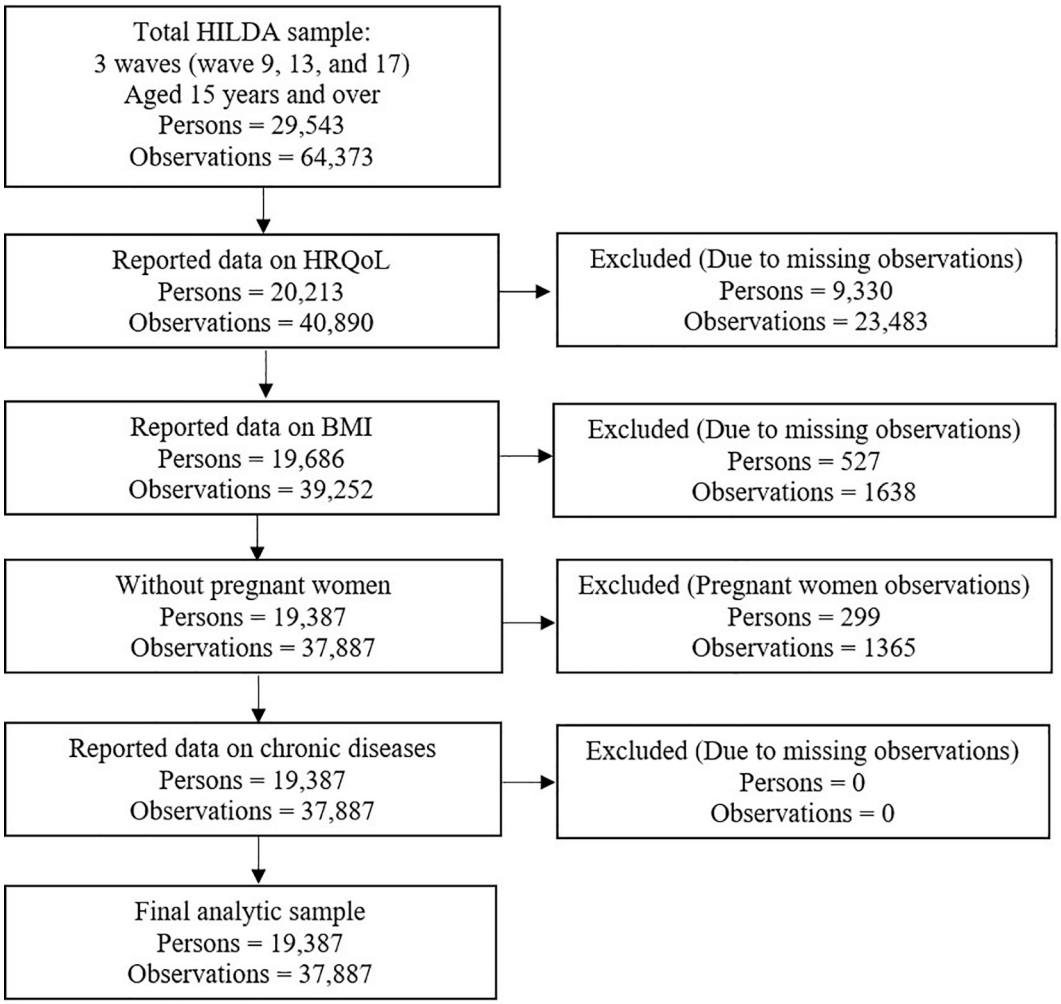

Fig. 1. Participants flow into the analytic sample and missing data.

2.3. Exposure variables

The present analyses considered morbid obesity and MLTCs to be the primary exposure variables. Morbid obesity was measured using BMI, a commonly used metric that captures an adult's nutritional status. It is calculated by dividing a person's weight in kilograms by the square of their height in meters (kg/m^2). For instance, an adult weighing 100 kg and standing 1.55 m tall will have a BMI of 41.62, which is considered morbidly obese by conventional standards. In the HILDA survey, self-reported height and weight were used to compute an individual's BMI. This study classified the BMI score into one of six categories following the recommendations of the World Health Organization (WHO): underweight (BMI = below 18.50), healthy weight (BMI = 18.50 to < 25), overweight (BMI = 25 to < 30), obese class I (BMI = 30 to < 35), obese class II (BMI = 35 to < 40), and obese class III or morbidly obese (BMI = 40 and above) (World Health Organisation, 2022).

This study captured data on eleven self-reported chronic diseases: heart disease, circulatory disease, hypertension, type 1 diabetes, type 2 diabetes, asthma, bronchitis, arthritis, anxiety or depression, other mental health conditions, and cancer. The HILDA survey collects information on these chronic diseases by asking respondents, "have you ever been told by a medical practitioner that you have been diagnosed with a serious illness or medical condition," with responses scored on a binary scale where 0 indicated that the respondent had not received a diagnosis for a particular disease, and 1 indicating that the respondent had. The presence of at least two of the eleven chronic diseases in the same individual was used to indicate that a respondent had MLTCs for the purposes of this study.

2.4. Other covariates

A set of socio-demographic and health behaviour characteristics were included in the study as potential confounders. All the explanatory variables were categorised using dummies. The details regarding the formation of the covariates are outlined in Table 1.

2.5. Statistical analysis

The authors constructed an unbalanced longitudinal data set consisting of 37,887 person-year observations of 19,387 unique participants by linking de-identified individuals' records wherein a respondent may appear up to three times. The current analyses report the descriptive statistics as mean (SD) for continuous variables and percentages for categorical variables. This study fitted the random-effects Tobit regression model to explore the relationship between morbid obesity, MLTCs, and HRQoL. The regression models take the following form:

$$\mathrm{HRQoL}_{it} = \alpha_0 + \beta_1 BMI_{it} + \beta_2 MLTCs_{it} + \mathrm{Y}_i \Sigma X_{it} + \mu_{\mathrm{it}} + \varepsilon_{\mathrm{it}}$$

In Eq. (1), $HRQoL_{it}$ represents the summary measures and health utility index representing respondents' quality of life. $\mathrm{BMI_{it}}$ and $\mathrm{MLTCs_{it}}$ indicate the key variables of interest: morbid obesity and multiple long-term chronic conditions. X refers to the vector of control variables. αi (i = 1 to n) refers to the unknown intercept for each entity (n entity-

Table 1
Description of the covariates.

Variables	Description
Age group	15–29, 30–44, 45–59, and ≥ 60 years.
Sex	Male and female.
Marital status	Single (never married and not living with someone in a relationship, separated but not divorced, divorced, and widowed), and couple (married in a registered marriage, and never married but living with someone in a relationship).
Highest attained education Level	Year 12 and below (year 12, and year 11 and below), certificate courses (advance diploma or diploma, and certificate III or IV), and university degrees (postgraduate - masters or doctorate, graduate diploma or certificate, bachelor or honours).
Annual household income	Lowest quintile (poorest), second quintile (poorer), middle quintile (middle), fourth quintile (richer), and highest quintile (richest).
Labour market status	Employed, unemployed, and not in the labour force.
Aboriginal status	Non-aboriginal, and aboriginal (Aboriginal, Torres Strait Islander, and both Aboriginal and Torres Strait Islander).
Geographic residency	Major city, regional area (inner regional and outer regional), remote area (remote and very remote Australia).
Smoking status	Never smoked, former smoker and current smoker (smoke daily, smoke at least weekly, and smoke less often than weekly).
Alcohol drinking	Never drunk, ex-drinker, current drinker (only rarely, 1–2 days, 2–3 days, 3–4 days, 5–6 days per week and every day).
Physical exercise	Not at all, ≤ 1 to 3 times per week (less than once, 1–2 times, and 3 times a week), and ≥ 4 to 7 times per week (more than 3 times a week, and every day).

specific intercepts). μ it refers to between-entity error and ε_{it} indicates within-entity error. Subscripts i refer to individual and t indicates periods.

This study deployed multivariate regression models, defined by the outcome variables: component summary measures (PCS and MCS) and SF-6D utility score. All models were adjusted for age, sex, marital status, highest attained education level, annual household income, labour market status, Aboriginal status, geographic residency, smoking status, alcohol drinking, and physical exercise.

This study fitted the random-effects Tobit regression model to estimate the effects of morbid obesity and MLTCs on HRQoL. Additionally, this study included a multiplicative interaction term (BMI × MLTCs) into the regression model to see whether the combined effect of morbid obesity and MLTCs has a statistically significant influence on HRQoL. A significant advantage of the random-effects Tobit regression model is that it takes into account both left- and right-censoring of the outcome variable, as well as within-cluster dependence of the outcome variable. A *p*-value of<0.05 was considered statistically significant, and the regression results were reported for three levels: $P < 0.001$, <0.01, and < 0.05. All analyses were performed using Stata version 17.0 (Stata SE 17, College Station, TX: StataCorp LLC, USA).

3. Results

Table 2 summarises the analytic sample's socio-demographic and health behaviour characteristics at the baseline, final wave, and pooled over all waves. The findings indicated that about a quarter of the participants were sixty years or older (25%), more than half were female (52%), and approximately two-thirds were married or living together (59%). Of the total, 25% had university qualifications, 65% were employed, 97% were non-aboriginal, 66% lived in major cities, 18% were current smokers, 82% drank alcohol, and more than one-third (35%) exercised 4 to 7 times each week (pooled in all waves).

Summary statistics of the study participants at the baseline, final, and pooled across all waves are shown in Table 3. The mean score for the eight domains of the SF-36 were 83.78 (SD = 23.05) for PF, 79.09 (SD = 36.02) for RP, 82.98 (SD = 32.98) for RE, 82.79 (SD = 23.31) for SF, 74.20 (SD = 17.27) for MH, 59.80 (SD = 19.97) for VT, 72.94 (SD = 23.74) for BP, and 68.18 (SD = 20.96) for GH. The mean PCS, MCS and SF-6D utility scores were 49.35 ± 10.35, 48.67 ± 10.60, and 0.76 ± 0.12 (mean ± SD), respectively. Around 3% of the study sample were morbidly obese and nearly one-fifth (20%) had multimorbidity (pooled in all waves).

Fig. 2 displays the distribution of SF-36 component summary scores (PCS and MCS) and SF-6D utility values for the study sample. The PCS and MCS scores of a high majority of respondents were found to be between 50 and 60. There are few observations ranging from 20 to 40 scores. The distribution of SF-6D scores is right-skewed, with a mass of

Table 2
Distribution of the analytic sample (socio-demographic and health behaviour characteristics): Baseline, final wave and all waves pooled (persons = 19,387; observations = 37,887).

Characteristics	Baseline wave (2009)		Final wave (2017)		Pooled in all waves (2009, 2013, & 2017)	
	N	%	n	%	n	%
Socio-demographic characteristics						
Age group						
15–29 years	2,578	25.89	3,535	24.78	9,670	25.52
30–44 years	2,426	24.36	3,378	23.68	8,944	23.61
45–59 years	2,715	27.26	3,578	25.08	9,905	26.14
≥ 60 years	2,239	22.48	3,775	26.46	9,368	24.73
Sex						
Male	4,751	47.71	6,789	47.59	18,022	47.57
Female	5,207	52.29	7,477	52.41	19,865	52.43
Marital status						
Single	4,153	41.71	5,742	40.25	15,393	40.63
Couple	5,805	58.29	8,524	59.75	22,494	59.37
Highest attained education level						
Year 12 and below	4,802	48.22	5,583	39.14	16,299	43.02
Certificate courses	2,862	28.74	4,725	33.12	11,840	31.25
University degrees	2,294	23.04	3,958	27.74	9,748	25.73
Annual household income						
Lowest quintile (Poorest)	1,992	20	2,854	20.01	7,579	20
Second quintile	1,993	20.01	2,854	20.01	7,577	20
Middle quintile	1,991	19.99	2,854	20.01	7,578	20
Fourth quintile	1,991	19.99	2,852	19.99	7,579	20
Highest quintile (Richest)	1,991	19.99	2,852	19.99	7,574	19.99
Labor market status						
Employed	6,576	66.04	9,222	64.64	24,513	64.70
Unemployed	336	3.37	521	3.65	1,395	3.68
Not in the labour force	3,046	30.59	4,523	31.70	11,979	31.62
Aboriginal status						
Non-aboriginal	9,729	97.70	13,845	97.05	36,849	97.26
Aboriginal	229	2.30	421	2.95	1,038	2.74
Geographic residency						
Major city	6,474	65.01	9,460	66.31	25,155	66.39
Regional area	3,305	33.19	4,614	32.34	12,178	32.14
Remote area	179	1.80	192	1.35	554	1.46
Health behaviour characteristics						
Smoking status						
Never smoked	5,251	52.73	8,059	56.49	20,789	54.87
Ex-smoker	2,742	27.54	3,873	27.15	10,414	27.49
Current smoker	1,965	19.73	2,334	16.36	6,684	17.64
Alcohol drinking						
Never drunk	1,018	10.22	1,534	10.75	4,057	10.71
Ex-drinker	589	5.91	1,178	8.26	2,755	7.27
Current drinker	8,351	83.86	11,554	80.99	31,075	82.02
Physical exercise						
Not at all	943	9.47	1,718	12.04	4,145	10.94
≤ 1 to 3 times per week	5,461	54.84	7,779	54.53	20,512	54.14
≥ 4 to 7 times per week	3,554	35.69	4,769	33.43	13,230	34.92

Table 3
Distribution of subjective health scores, BMI, and MLTCs: Baseline, final and pooled in all waves (persons = 19,387; observations = 37,887).

Variables	Baseline wave (2009)		Final wave (2017)		Pooled in all waves (2009, 2013, & 2017)	
	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
SF-36 domain scores						
Physical functioning	9,958	84.51 (22.27)	14,266	83.40 (23.52)	37,887	83.78 (23.05)
Role physical	9,958	80.38 (35.14)	14,266	77.95 (36.76)	37,887	79.09 (36.02)
Role emotional	9,958	84.32 (32.02)	14,266	81.44 (34.06)	37,887	82.98 (32.98)
Social functioning	9,958	83.87 (22.66)	14,266	81.58 (23.96)	37,887	82.79 (23.31)
Mental health	9,958	74.94 (16.79)	14,266	73.41 (17.68)	37,887	74.20 (17.27)
Vitality	9,958	60.84 (19.56)	14,266	58.54 (20.33)	37,887	59.80 (19.97)
Bodily pain	9,958	74.06 (23.54)	14,266	72.10 (23.90)	37,887	72.94 (23.74)
General health	9,958	69.59 (20.99)	14,266	66.92 (21.01)	37,887	68.18 (20.96)
SF-36 component summary scores						
PCS	9,958	49.74 (10.17)	14,266	49.13 (10.50)	37,887	49.35 (10.35)
MCS	9,958	49.16 (10.23)	14,266	48.05 (10.89)	37,887	48.67 (10.60)
SF-6D	9,958	0.77 (0.12)	14,266	0.75 (0.12)	37,887	0.76 (0.12)
BMI Category (% observations)						
Underweight	275	2.76	337	2.36	1,004	2.65
Healthy weight	4,077	40.94	5,392	37.8	14,901	39.33
Overweight	3,425	34.39	4,847	33.98	12,892	34.03
Obese class I	1,496	15.02	2,328	16.32	5,960	15.73
Obese class II	474	4.76	869	6.09	2,053	5.42
Obese class III (Morbid obesity)	211	2.12	493	3.46	1,077	2.84
MLTCs (% observations)						
No	8,127	81.61	11,198	78.49	30,314	80.01
Yes	1,831	18.39	3,068	21.51	7,573	19.99

unity, as expected, and there were few observations between 0.4 and 0.6 scores (Fig. 2).

The mean values of the composite measures (PCS and MCS) and the health utility index (SF-6D) by BMI category are depicted in Fig. 3. As can be observed, the mean PCS, MCS, and health utility values decline with higher BMI. For example, morbidly obese people had the lowest scores among all the BMI categories. In wave 17, the mean PCS, MCS, and SF-6D scores of morbidly obese (41.97, 45.39, and 0.68, respectively) were significantly lower than those of healthy weight adults (51.63, 48.03, and 0.77, respectively).

Fig. 4 depicts the PCS, MCS, and SF-6D utility ratings in terms of MLTCs. The image demonstrates that persons with MLTCs had significantly lower PCS, MCS, and SF-6D utility scores in all analysed waves. For example, in wave 17, the mean PCS, MCS, and SF-6D utility scores of adults with MLTCs were considerably lower (40.27, 44.71, and 0.66, respectively) than those without MLTCs (51.55, 48.96, and 0.78, respectively).

Table 4 displays the association between morbid obesity, MLTCs and summary measures of the SF-36 (PCS and MCS) and SF-6D utility score. The estimated coefficients of the morbid obesity and MLTCs concerning the summary measures and health utility index were reported in models 1 to 6. Models 2 and 4 indicate that morbidly obese people scored significantly worse on both PCS and MCS scores than their healthy weight counterparts. Morbidly obese people scored 5 ($\beta = -5.05$) points or units lower on the PCS indicator, and 1 ($\beta = -1.03$) units lower on the MCS indicator, respectively, compared with their healthy weight peers. Models 2 and 4 also report the effects of MLTCs on both PCS and MCS indicators. The result showed that MLTCs had significantly lower PCS and MCS scores. The effect of MLTCs on both PCS ($\beta = -4.79$) and MCS ($\beta = -4.95$) were lower for adults than without MLTCs. Additionally, the present study discovered that a multiplicative interaction between morbid obesity and MLTCs exacerbated the morbid obesity's detrimental effect on PCS score ($\beta = -1.69$). However, the interaction effect has reduced the negative effect of morbid obesity on the MCS score ($\beta = 1.34$).

On the SF-6D scale, morbidly obese scored 4 ($\beta = -0.045$) percentage points lower, compared with healthy weight adults (model 6). Similarly, the results also showed that adults with MLTCs scored lower on the SF-6D scale than those without MLTCs. Adults with MLTCs scored 7 ($\beta = -0.071$) percentage points lower on the SF-6D scale than their counterparts.

4. Discussion

This study assessed the relationships between obesity, multiple long-term chronic illness, and health-related quality of life for a nationally-representative sample of Australian adults. Persons classified as morbidly obese exhibited significantly lower scores for overall quality of life (SF-6D), and both the physical (PCS) and mental (MCS) components of well-being. The present study also found that multiplicative interaction between morbid obesity and MLTCs slightly increased the negative effect of morbid obesity on PCS scores. However, the interaction effect has substantially reduced the negative impact of morbid obesity on MCS score. These findings are consistent with the existing literature, which has reported a strong correlation between severe obesity and reduced HRQoL in Spain (Busutil et al., 2017), the United States (Fontaine and Barofsky, 2001; Andenæs et al., 2012), Brazil (Tamura et al., 2017), and Norway (Duval et al., 2006), particularly in relation to the physical and physiological components of HRQoL (Pimenta et al., 2015; Hopman et al., 2007; Swinburn and Wood, 2013).

However, these findings do contradict those of an earlier Australian study that found no support for a negative association between BMI and quality of life over time using earlier waves of the HILDA dataset (Kortt and Dollery, 2011). One possible explanation for this difference is that the so-called obesity epidemic was a relatively new phenomenon at the time of the earlier paper. The Australian Government only launched a strategic response to obesity in 2007, with advocacy and health promotion efforts not coming into full effect until after the article was published (Wooden et al., 2008). Public discourse on the risks of obesity and awareness of the health-related impacts were thus not well advanced at the time of the earlier study. As the measure of HRQoL used within HILDA (SF-36) requires subjective evaluation, it is possible that the negative impacts were understated. The earlier paper also employed a correction to the BMI calculation that could also have led to differences. The present study did not employ this correction as the findings of a technical paper (Sundh et al., 2015) published by the HILDA Project found that BMI scores compared favourably with the Australian National Health Survey, and if anything, were likely to be overstated not understated it as was the contention of the earlier study. Both explanations suggest that the earlier study's findings should be viewed with caution.

The study results also indicated that HRQoL reduced sharply in the presence of MLTCs for the Australian sample. The negative association

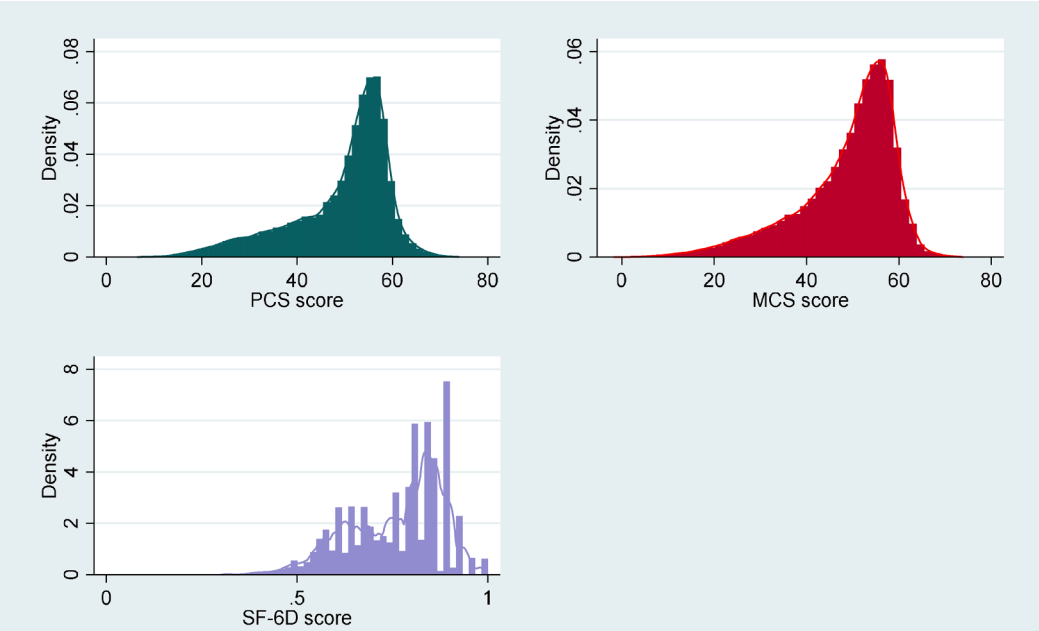

Fig. 2. Distribution of PCS and MCS scores and SF-6D utility values.

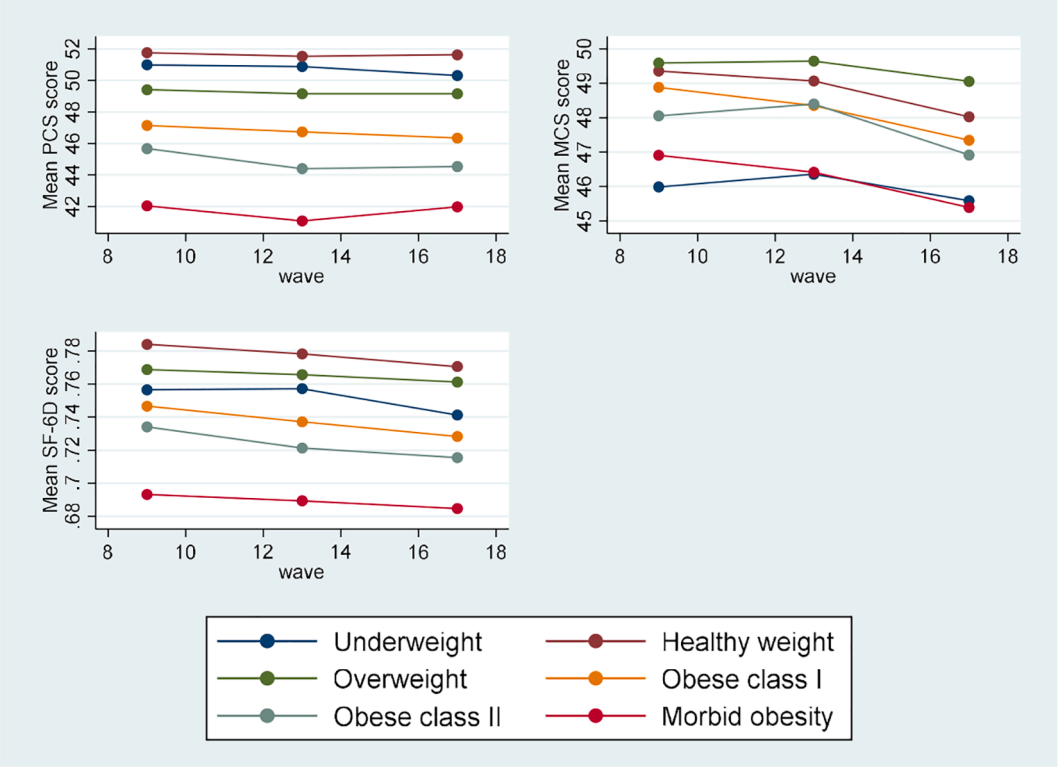

Fig. 3. Mean SF-36 component summary scores and SF-6D utility score by weight category, waves 9, 13, and 17.

between MLTCs and overall HRQoL (SF-6D) is in line with previous studies that reported a significant reduction in HRQoL among persons having multimorbidity in other countries, including Scotland (Ul-Haq et al., 2012), United States (Tyack et al., 2018), Canary Islands (Serrano-Aguilar et al., 2009), Sweden (Hunger et al., 2011), Germany (Wang et al., 2016), and China (Brettschneider et al., 2013).

Although consistent findings were obtained, some prior research measured HRQoL using a different survey instrument than the SF-36 (Wang et al., 2016; Sendi et al., 2005; Mujica-Mota et al., 2015; Adriaanse et al., 2016). As a result, a cautious assessment of the current study's findings compared to the prior literature is required. The present findings demonstrate that the burden imposed by comorbid chronic diseases is independent of the underlying condition, and the link can be attributed to several plausible explanations. The observed decrease in HRQoL could be explained by the synergistic effects of chronic conditions, which occur when one ailment impairs an individual's capacity to adhere to therapy for another (Busetto et al., 2013). Comorbidities can substantially impact individuals' ability to manage their own care and

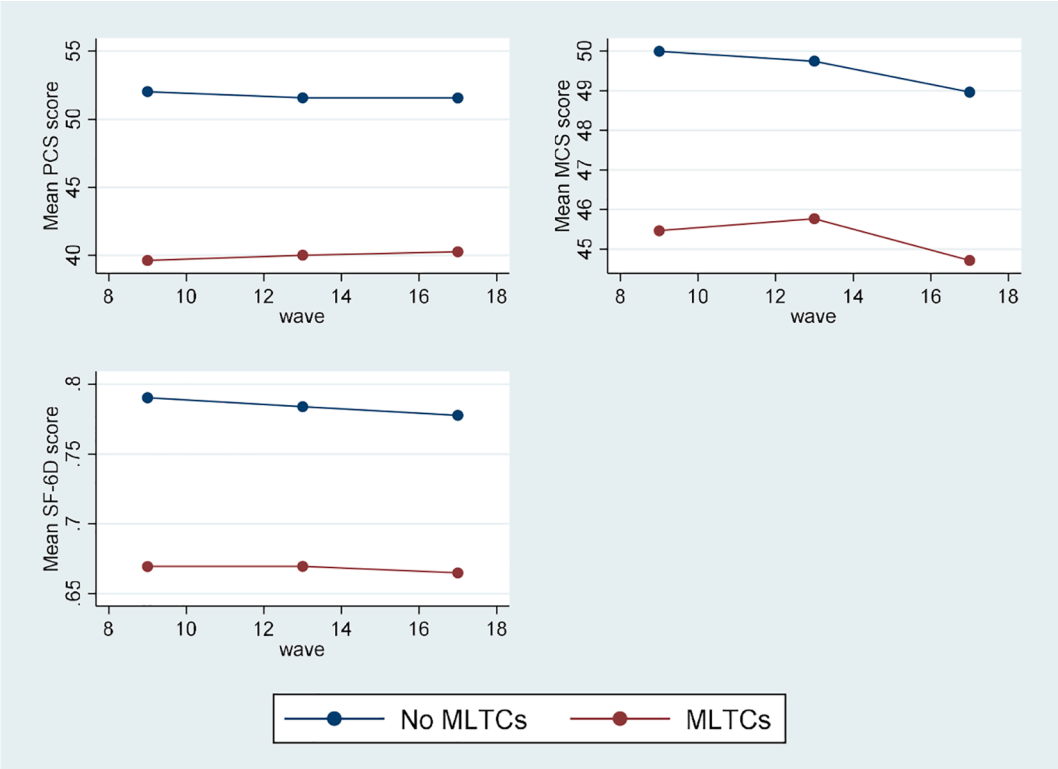

Fig. 4. Mean SF-36 component summary scores and SF-6D utility score by MLTCs, waves 9, 13, and 17.

obstruct lifestyle adjustments and regimen adherence (Banegas et al., 2007). Further, the current study's findings may have been influenced by concurrent mental health conditions, which are particularly prevalent in those with chronic diseases.

The current study has several strengths. First and foremost, it uses three waves of cohort data to determine the between-person differences in the relationships between morbid obesity, MLTCs, and HRQoL using a random-effects technique. Second, to the best of the authors' knowledge, this is the first longitudinal study that examines the associations between morbid obesity, MLTCs, and HRQoL in Australian adults utilising summary measures (PCS and MCS) of the SF-36 and health utility index (SF-6D). Third, the present study is based on a nationally representative survey of Australian adults. Finally, the findings of this study can aid Australian policymakers by highlighting where to focus their attention to improve the HRQoL for the morbidly obese and those afflicted with MLTCs.

Notwithstanding, the current study is not without limitations. Firstly, the unbalanced longitudinal nature of the study prevents the establishment of causal associations. Secondly, the study is limited in generalizability because it was limited to the Australian adult population, which might portray features different from those in other countries and settings. Thirdly, the current study did not examine the cumulative effects of chronic illness. Previous empirical studies found that more chronic conditions in an individual led to a lower HRQoL (Zhang et al., 2018; Lima et al., 2009; Busetto et al., 2013; Banegas et al., 2007), and a statistically significant negative correlation with PCS and MCS scores (Sundh et al., 2015; Marrie et al., 2012). Beyond the number of chronic conditions, there is also a possibility that the severity of a given condition could also have influenced the findings. Unfortunately, the HILDA dataset provides no information on the severity of chronic conditions.

5. Conclusion

This study aimed to provide a better understanding of the relationship between morbid obesity, MLTCs and HRQoL through a longitudinal regression analysis using three annual waves of the HILDA survey. This study provides first-hand evidence on the impact of morbid obesity and MLTCs on the HRQoL. The results demonstrate that morbid obesity and MLTCs are associated with poorer HRQoL. More specifically, morbid obesity and MLTCs are associated with a reduction in scores for summary measures (PCS and MCS), and health utility index (SF-6D) of the SF-36. The study's findings will be beneficial for future cost-effectiveness evaluations and quantifying disease burden, as they provide information (utility values) for morbid obesity and MLTCs. The findings also have implications for boosting public health initiatives. Preventive measures are needed to reduce the burden of obesity and MLTCs. More comprehensive and holistic care should be given to morbidly obese and individuals with MLTCs to improve their HRQoL.

6. Ethics approval

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

7. 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

Table 4
The relationship between morbid obesity and MLTCs with the SF-36 component summary scores and SF-6D utility score, random-effects Tobit model.

Variables	Model 1: PCS β (95% CI), P-value	Model 2: PCS (Interaction) β (95% CI), P-value	Model 3: MCS β (95% CI), P-value	Model 4: MCS (Interaction) β (95% CI), P-value	Model 5: SF-6D β (95% CI), P-value	Model 6: SF-6D (Interaction) β (95% CI), P-value
BMI Category						
Underweight	**−0.53 (−1.06, −0.01), 0.05**	**−0.56 (−1.12, −0.01), 0.05**	−0.60 (−1.22, 0.02), 0.06	−0.29 (−0.95, 0.37), 0.39	−0.005 (−0.012, 0.002), 0.13	−0.003 (−0.010, 0.005), 0.51
Healthy weight (ref)						
Overweight	**−0.72 (−0.93, −0.52), <0.001**	**−0.73 (−0.95, −0.51), <0.001**	0.08 (−0.16, 0.33), 0.50	−0.06 (−0.32, 0.20), 0.66	**−0.005 (−0.008, −0.002), <0.001**	**−0.006 (−0.009, −0.003), <0.001**
Obese class I	**−1.84 (−2.11, −1.57), <0.001**	**−1.68 (−1.98, −1.37), <0.001**	**−0.33 (−0.65, −0.01), 0.04**	**−0.58 (−0.94, −0.22), 0.01**	**−0.016 (−0.019, −0.012), <0.001**	**−0.017 (−0.021, −0.013), <0.001**
Obese class II	**−3.59 (−3.99, −3.19), <0.001**	**−3.30 (−3.77, −2.83), <0.001**	−0.14 (−0.61, 0.34), 0.58	−0.29 (−0.85, 0.27), 0.30	**−0.025 (−0.03, −0.02), <0.001**	**−0.026 (−0.032, −0.019), <0.001**
Obese class III (Morbid obesity)	**−5.65 (−6.20, −5.10), <0.001**	**−5.05 (−5.73, −4.37), <0.001**	**−0.67 (−1.32, −0.01), 0.05**	**−1.03 (−1.84, −0.23), 0.01**	**−0.043 (−0.05, −0.035), <0.001**	**−0.045 (−0.054, −0.036), <0.001**
MLTCs						
No (ref)						
Yes	**−5.11 (−5.35, −4.87), <0.001**	**−4.79 (−5.20, −4.38), <0.001**	**−4.95 (−4.56, −4.00), <0.001**	**−4.28 (−5.43, −4.48), <0.001**	**−0.067 (−0.07, −0.064), <0.001**	**−0.071 (−0.076, −0.066), <0.001**
Interaction term: (BMI × MLTCs)						
Underweight × MLTCs		0.24 (−1.25, 1.72), 0.76		**−2.26 (−4.01, −0.52), 0.01**		**−0.021 (−0.04, −0.001), 0.04**
Healthy weight × No MLTCs (ref)						
Overweight × MLTCs		−0.04 (−0.56, 0.47), 0.87		**0.93 (0.32, 1.53), 0.01**		**0.007 (0.001, 0.013), 0.05**
Obese class I × MLTCs		**−0.70 (−1.29, −0.11), 0.02**		**1.22 (0.52, 1.91), 0.01**		0.005 (−0.003, 0.013), 0.20
Obese class II × MLTCs		**−1.02 (−1.83, −0.20), 0.02**		0.87 (−0.09, 1.83), 0.08		0.004 (−0.006, 0.015), 0.42
Morbid obesity × MLTCs		**−1.69 (−2.74, −0.64), 0.01**		**1.34 (0.10, 2.58), 0.03**		0.009 (−0.005, 0.022), 0.23
Age						
15–29 years (ref)						
30–44 years	**−1.36 (−1.63, −1.10), <0.001**	**−1.38 (−1.64, −1.11), <0.001**	**0.42 (0.11, 0.73), 0.01**	**0.45 (0.14, 0.76), 0.01**	**−0.007 (−0.01, −0.003), <0.001**	**−0.006 (−0.01, −0.003), <0.001**
45–59 years	**−4.02 (−4.29, −3.74), <0.001**	**−4.02 (−4.30, −3.75), <0.001**	**2.09 (1.76, 2.42), <0.001**	**2.11 (1.78, 2.44), <0.001**	**−0.017 (−0.021, −0.013), <0.001**	**−0.017 (−0.021, −0.013), <0.001**
≥ 60 years	**−6.86 (−7.18, −6.54), <0.001**	**−6.88 (−7.20, −6.57), <0.001**	**5.99 (5.61, 6.37), <0.001**	**6.02 (5.64, 6.40), <0.001**	**−0.008 (−0.012, −0.004), <0.001**	**−0.008 (−0.012, −0.004), <0.001, <0.001**
Sex						
Male (ref)						
Female	0.04 (−0.17, 0.25), 0.74	0.04 (−0.17, 0.25), 0.73	**−1.18 (−1.43, −0.93), <0.001**	**−1.18 (−1.43, −0.93), <0.001**	**−0.013 (−0.016, −0.011), <0.001**	**−0.013 (−0.016, −0.011), <0.001**
Marital status						
Single						
Couple	−0.10 (−0.30, 0.10), 0.35	−0.10 (−0.30, 0.10), 0.34	**1.35 (1.11, 1.59), <0.001**	**1.35 (1.11, 1.59), <0.001**	**0.012 (0.009, 0.014), <0.001**	**0.012 (0.009, 0.014), <0.001**
Highest attained education level						
Year 12 and below (ref)						
Certificate courses	−0.16 (−0.39, 0.08), 0.19	−0.16 (−0.40, 0.07), 0.18	−0.18 (−0.47, 0.10), 0.21	−0.18 (−0.46, 0.11), 0.22	**−0.004 (−0.007, −0.001), 0.01**	**−0.004 (−0.007, −0.001), 0.01**
University degrees	**0.66 (0.39, 0.92), <0.001**	**0.66 (0.40, 0.93), <0.001**	**−0.48 (−0.80, −0.17), 0.01**	**−0.48 (−0.80, −0.17), 0.01**	0.001 (−0.004, 0.003), 0.85	0.001 (−0.004, 0.003), 0.86
Annual household income						
Lowest quintile (poorest)	**−1.66 (−1.96, −1.37), <0.001**	**−1.67 (−1.96, −1.37), <0.001**	**−1.16 (−1.51, −0.82), <0.001**	**−1.17 (−1.51, −0.82), <0.001**	**−0.022 (−0.026, −0.018), <0.001**	**−0.022 (−0.026, −0.018), <0.001**
Second quintile (poorer)	**−0.50 (−0.77, −0.23), <0.001**	**−0.50 (−0.77, −0.23), <0.001**	**−0.72 (−1.04, −0.40), <0.001**	**−0.72 (−1.04, −0.40), <0.001**	**−0.009 (−0.013, −0.006), <0.001**	**−0.01 (−0.013, −0.006), <0.001**
Middle quintile (middle)	**−0.51 (−0.77, −0.25), <0.001**	**−0.51 (−0.77, −0.26), <0.001**	−0.25 (−0.55, 0.05), 0.11	−0.25 (−0.55, 0.05), 0.11	**−0.006 (−0.009, −0.002), 0.01**	**−0.006 (−0.009, −0.003), 0.01**
Fourth quintile (richer)	**−0.50 (−0.75, −0.26), <0.001**	**−0.51 (−0.75, −0.26), <0.001**	0.05 (−0.24, 0.34), 0.72	0.05 (−0.24, 0.34), 0.73	**−0.003 (−0.007, −0.001), 0.05**	**−0.003 (−0.007, −0.001), 0.04**

(*continued on next page*)

Table 4 (*continued*)

Variables	Model 1: PCS β (95% CI), P-value	Model 2: PCS (Interaction) β (95% CI), P-value	Model 3: MCS β (95% CI), P-value	Model 4: MCS (Interaction) β (95% CI), P-value	Model 5: SF-6D β (95% CI), P-value	Model 6: SF-6D (Interaction) β (95% CI), P-value
Highest quintile (richest) (ref)						
Labor market status						
Employed (ref)						
Unemployed	0.29 (−0.13, 0.72), 0.18	0.28 (−0.14, 0.71), 0.19	**−1.72 (−2.22, −1.21), <0.001**	**−1.70 (−2.21, −1.20), <0.001**	**−0.016 (−0.022, −0.011), <0.001**	**−0.016 (−0.022, −0.011), <0.001**
Not in the labour force	**−2.34 (−2.57, −2.11), <0.001**	**−2.34 (−2.57, −2.11), <0.001**	**−1.23 (−1.50, −0.96), <0.001**	**−1.24 (−1.51, −0.97), <0.001**	**−0.027 (−0.030, −0.024), <0.001**	**−0.027 (−0.03, −0.024), <0.001**
Aboriginal status						
Non−aboriginal (ref)						
Aboriginal	−0.05 (−0.66, 0.56), 0.88	−0.04 (−0.65, 0.57), 0.90	−0.13 (−0.86, 0.61), 0.74	−0.12 (−0.85, 0.61), 0.75	−0.003 (−0.011, 0.005), 0.52	−0.003 (−0.011, 0.005), 0.52
Geographic residency						
Major city (ref)						
Regional area	**−0.36 (−0.57, −0.15), 0.01**	**−0.35 (−0.56, −0.14), 0.01**	**0.55 (0.29, 0.80), <0.001**	**0.55 (0.30, 0.80), <0.001**	0.002 (−0.001, 0.005), 0.19	0.002 (−0.001, 0.005), 0.18
Remote area	−0.50 (−1.25, 0.26), 0.20	−0.50 (−1.25, 0.26), 0.20	**1.53 (0.63, 2.43), 0.01**	**1.55 (0.65, 2.45), 0.01**	**0.011 (0.001, 0.021), 0.03**	**0.011 (0.001, 0.021), 0.03**
Smoking status						
Never smoked (ref)						
Former smoker	**−0.72 (−0.95, −0.48), <0.001**	**−0.72 (−0.95, −0.48), <0.001**	**−0.54 (−0.82, −0.26), <0.001**	**−0.54 (−0.82, −0.25), <0.001**	**−0.01 (−0.013, −0.007), <0.001**	**−0.01 (−0.013, −0.007), <0.001**
Current smoker	**−1.27 (−1.53, −0.99), <0.001**	**−1.28 (−1.54, −1.01), <0.001**	**−2.18 (−2.50, −1.87), <0.001**	**−2.16 (−2.47, −1.84), <0.001**	**−0.028 (−0.031, −0.024), <0.001**	**−0.027 (−0.031, −0.024), <0.001**
Alcohol drinking						
Never drunk (ref)						
Ex-drinker	−0.25 (−0.67, 0.16), 0.23	−0.26 (−0.68, 0.15), 0.21	**−2.44 (−2.93, −1.95), <0.001**	**−2.42 (−2.91, −1.93), <0.001**	**−0.017 (−0.023, −0.012), <0.001**	**−0.017 (−0.023, −0.012), <0.001**
Current drinker	**1.11 (0.81, 1.42), <0.001**	**1.11 (0.80, 1.41), <0.001**	**−0.85 (−1.21, −0.49), <0.001**	**−0.83 (−1.2, −0.47), <0.001**	0.003 (−0.001, 0.007), 0.17	0.003 (−0.001, 0.007), 0.16
Physical exercise						
Not at all (ref)						
≤ 1 to 3 times per week	**4.20 (3.93, 4.47), <0.001**	**4.19 (3.92, 4.46), <0.001**	**2.59 (2.28, 2.91), <0.001**	**2.59 (2.27, 2.91), <0.001**	**0.046 (0.042, 0.049), <0.001**	**0.046 (0.042, 0.049), <0.001**
≥ 4 to 7 times per week	**5.45 (5.16, 5.74), <0.001**	**5.44 (5.15, 5.74), <0.001**	**4.59 (4.25, 4.93), <0.001**	**4.58 (4.24, 4.92), <0.001**	**0.073 (0.069, 0.077), <0.001**	**0.073 (0.069, 0.077), <0.001**

Abbreviations: ref, reference category; PCS, Physical Component Summary; MCS, Mental Component Summary; SF-6D, Short-Form Six-Dimension health index. Values in bold are statistically significant.

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.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Authors contributions

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

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Adriaanse, M.C., Drewes, H.W., van der Heide, I., Struijs, J.N., Baan, C.A., 2016. The impact of comorbid chronic conditions on quality of life in type 2 diabetes patients. Qual. Life Res. 25 (1), 175–182. https://doi.org/10.1007/s11136-015-1061-0.

Andenæs, R., Fagermoen, M.S., Eide, H., Lerdal, A., 2012. Changes in health-related quality of life in people with morbid obesity attending a learning and mastery course. A longitudinal study with 12-months follow-up. Health Qual. Life Outcomes 10 (1), 1–7. https://doi.org/10.1186/1477-7525-10-95.

Audureau, E., Pouchot, J., Coste, J., 2016. Gender-related differential effects of obesity on health-related quality of life via obesity-related comorbidities. Circul. Cardiovasc. Quality Outcomes 9 (3), 246–256. https://doi.org/10.1161/CIRCOUTCOMES.115.002127.

Australian Bureau of Statistics. (1997). *1995 National health survey—SF-36 population norms, Australia.* ABS Catalogue No. 4399.0. Canberra: ABS.

Australian Institute of Health and Welfare. (2020). Chronic conditions and multimorbidity. Retrieved April 18, 2021, from https://www.aihw.gov.au/reports/australias-health/chronic-conditions-and-multimorbidity.

Australian Institute of Health and Welfare. (2020). Burden of disease. Retrieved April 19, 2021, from https://www.aihw.gov.au/reports/australias-health/burden-of-disease.

Banegas, J.R., López-García, E., Graciani, A., Guallar-Castillón, P., Gutierrez-Fisac, J.L., Alonso, J., Rodríguez-Artalejo, F., 2007. Relationship between obesity, hypertension and diabetes, and health-related quality of life among the elderly. Eur. J. Cardiovasc. Prevent. Rehabil. 14 (3), 456–462. https://doi.org/10.1097/HJR.0b013e3280803f29.

Brettschneider, C., Leicht, H., Bickel, H., Dahlhaus, A., Fuchs, A., Gensichen, J., … König, H.-H. (2013). Relative Impact of Multimorbid Chronic Conditions on Health-Related

Quality of Life – Results from the MultiCare Cohort Study. *PLoS ONE*, *8*(6), e66742. 10.1371/journal.pone.0066742.
Busetto, L., Pilone, V., Schettino, A.M., Furbetta, N., Zappa, M., Di Maro, A., Italian Group for Lap-Band, 2012. Determinants of health-related quality of life in morbid obese candidates to gastric banding. Eat. Weight Disord. EWD 17 (2), e93–e100. https://doi.org/10.3275/8244.
Busetto, L., Pilone, V., Schettino, A.M., Furbetta, N., Zappa, M., Di Maro, A., Mozzi, E., 2013. Determinants of health-related quality of life in morbid obese candidates to gastric banding. Eat. Weight Disord. Stud. Anorexia Bulimia Obes. 17 (2), e93–e100. https://doi.org/10.3275/8244.
Busutil, R., Espallardo, O., Torres, A., Martínez-Galdeano, L., Zozaya, N., Hidalgo-Vega, Á., 2017. The impact of obesity on health-related quality of life in Spain. Health Qual. Life Outcomes 15 (1), 197. https://doi.org/10.1186/s12955-017-0773-y.
Duval, K., Marceau, P., Lescelleur, O., Hould, F.-S., Marceau, S., Biron, S., Lebel, S., Pérusse, L., Lacasse, Y., 2006. Health-related quality of life in morbid obesity. Obes. Surg. 16 (5), 574–579.
Fontaine, K.R., Barofsky, I., 2001. Obesity and health-related quality of life. Obes. Rev. 2 (3), 173–182. https://doi.org/10.1046/J.1467-789X.2001.00032.X.
Fortin, M., Soubhi, H., Hudon, C., Bayliss, E.A., van den Akker, M., 2007. Multimorbidity's many challenges. BMJ 334 (7602), 1016–1017. https://doi.org/10.1136/bmj.39201.463819.2C.
Guh, D.P., Zhang, W., Bansback, N., Amarsi, Z., Birmingham, C.L., Anis, A.H., 2009. The incidence of co-morbidities related to obesity and overweight: a systematic review and meta-analysis. BMC Public Health 9, 1–20. https://doi.org/10.1186/1471-2458-9-88.
Hayes, A.J., Lung, T.W.C., Bauman, A., Howard, K., 2017. Modelling obesity trends in Australia: Unravelling the past and predicting the future. Int. J. Obes. 41 (1), 178–185. https://doi.org/10.1038/ijo.2016.165.
Hopman, W.M., Berger, C., Joseph, L., Barr, S.I., Gao, Y., Prior, J.C., Poliquin, S., Towheed, T., Anastassiades, T., 2007. The association between body mass index and health-related quality of life: data from CaMos, a stratified population study. Qual. Life Res. 16 (10), 1595–1603.
Hunger, M., Thorand, B., Schunk, M., Döring, A., Menn, P., Peters, A., Holle, R., 2011. Multimorbidity and health-related quality of life in the older population: results from the German KORA-Age study. Health Qual. Life Outcomes 9 (1), 53. https://doi.org/10.1186/1477-7525-9-53.
Jia, H., Lubetkin, E.I., 2005. The impact of obesity on health-related quality-of-life in the general adult US population. J. Public Health 27 (2), 156–164. https://doi.org/10.1093/pubmed/fdi025.
Keramat, S.A., Alam, K., Al-Hanawi, M.K., Gow, J., Biddle, S.J.H., Hashmi, R., 2021. Trends in the prevalence of adult overweight and obesity in Australia, and its association with geographic remoteness. Sci. Rep. 11 (1), 11320. https://doi.org/10.1038/s41598-021-90750-1.
Klassen, A., Wickert, N., Tsangaris, E., Klaassen, R., & Anthony, S. (2017). Health-Related Quality of Life. In *Pediatric Oncology* (pp. 735–747). 10.1007/978-3-319-33679-4_30.
Kolotkin, R.L., Crosby, R.D., Williams, G.R., Hartley, G.G., Nicol, S., 2001. The relationship between health-related quality of life and weight loss. Obes. Res. 9 (9), 564–571. https://doi.org/10.1038/oby.2001.73.
Kortt, M.A., Dollery, B., 2011. Association between body mass index and health-related quality of life among an australian sample. Clin. Ther. 33 (10), 1466–1474. https://doi.org/10.1016/j.clinthera.2011.08.009.
Lima, M.G., De Azevedo Barros, M.B., César, C.L.G., Goldbaum, M., Carandina, L., Ciconelli, R.M., 2009. Impact of chronic disease on quality of life among the elderly in the state of Sao Paulo, Brazil: a population-based study. Rev. Panam. Salud Publica/Pan Am. J. Public Health 25 (4), 314–321. https://doi.org/10.1590/S1020-49892009000400005.
Marrie, R.A., Horwitz, R., Cutter, G., Tyry, T., 2012. Cumulative impact of comorbidity on quality of life in MS. Acta Neurol. Scand. 125 (3), 180–186. https://doi.org/10.1111/j.1600-0404.2011.01526.x.
Mujica-Mota, R.E., Roberts, M., Abel, G., Elliott, M., Lyratzopoulos, G., Roland, M., Campbell, J., 2015. Common patterns of morbidity and multi-morbidity and their impact on health-related quality of life: evidence from a national survey. Qual. Life Res. 24 (4), 909–918. https://doi.org/10.1007/s11136-014-0820-7.
National Institute for Health Research. (2021). Multiple long-term conditions (multimorbidity): making sense of the evidence. Retrieved January 10, 2022, from https://evidence.nihr.ac.uk/collection/making-sense-of-the-evidence-multiple-long-term-conditions-multimorbidity/.
Perales, F., del Pozo-Cruz, J., del Pozo-Cruz, J., del Pozo-Cruz, B., 2014. On the associations between physical activity and quality of life: findings from an Australian nationally representative panel survey. Qual. Life Res. 23 (7), 1921–1933. https://doi.org/10.1007/s11136-014-0645-4.
Pimenta, F.B.C., Bertrand, E., Mograbi, D.C., Shinohara, H., Landeira-Fernandez, J., 2015. The relationship between obesity and quality of life in Brazilian adults. Front. Psychol. 6, 1–7. https://doi.org/10.3389/fpsyg.2015.00966.
Renzaho, A., Wooden, M., Houng, B., 2010. Associations between body mass index and health-related quality of life among Australian adults. Qual. Life Res. 19 (4), 515–520. https://doi.org/10.1007/s11136-010-9610-z.
Schelbert, K.B., 2009. Comorbidities of obesity. Primary Care Clin. Office Pract. 36 (2), 271–285. https://doi.org/10.1016/j.pop.2009.01.009.
Schienkiewitz, A., Mensink, G.B.M., Scheidt-Nave, C., 2012. Comorbidity of overweight and obesity in a nationally representative sample of German adults aged 18–79 years. BMC Public Health 12 (1). https://doi.org/10.1186/1471-2458-12-658.
Sendi, P., Brunotte, R., Potoczna, N., Branson, R., Horber, F.F., 2005. Health-related quality of life in patients with class II and class III obesity. Obes. Surg. 15 (7), 1070–1076. https://doi.org/10.1381/0960892054621323.
Serrano-Aguilar, P., Muñoz-Navarro, S. R., Ramallo-Fariña, Y., & Trujillo-Martín, M. M. (2009). Obesity and health related quality of life in the general adult population of the Canary Islands. *Quality of Life Research*, *18*(2), 171–177. 10.1007/s11136-008-9427-1.
Slagter, S.N., Van Vliet-Ostaptchouk, J.V., Van Beek, A.P., Keers, J.C., Lutgers, H.L., Van Der Klauw, M.M., Wolffenbuttel, B.H.R., 2015. Health-Related quality of life in relation to obesity grade, type 2 diabetes, metabolic syndrome and inflammation. PLoS ONE 10 (10), 1–17. https://doi.org/10.1371/journal.pone.0140599.
Song, H.J., Lee, E.K., Kwon, J.W., 2015. Gender differences in the impact of obesity on health-related quality of life. Asia Pac. J. Public Health 28 (2), 146–156. https://doi.org/10.1177/1010539515626267.
Stephenson, J., Smith, C.M., Kearns, B., Haywood, A., Bissell, P., 2021. The association between obesity and quality of life: a retrospective analysis of a large-scale population-based cohort study. BMC Public Health 21 (1), 1–9. https://doi.org/10.1186/s12889-021-12009-8.
Sundh, J., Johansson, G., Larsson, K., Lindén, A., Löfdahl, C.-G., Janson, C., Sandström, T., 2015. Comorbidity and health-related quality of life in patients with severe chronic obstructive pulmonary disease attending Swedish secondary care units. Int. J. Chronic Obstruct. Pulm. Dis. 10, 173–183. https://doi.org/10.2147/COPD.S74645.
Swinburn, B., Wood, A., 2013. Progress on obesity prevention over 20 years in Australia and New Zealand. Obes. Rev. 14, 60–68. https://doi.org/10.1111/obr.12103.
Tamura, L.S., Cazzo, E., Chaim, E.A., Piedade, S.R., 2017. Influence of morbid obesity on physical capacity, knee-related symptoms and overall quality of life: a cross-sectional study. Rev. Assoc. Méd. Brasil. 63 (2), 142–147. https://doi.org/10.1590/1806-9282.63.02.142.
Tyack, Z., Kuys, S., Cornwell, P., Frakes, K.-A., McPhail, S., 2018. Health-related quality of life of people with multimorbidity at a community-based, interprofessional student-assisted clinic: implications for assessment and intervention. Chronic Illness 14 (3), 169–181. https://doi.org/10.1177/1742395317724849.
Ul-Haq, Z., Mackay, D.F., Fenwick, E., Pell, J.P., 2012. Impact of metabolic comorbidity on the association between body mass index and health-related quality of life: a scotland-wide cross-sectional study of 5,608 participants. BMC Public Health 12 (1), 143. https://doi.org/10.1186/1471-2458-12-143.
Wang, J.W., Sun, L., Ding, N., Li, J., Gong, X.H., Chen, X.F., Yu, J.M., 2016. The association between comorbidities and the quality of life among colorectal cancer survivors in the People's Republic of China. Patient Preference Adherence 10, 1071. https://doi.org/10.2147/PPA.S100873.
Watson, N., 2021. Finding your way around the HILDA survey data. Aust. Econ. Rev. 54 (4), 554–564. https://doi.org/10.1111/1467-8462.12437.
Wooden, M. Watson, N. Agius, P. and Freidin, S. (2008). *Assessing the Quality of the Height and Weight Data in the HILDA Survey*. HILDA project technical paper series No. 1/08. The university of Melourne: Melourne.
World Health Organisation. (2022). Body mass index - BMI. Retrieved February 9, 2022, from https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi.
Zhang, L., Lix, L.M., Ayilara, O., Sawatzky, R., Bohm, E.R., 2018. The effect of multimorbidity on changes in health-related quality of life following hip and knee arthroplasty. The Bone & Joint Journal 100-B (9), 1168–1174. https://doi.org/10.1302/0301-620X.100B9.BJJ-2017-1372.R1.
Zhu, Y., Wang, Q., Pang, G., Lin, L., Origasa, H., Wang, Y., … Shi, H. (2015). Association between Body Mass Index and Health-Related Quality of Life: The "Obesity Paradox" in 21,218 Adults of the Chinese General Population. *PLOS ONE*, *10*(6), e0130613. 10.1371/journal.pone.0130613.