




BMJ Open Epidemiology of physical-mental multimorbidity and its impact among Aboriginal and Torres Strait Islander in Australia: a cross-sectional analysis of a nationally representative sample

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ABSTRACT

Objectives This study aimed to examine the differences in multimorbidity between Aboriginal and Torres Strait Islander people and non-Indigenous Australians, and the effect of multimorbidity on health service use and work productivity.

Setting Cross-sectional sample of the Household, Income and Labour Dynamics in Australia wave 17.

Participants A nationally representative sample of 16 749 respondents aged 18 years and above.

Outcome measures Multimorbidity prevalence and pattern, self-reported health, health service use and employment productivity by Indigenous status.

Results Aboriginal respondents reported a higher prevalence of multimorbidity (24.2%) compared with non-Indigenous Australians (20.7%), and the prevalence of mental-physical multimorbidity was almost twice as high (16.1% vs 8.1%). Multimorbidity pattern varies significantly among the Aboriginal and non-Indigenous Australians. Multimorbidity was associated with higher health service use (any overnight admission: adjusted OR=1.52, 95% CI=1.46 to 1.58), reduced employment productivity (days of sick leave: coefficient=0.25, 95% CI=0.19 to 0.31) and lower perceived health status (SF6D score: coefficient=-0.04, 95% CI=-0.05 to -0.04). These associations were found to be comparable in both Aboriginal and non-Indigenous populations.

Conclusions Multimorbidity prevalence was significantly greater among Aboriginal and Torres Strait Islanders compared with the non-Indigenous population, especially mental-physical multimorbidity. Strategies are required for better prevention and management of multimorbidity for the aboriginal population to reduce health inequalities in Australia.

INTRODUCTION

Non-communicable diseases (NCDs) are major contributors to health burden and health inequalities. As NCD prevalence has increased, so too has multimorbidity, the presence of two or more chronic health

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This study analysed a large nationally representative survey of Australian individuals and households. The survey covers all Australian states and territories and includes detailed information on respondents' health and socioeconomic situation.
- ⇒ The study assessed the effect of multimorbidity on not only health service utilisation, but also on labour participation outcomes and self-reported health status by socioeconomic and Indigenous status.
- ⇒ A small sample of Aboriginal Australians, which may be insufficient to justify their representativeness and evaluate the study's findings.
- ⇒ Association between multimorbidity and health service use, work productivity loss and reported health might be overestimated because these may not be attributable to chronic health conditions.

conditions within an individual.¹ Evidence shows that multimorbidity is associated with poor health and disability,^{2,3} increased health service use,^{1,4} polypharmacy⁵ and poorer work-related productivity.^{4,6} Multimorbidity contributes to health and financial inequality,¹ with the impact greatest among those of lower socioeconomic position.²

Australia faces a significant burden from NCDs and multimorbidity, with NCDs being responsible for 90% of all deaths and significant disability,⁷ while multimorbidity now affects almost one-third of all Australians and 80% of those aged over 65 years.⁸ Previous studies found that the burden of NCDs in Australia is not uniform, with Aboriginal and Torres Strait Islander peoples bearing a disproportionate burden.^{8,9} While our understanding of the impact of social determinants on the health and well-being of an individual has continued to grow, Aboriginal people

KEY POINTS

- ⇒ Aboriginal and Torres Strait Islander people experience a greater burden of multimorbidity of chronic disease compared with non-Indigenous Australians, of which chronic mental health conditions are a significant component.
- ⇒ The associations between multimorbidity and health service use, self-reported health, and employment-related productivity are similar for both Aboriginal and Torres Strait Islander people, and non-Indigenous Australians.
- ⇒ Efforts to adequately address chronic health multimorbidity must account for the existing disparity between Aboriginal and non-Indigenous multimorbidity, in order to prevent worsening of current health inequities.
- ⇒ Building stronger relationships between primary care networks and Aboriginal and Torres Strait Islander people, expanding and endorsing safe cultural practices, and increasing health workforce participation by Indigenous Australians are feasible steps to address this.

have historically endured, and continue to endure, significant challenges to their health and well-being which impacted individuals across all age groups.^{10 11} The health and well-being of Aboriginal people has been significantly disrupted since the commencement of colonisation. It is known that colonisation and its ongoing impacts, such as intergenerational trauma, the disruption of family and cultural networks,^{12 13} systemic racism and discrimination, have all contributed to poorer outcomes and reduced access to opportunities more readily available to non-Indigenous Australians.^{14 15} The over-representation of NCDs among Aboriginal peoples contributes significantly to a pronounced gap in health outcomes between Aboriginal and non-Indigenous Australians.^{16 17}

Few studies have examined the prevalence of multimorbidity among Aboriginal people,^{9 18 19} and those who have used population samples from single states or territories. However, these studies tend to focus on specific geographical location such as New South Wales. Moreover, evidence on disparities in mental and physical multimorbidity among Aboriginal and Torres Strait Islander people is lacking.^{20 21} To address this important evidence gap, this study aims to use nationally representative data to examine the nature and prevalence of multimorbidity among Aboriginal and non-Indigenous Australians, and its impact on health, health service use and work productivity.

METHODS

Sample

We conducted a cross-sectional analysis of the Household, Income and Labour Dynamics in Australia (HILDA) Survey from 2018 (wave 17).²² The HILDA Survey is an annual, nationally representative household-based panel study of Australian residents, designed to collect respondents' information on economic and personal well-being, household dynamics and labour market participation.²³ Having started in 2001, the HILDA Survey is completed via interviews with all survey household members over

the age of 15 years, with the interviews then completed yearly from the same sample. A multistage cluster-based sampling was used to choose study participants from the entire population in Australia. Exempt from the HILDA Survey are Australian overseas residents, diplomatic personnel, members of non-Australian defence forces and people living in very remote areas. Further detailed descriptions of the survey are described elsewhere.²⁴

Individuals and households are required to provide written consent to participate in the HILDA survey and the dataset has been de-identified.

Wave 17 had a total of 17 571 respondents, with a response rate of 96.4%. For this study, we included those respondents aged 18 years and over (n=16833) and removed respondents with missing values in the dependent or independent variables (0.5% of the sample), leaving a total of 16749 respondents. A flow chart is included in the online supplemental figure 1.

Patient and public involvement

No patient involved.

Variables

Multimorbidity

The predicting variable was the number of NCDs, self-reported by respondents in answer to the question 'Have you been told by a doctor or nurse that you have any of these conditions?' The HILDA Survey accounts for 10 NCDs: nine physical health conditions (arthritis/osteoporosis, asthma, cancer, chronic bronchitis/emphysema, type 1 diabetes, type 2 diabetes, heart diseases, high blood pressure/hypertension, any other serious circulatory condition) and mental health condition. Respondents were defined as experiencing multimorbidity if they reported two or more of any of these physical or mental conditions. To understand patterns of multimorbidity, we examined the prevalence of (1) two or more physical health conditions without mental health conditions (physical only), and (2) two or more conditions including at least one physical and mental health condition (physical-mental).

Outcome variables

Health service use was measured over the previous 12 months, including primary or secondary care health service use, as well as medication use. Primary health service use was measured through general practitioner (GP) visits (both 'any' and total number), while secondary health service use was captured through any visit to medical specialists, inpatient hospitalisation(s) and length of stay, and day hospital (outpatient) appointment(s). Medication use was measured as number of different prescribed medications, as well as presence of polypharmacy (defined as five and more prescription medications).

Work productivity loss was measured through reduction in labour force participation, reduced working hours,

and days of sick leave or unpaid leave taken in the last 12 months.

Health status was assessed through self-reported health (1: poor/fair, 0: good/very good/excellent), SF6D score,²⁵ self-reported disability and a psychological distress risk derived from Kessler Psychological Distress Score²⁶ (1: very high/high, 0: moderate/low risk of psychological distress), as well as receiving a disability support payment (disability support pension). Unadjusted population-level differences in outcomes can be found in online supplemental table 1.

Stratification by Indigenous status

All respondents were stratified by Indigenous status. Respondents were asked 'Are you of Aboriginal and Torres Strait Islander origin?', with those who identified as Aboriginal, Torres Strait Islander, or Aboriginal and Torres Strait Islander categorised as Aboriginal and all other responses considered non-Indigenous.

Covariates

Covariates included Indigenous status (Aboriginal, non-Indigenous), sex (male/female), age categories (18–29, 30–39, 40–49, 50–59, 60–69, 70+ years), education level (<year 12 schooling, year 12/certificate/diploma, bachelor or higher), quartile of household income (Q1: lowest, Q4: highest), employment status (employed full time, employed part-time, not employed but looking for work, not in workforce), marital status (married/de facto, never married/single, formerly married/formerly de facto), location by Australian state or territory (New South Wales, Victoria, South Australia, Queensland, Western Australia, Tasmania, Northern Territory, Australian Capital Territory), region (urban, regional, remote), country of birth (Australia, other) and having private health insurance (yes/no).

Statistical analysis

We summarised the sample characteristics and presented the prevalence of the most common NCD combinations, and prevalence of physical-only and physical-mental multimorbidity, stratifying by Indigenous status. We used χ^2 tests to explore differences in the prevalence of multimorbidity, physical-only and physical-mental multimorbidity between two population groups.

We applied multivariable negative binomial, linear and logistic regression models to assess the association between multimorbidity and outcomes (online supplemental table 2). Multivariable logistic regression models were applied to examine the association between multimorbidity and binary outcomes, such as any GP visit, specialist visit or hospital/day hospital admission, as well as unemployment and self-reported health. Multivariable negative binomial regression models were performed for outcomes modelled on count data such as number of medications, number of days of leave or number of health service interactions (GP/hospital/day hospital), given the skewed nature of the count data. A multivariable

linear regression model was applied to examine changes in function as reported on the SF6D.

Two-way interaction terms were used in each regression model to examine the difference in the associations between multimorbidity and outcome differed, between Aboriginal and non-Indigenous Australians. Results are presented for the pooled sample and stratified by Indigenous status.

Results were weighted to account for the multistage sampling design of the HILDA Survey. Multivariable regression models were adjusted for covariates listed above. All analyses were performed using Stata V.15 (Stata Corp), sample weights were applied and the level of statistical significance was set at 5%.

RESULTS

Sample characteristics

Table 1 displays the characteristics of the sample. The median age of respondents was 46.7 years (IQR=30–61 years). The mean number of NCDs was 0.85 (SD=1.14). The overall prevalence of multimorbidity was 20.8%, and ranged from 5.0% in those aged 18–29 years, to 57.3% in those aged 70 years and above. A total of 97.7% of the sample were non-Indigenous Australians. A total of 51.2% of the sample was female, 64.4% were employed (full time or part-time), the majority lived in an urban region (72.3%) and 52.7% had private insurance.

Among the study population, Aboriginal respondents were less likely to report income in the highest quartile (19.2% vs 29.9%), or completion of a bachelor's degree or higher (9.5% vs 29.4%), and were younger, more likely to live in a rural area (49.3% vs 26.0%) and more likely to be unemployed but looking for work (9.3 vs 3.2%) (see online supplementary table 3).

Prevalence and type of multimorbidity

The prevalence of respondents with multimorbidity increased substantially with age in both non-Indigenous and Aboriginal populations (figure 1). Aboriginal respondents reported the higher prevalence of multimorbidity (24.2%, $p<0.01$), compared with non-Indigenous Australians (20.7%, $p<0.01$).

Table 2 shows the prevalence of physical-only and physical-mental multimorbidity stratified by Indigenous status and age. The prevalence of physical-mental was twice as high in Aboriginal respondents compared with non-Indigenous Australians (16.1% vs 8.1% of total sample, $p<0.05$), and the inverse was true for physical only (8.1% vs 12.6%, $p<0.05$). The proportion of respondents with physical-mental contributed to 67% of total multimorbidity for Aboriginal participants, while among non-Indigenous Australians, physical-mental accounted for 39% of total multimorbidity ($p<0.05$) (online supplemental figure 2).

Table 1 Sample characteristics and prevalence of multimorbidity

	Non-Indigenous n (%)	Aboriginal n (%)	Total n (%)	Multimorbidity prevalence % (95% CI)
Overall	16 240 (97.7)	509 (2.3)	16 749 (100)	20.8 (13.4 to 30.7)
Multimorbidity				
Zero NCDs	8348 (53.2)	235 (45.2)	8583 (53.0)	–
Single NCD	4398 (26.1)	154 (30.6)	4552 (26.2)	–
2 NCDs	2039 (11.8)	60 (10.7)	2099 (11.7)	–
3 NCDs	881 (5.3)	35 (8.4)	916 (5.4)	–
4 NCDs	574 (3.6)	25 (5.1)	599 (3.7)	–
Gender				
Male	7651 (48.9)	229 (45.1)	7880 (48.8)	18.4 (12.7 to 26.1)
Female	8589 (51.1)	280 (54.9)	8869 (51.2)	23.0 (14.2 to 35.1)
Age (years)				
18–29	3630 (21.6)	230 (39.3)	3860 (22.0)	5.0 (2.2 to 11.0)
30–39	2841 (17.9)	93 (19.3)	2934 (18.0)	6.4 (4.5 to 9.0)
40–49	2628 (17.8)	78 (16.3)	2706 (17.7)	11.9 (5.6 to 23.4)
50–59	2690 (16.3)	63 (14.2)	2753 (16.3)	23.0 (18.8 to 27.8)
60–69	2229 (13.5)	29 (5.8)	2258 (13.4)	40.2 (33.3 to 47.5)
70+	2222 (12.9)	16 (5.0)	2238 (12.8)	57.3 (54.3 to 60.2)
Marital status				
Married/de facto	10 761 (63.0)	265 (43.9)	11 026 (62.6)	20.5 (14.4 to 28.3)
Single/never married or de facto	3217 (23.8)	188 (42.6)	3405 (24.2)	10.6 (5.1 to 20.5)
Former married/de facto	2262 (13.3)	56 (13.5)	2318 (13.3)	40.9 (32.1 to 50.3)
Education level				
<Year 12 schooling	3642 (21.3)	198 (36.0)	3840 (21.6)	37.9 (33.4 to 42.7)
Year 12 to diploma	8060 (49.4)	265 (54.6)	8325 (49.5)	18.6 (13.6 to 24.9)
Bachelor or higher	4538 (29.4)	46 (9.5)	4584 (28.9)	11.8 (8.3 to 16.4)
Employment status				
Employed full time	7173 (44.8)	153 (28.6)	7326 (44.5)	8.3 (5.8 to 11.7)
Employed part-time	3318 (20.0)	80 (17.7)	3398 (19.9)	12.2 (6.7 to 21.4)
Not employed	530 (3.2)	73 (9.3)	603 (3.2)	19.5 (15.1 to 24.9)
Not in workforce	5193 (32.2)	201 (44.4)	5394 (32.4)	43.3 (35.5 to 51.6)
Annual income				
1st quantile (lowest)	4016 (20.2)	173 (24.5)	4189 (20.3)	40.1 (32.1 to 48.8)
2nd quantile	4026 (24.0)	161 (30.0)	4187 (24.2)	21.5 (14.6 to 32.2)
3rd quantile	4071 (25.9)	115 (26.3)	4186 (25.9)	14.0 (9.4 to 20.3)
4th quantile (highest)	4127 (29.9)	60 (19.2)	4187 (29.7)	12.9 (10.8 to 15.4)
Region				
Urban	10 815 (72.9)	226 (49.1)	11 041 (72.3)	18.4 (16.1 to 21.0)
Regional	5190 (26.0)	271 (49.3)	5461 (26.5)	27.2 (22.2 to 32.8)
Remote	235 (1.1)	12 (1.6)	247 (1.2)	21.8 (11.5 to 37.5)
State				
New South Wales	4379 (32.3)	136 (29.5)	4875 (32.2)	21.1 (12.0 to 34.4)
Victoria	4181 (26.4)	70 (13.8)	4251 (26.2)	19.3 (13.7 to 26.5)
Queensland	3413 (19.4)	170 (33.2)	3583 (19.7)	21.0 (14.0 to 30.3)
South Australia	1486 (7.2)	46 (6.9)	1532 (7.2)	25.2 (18.1 to 33.9)

Continued

Table 1 Continued

	Non-Indigenous	Aboriginal	Total	Multimorbidity prevalence
	n (%)	n (%)	n (%)	% (95% CI)
Western Australia	1451 (10.3)	28 (7.1)	1479 (10.2)	20.5 (11.0 to 34.9)
Tasmania	503 (2.0)	45 (7.1)	548 (2.2)	25.4 (19.1 to 32.8)
Northern Territory	122 (0.7)	5 (1.3)	127 (0.7)	13.5 (11.6 to 15.7)
Australian Capital Territory	345 (1.7)	9 (1.1)	354 (1.7)	14.8 (10.2 to 21.1)
Country of birth				
Australia	12 645 (68.9)	509 (100)	13 154 (69.6)	20.9 (13.6 to 30.8)
Other	3595 (31.1)	0 (0.0)	3595 (30.4)	20.4 (13.3 to 30.0)
Private health				
No	7672 (46.5)	423 (78.4)	8095 (47.3)	22.9 (15.8 to 32.0)
Yes	8568 (53.5)	86 (21.6)	8654 (52.7)	18.9 (11.9 to 28.6)

Authors' estimates; proportions were calculated using weights.
NCDs, non-communicable diseases.

Common NCD combinations

There were 45 dyad combinations from the 10 NCDs reported in this study. The most prevalent NCD dyads among non-Indigenous Australians were the combinations of asthma and hypertension (7.2%), arthritis and any mental health condition (4.0%), and hypertension and any mental health condition (3.4%).

Among Aboriginal participants, the common combinations were asthma and any mental health condition (8.4%), type 2 diabetes and hypertension (6.5%), and hypertension and any mental health condition (5.4%) (online supplemental figure 3).

The associated costs of multimorbidity by Indigenous status

The associations between multimorbidity, health service use, employment productivity and health status are presented in figure 2 (see online supplemental tables 4–6).

Health service use

Having more NCDs was associated with increased odds of any GP visit (adjusted OR (AOR)=2.70, 95% CI=2.50 to

2.92), more GP visits (coefficient=0.37, 95% CI=0.30 to 0.44), odds of any overnight hospital admission (AOR=1.52, 95% CI=1.46 to 1.58) or day hospital admission (AOR=1.28, 95% CI=1.22 to 1.35), more overnight admissions (coefficient=0.40, 95% CI=0.38 to 0.43), nights admitted (coefficient=0.52, 95% CI=0.43 to 0.61), and more day hospital admissions (coefficient=0.37, 95% CI=0.21 to 0.53).

Having multimorbidity was associated with increased odds of visiting a medical specialist in the past 12 months (AOR=1.62, 95% CI=1.48 to 1.77), increased odds of polypharmacy (AOR=2.86, 95% CI=2.75 to 2.97) and more prescription medications (coefficient=0.55, 95% CI=0.45 to 0.65).

Interactions between number of NCDs and Indigenous status were statistically significant for any specialist visit and number of nights at hospital. Stratified analysis shows a similar impact of having more NCDs on health service use for both non-Indigenous and Aboriginal adults ($p>0.05$).

Work productivity

Increasing number of NCDs was associated with decreased odds of labour force participation (AOR=0.61, 95% CI=0.58 to 0.65), increased odds of working reduced hours as opposed to full time (AOR=1.08, 95% CI=0.95 to 1.23), higher mean number of paid sick leave days in the previous 12 months (coefficient=0.25, 95% CI=0.19 to 0.31) and a higher mean number of days of unpaid leave from work (coefficient=0.10, 95% CI=0.06 to 0.15). Interaction between number of NCDs and Indigenous status was not statistically significant for any of work productivity outcomes. Similar patterns of work productivity were observed between Aboriginal and non-Indigenous Australians from stratified analysis, but number of sick leave was not associated with number of NCDs among Aboriginal Australians (coefficient=0.21, 95% CI=-0.14 to 0.55).

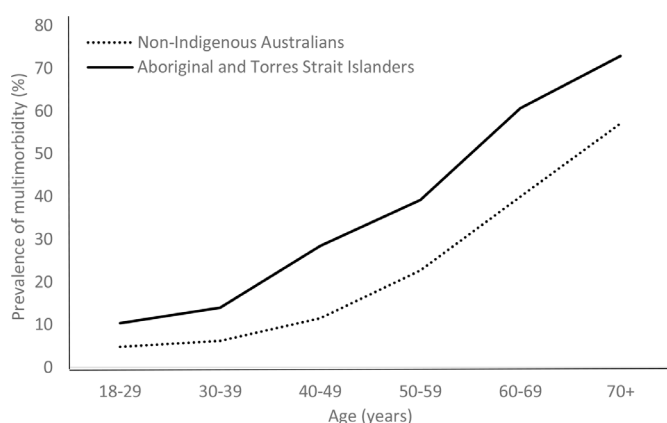


Figure 1 The prevalence of multimorbidity by age and Indigenous status.

Table 2 Multimorbidity prevalence (type) by age and by Indigenous status

Age group	All multimorbidity (n, %)		Physical-only multimorbidity (n, %)		Coexisting physical and mental condition (n, %)	
	Non-Indigenous	Aboriginal	Non-Indigenous	Aboriginal	Non-Indigenous	Aboriginal
18–29	208 (4.81)	24 (10.3)	16 (0.4)	1 (0.3)	192 (4.4)	23 (10.1)
30–39	232 (6.22)	13 (14.0)	34 (0.9)	2 (1.0)	198 (5.3)	11 (13.0)
40–49	323 (11.5)	23 (28.5)	111 (4.2)	5 (5.2)	212 (7.3)	18 (23.3)
50–59	605 (22.7)	32 (39.2)	316 (11.9)	17 (21.5)	289 (10.8)	15 (17.8)
60–69	867 (40.0)	15 (51.7)	593 (29.1)	6 (17.7)	274 (10.9)	9 (43.0)
70+	1259 (57.1)	13 (72.9)	983 (44.5)	11 (57.8)	276 (12.7)	2 (15.2)
Total	3494 (20.7)	120 (24.2)	2053 (12.6)	42 (8.1)	1441 (8.08)	78 (16.1)

Authors' estimates; proportions were calculated using weights.

Perceived health status

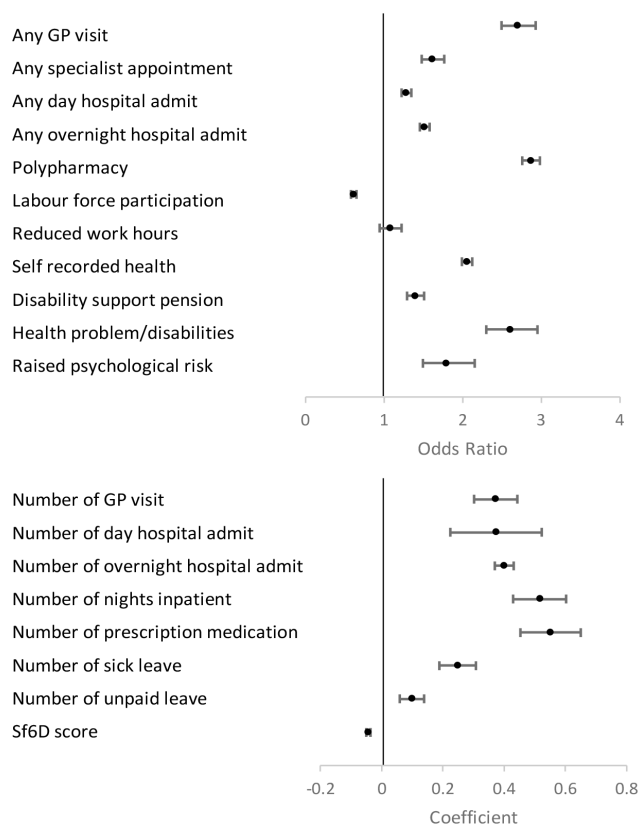
Having multimorbidity was associated with increased odds of poor self-reported health (AOR=2.06, 95% CI=1.99 to 2.12), increased odds of raised psychological distress risk (AOR=1.79, 95% CI: 1.50 to 2.14), increased odds of receiving the disability support pension (AOR=1.39, 95% CI=1.31 to 1.48) and increased odds of limitations in everyday activities due to health, illness or disability (AOR=2.61, 95% CI=2.31 to 2.95). Multimorbidity was associated with a significant decrease in quality of life

(coefficient=−0.04, 95% CI=−0.05 to −0.04). The association between number of NCDs and disability support pension, while significant for non-Indigenous participants, was not statistically significant for Aboriginal participants.

DISCUSSION

In a nationally representative sample of Australian adults, we found that multimorbidity was present among 20.8%,

Non-Indigenous Australians



Aboriginal and Torres Strait Islanders

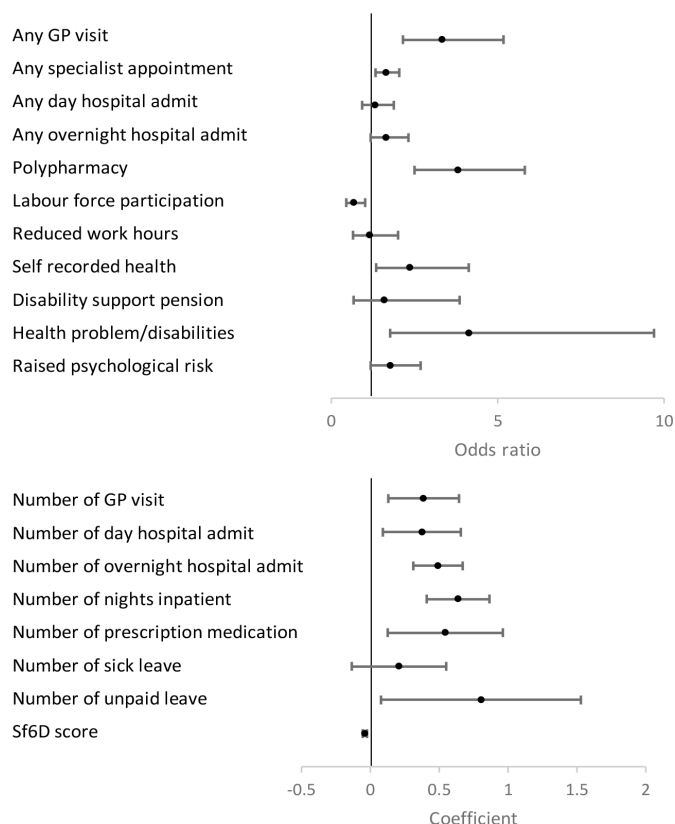


Figure 2 Impact of multimorbidity on health service use, work productivity and self-reported health by Indigenous status. All regression models were adjusted for sex, income quantiles, education level, employment, country of birth, marital status, state, residential location, age and private health insurance. GP, general practitioner.

and that prevalence increased with age. The prevalence was greater among Aboriginal people (24.2%) compared with non-Indigenous Australians (20.7%), and the findings also demonstrated different patterns of multimorbidity between Aboriginal and non-Indigenous adults, with the most common combination of NCDs being asthma and hypertension for non-Indigenous Australian respondents, and asthma and any mental health condition for Aboriginal participants. Additionally, we found that physical–mental multimorbidity is the predominant multimorbidity pattern among Aboriginal and Torres Strait Islander as it was almost twofold higher compared with non-Indigenous Australians (16.1% vs 8.1%).

Multimorbidity was associated with substantial direct and indirect costs, with increased health service use, decreased work productivity and reductions in health status among those with multimorbidity. These results were largely consistent across both Aboriginal and non-Indigenous respondents; however, multimorbidity was found to have no association with likelihood of day hospital use, days of sick leave, part-time employment or receipt of the disability pension for Aboriginal participants. We found that the effect of multimorbidity on healthcare utilisation and productivity was similar among the Aboriginal and non-Indigenous adults.

Comparison with existing literature

These findings are in line with previous literature addressing multimorbidity in Australia. Age, lower socioeconomic status¹⁸ and Indigenous Australian status^{9 18} have been reported to be associated with increased likelihood of multimorbidity. That Aboriginal people suffer from a greater prevalence and earlier onset of multimorbidity is consistent with previous literature.⁹ This is in line with the fact that Aboriginal people experience a greater burden and earlier onset of chronic disease compared with non-Indigenous Australians.²⁰

The associations between multimorbidity and health service use are consistent with previous research in Australia and European countries.^{3 27} The associations between multimorbidity and health service were similar for both groups, although with a smaller increase in the utilisation of specialist and day hospital services for Aboriginal respondents. These results may indicate unmet need by aboriginal population.^{28 29} Further research is warranted to investigate barriers for health seeking among the aboriginal population with multimorbidity. Multimorbidity was similarly associated with unemployment for both Aboriginal and non-Indigenous Australians, noting national statistics indicate a greater proportion of Aboriginal people are out of work.¹⁶ The associations between multimorbidity and work outcomes were not consistent for Aboriginal respondents; however, this may reflect variance and small sample in employment conditions between groups, such as casual labour engagement or limited access to sick leave. Multimorbidity was associated with a reduction in health status, in keeping with previous literature, with poor self-reported health,

quality of life, increased likelihood of psychological distress and disability, associations being similar for both stratified samples.^{3 30}

Study limitations

The HILDA Survey collected data from a small sample of Aboriginal Australians, which may be insufficient to justify their representativeness and evaluate the study's findings. The HILDA Survey, according to the sampling frame, excludes those who live in extremely remote areas in Australia where Aboriginal Australians make up 45% of the population.³¹ This may have an impact on the representativeness of our findings for the complete aboriginal population. Furthermore, although we used extensive number of physical chronic conditions which are collected in the HILDA Survey, it lacks a number of major chronic diseases, such as chronic kidney disease, hyperlipidaemia and gastro-oesophageal reflux disease. While the HILDA Survey provides comprehensive information about respondents across a number of metrics, the data are primarily self-reported. This exposes risks of self-report bias, as errors in reporting health conditions, or poor recall about health, which may cause under-reporting of the prevalence of multimorbidity.⁸ It is possible that self-report bias differs between Aboriginal and non-Indigenous Australians. This is especially likely considering cultural differences that exist in relation to conceptualisations of health. For instance, within Aboriginal cultures and languages, disability (as a Western construct) does not exist. For Aboriginal peoples, disability is not a defining characteristic of a person that categorically separates them from people without a disability.¹⁹ Further research is needed that employs more objective data collection methodologies, such as from electronic medical records.³²

Due to known barriers in accessing health services for Aboriginal peoples,³³ it is likely that there is a degree of undiagnosed chronic illness, underestimating the prevalence of multimorbidity for this group.³⁴ Finally, while the HILDA Survey captures health service use, productivity loss and self-reported health, these data may not be attributable to chronic health conditions. Increased health service use in a multimorbid individual may be the result of injuries or acute health conditions, and inversely low rates of health service use may indicate a lack of supply or barriers to accessing care, as opposed to a lack of need for services.

Policy and clinical implications

The associations identified within this study provide additional evidence of the substantial societal cost of multimorbidity. Reductions in multimorbidity and its implications would likely see returns in both improved health and work productivity, and reductions in health service use. Our data demonstrate significant disparities in multimorbidity patterns and prevalence among Aboriginal and socioeconomic status groups. These findings are most likely due to underlying differences in

chronic disease risk factors (such as smoking and obesity) between these Australian demographic groups. To reduce health disparities, sustained measures to promote multimorbidity prevention and care for low socioeconomic and Aboriginal Australians are required. This could include targeted interventions to reduce smoking among the Indigenous population and to enhance diet and physical activity among the people with the lowest socioeconomic status. The findings suggest that multimorbidity is disproportionately impacting Aboriginal peoples and that mental health conditions play a substantive role in this disproportionality. This is particularly important as Aboriginal people more often experience additional barriers to accessing mental health services than their non-Indigenous counterparts.³⁵

It is clear there is an established need for improvement in multimorbidity management and prevention,³⁶ and clinical guidelines for multimorbidity such as the UK's National Institute for Health and Care Excellence (NICE) guidelines on multimorbidity highlight both multidisease models and the need to address social determinants of health.³⁷ In the Australian context, there is recognition of the impact of both social and early life determinants on health,³⁸ as well as the need for culturally safe and appropriate care to reduce health inequities experienced by Aboriginal peoples.³⁹ There is a growing body of evidence for a number of strategies to target the disparity in NCD rates for Aboriginal communities. Adoption of multimorbid primary care models should be supported by the expansion of Indigenous health worker training and culturally safe practices to address the experiences of racism and discrimination endured by Aboriginal people accessing healthcare.²⁹ Building stronger relationships between primary health services and Aboriginal communities would facilitate both improvements in service utilisation rates and appropriate primary health service design,^{40 41} while expansion of programmes to address health literacy among those with chronic disease would see greater control over health and well-being.⁴² Aboriginal respondents were also more likely to reside in remote areas where there is a need to strengthen health and medical services.

Those with multimorbidity face financial risk through increased health service and medication use, in turn compounded by the reduced likelihood of employment, and higher number of days of paid sick or unpaid leave. Our findings indicate that Aboriginal people may be at heightened risk of financial hardship due to their higher prevalence of multimorbidity. The association identified in this study between multimorbidity and unemployment, as well as sick leave, may indicate a need to further invest in workplace flexibility and support by employers to facilitate greater productivity among those with multimorbidity. An area of future research would be to address what factors may keep multimorbid respondents in the workforce for longer. Furthermore, future research is warranted to better understand the financial impact of multimorbidity for Aboriginal peoples and how

organisations can support them to maintain employment and financial stability.

CONCLUSION

Our study highlighted substantial disparities in mixed physical and mental multimorbidity among Aboriginal and non-Aboriginal population in Australia. Prevention and management strategies of multimorbidity for low socioeconomic and Aboriginal Australians should be developed to mitigate health inequality.

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Contributors WC developed the hypothesis and methods, obtained the data and analysed the data and results. MI analysed the data and results, contributed to the methodology and manuscript. JST provided valuable insight from a mental health and indigenous perspective and assisted with policy implications. KA and GS assisted in drafting and revising the final manuscript. SWM, BM, GA, BO and JTL all assisted with the policy implications (healthcare and productivity loss), as well as providing depth of insight on multimorbidity. All authors have reviewed and approved this manuscript. WC, MI, and JTL are the guarantors of the manuscript and accept full responsibility for the work and conduct of the study, had access to the data, and controlled the decision to publish.

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APPENDIX

Appendix Table 1. Sample averages for outcome measures by Indigenous status

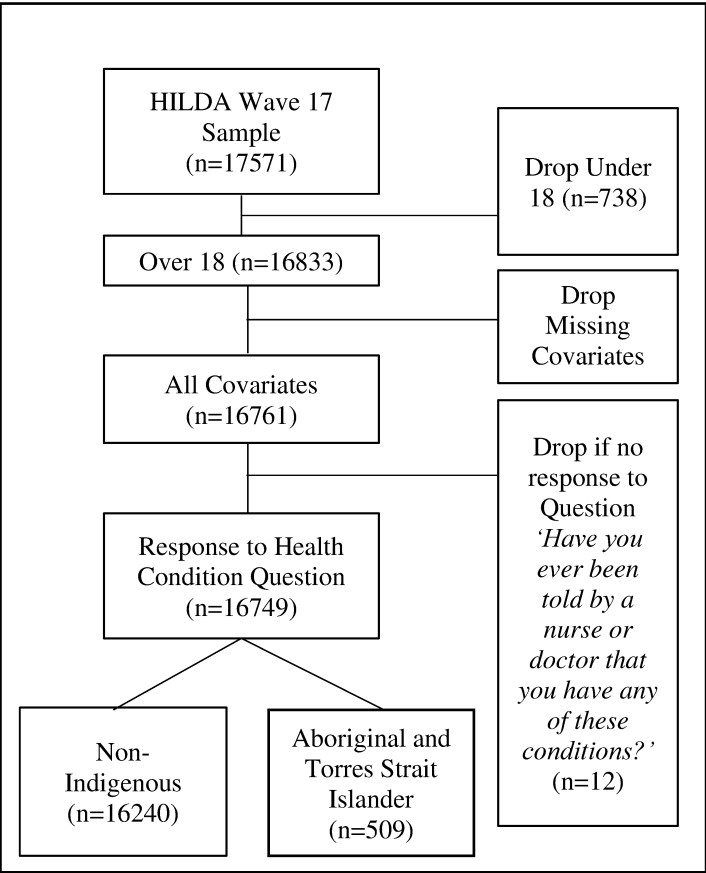
Population average for outcome measures	Aboriginal and Torres Strait Islander	Non-Indigenous Australians
Proportion to see GP in past 12/12 (%)	84.00	84.95
Average Number of GP visits past 12/12 (visits)	6.67	4.82
Proportion to see Specialist past 12/12 (%)	27.59	30.41
Proportion with Day Hospital admission past 12/12 (%)	12.17	12.78
Mean Number of day hospital admissions past 12/12 (visits)	0.66	0.22
Proportion with overnight admission past 12/12 (%)	16.70	12.87
Mean number of overnight admissions	0.28	0.19
Mean number of nights in Hospital (visits)	0.95	0.92
Proportion with Polypharmacy (%)	11.65	8.92
Mean number of prescription medications (meds)	1.47	1.37
Proportion unemployed, looking for work (%)	16.65	4.44
Proportion working reduced Hours (%)	38.18	30.84
Mean Sick leave Days past 12/12 (days)	1.56	1.99
Mean Unpaid leave days past 12/12 (days)	1.16	1.72
Proportion with difficulty at work due to health or disability (%)	20.79	8.27
Mean SF6D Score (0-1 decimal)	0.707	0.751
Proportion with Health Status as Fair or Poor (%)	29.09	18.41
Proportion on Disability Support Pension (%)	11.18	3.89
Proportion with Self-Reported Disability (%)	41.65	29.80
Proportion with High Psychological Distress Risk (%)	32.27	18.41

Note: authors estimates; sample averages and proportions were calculated using weights

Appendix Table 2. Statistical Analysis

Outcome Type	Outcome	Statistical Method
Health	SF6D Score	Multivariable Linear Regression
	Psychological Distress Risk Disability Support Pension Health Status Disability	Multivariable Logistic Regression
Health Service Use	Any GP appointment Any Hospital Admission Any Day Hospital Admission Any Specialist Appointment Polypharmacy (>5 regular medications)	Multivariable Logistic Regression
	Number of GP appointments Number of regular medications Number of Hospital admissions	Multivariable Negative Binomial Regression
Work Productivity	Employment Status Full or Part Time Hours	Multivariable Logistic Regression
	Number of sick Days Number of unpaid leave Days	Multivariable Negative Binomial Regression

Appendix Figure 1. Flow Chart

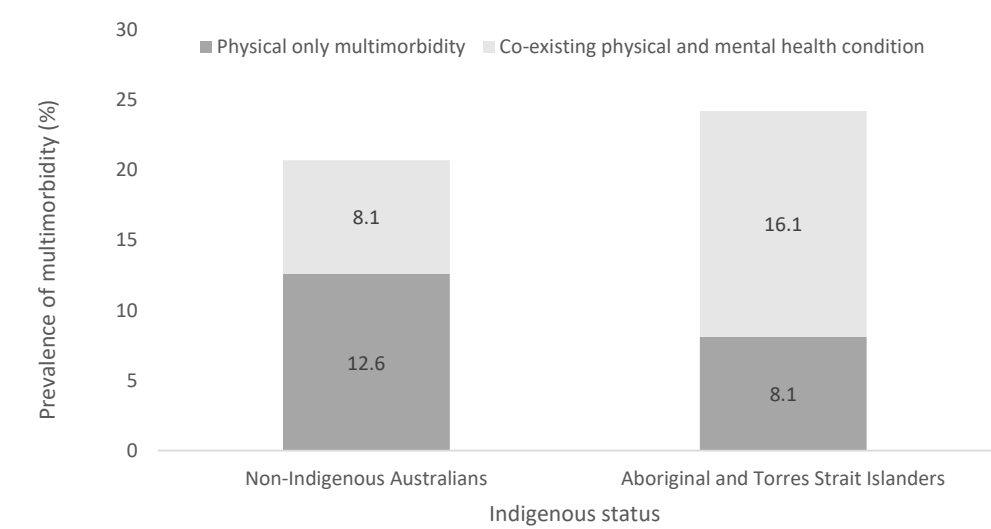


Appendix Table 3. Sample Characteristics, Indigenous status

	Aboriginal and Torres Strait Islander n (%)	Non-Indigenous Australians n (%)
Overall	509 (100)	16240 (100)
Multimorbidity		
Zero NCDs	235 (45.24)	8348 (53.17)
Single NCD	154 (30.57)	4398 (26.12)
2 NCDs	60 (10.65)	2039 (11.75)
3 NCDs	35 (8.44)	881 (5.32)
4 NCDs	25 (5.1)	574 (3.64)
Multimorbid (No/Yes)		
Not Multimorbid	389 (75.81)	12476 (79.30)
Multimorbid	120 (24.19)	3494 (20.70)
Gender		
Male	229 (45.12)	7651 (48.87)
Female	280 (54.88)	8589 (51.13)
Age		
18-29	230 (39.31)	3630 (21.55)
30-39	93 (19.33)	2841 (17.94)
40-49	78 (16.34)	2628 (17.75)
50-59	63 (14.21)	2690 (16.30)
60-69	29 (5.77)	2229 (13.52)
70+	16 (5.04)	2222 (12.94)
Marital status		
Married/De Facto	265 (43.92)	10761 (62.98)
Single/Never Married or De Facto	188 (42.63)	3217 (23.75)
Former Married/De Facto	56 (13.45)	2262 (13.26)
Education Level		
<Year 12 Schooling	198 (35.95)	3642 (21.25)
Year 12/Certificate/Diploma	265 (54.59)	8060 (49.37)
Bachelors or Higher	46 (9.46)	4538 (29.38)
Employment Status		
Employed Full Time	153 (28.63)	7173 (44.83)
Employed Part Time	80 (17.69)	3318 (19.99)
Not employed	73 (9.3)	530 (3.20)
Not in workforce	201 (44.38)	5193 (32.17)
Annual income		
1st quantile (lowest)	173 (24.45)	4016 (20.20)
2nd quantile	161 (30.02)	4026 (24.03)
3rd quantile	115 (26.33)	4071 (25.86)
4th quantile (highest)	60 (19.21)	4127 (29.92)
Region		
Urban	226 (49.08)	10815 (72.88)
Regional	271 (49.31)	5190 (25.98)
Remote	12 (1.61)	235 (1.14)
State		
New South Wales	136 (29.50)	4739 (32.25)
Victoria	70 (13.75)	4181 (26.44)
Queensland	170 (33.23)	3413 (19.41)
South Australia	46 (6.91)	1486 (7.17)
Western Australia	28 (7.13)	1451 (10.31)
Tasmania	45 (7.06)	503 (2.04)
Northern Territory	5 (1.3)	122 (0.71)
Australian Capital Territory	9 (1.12)	345 (1.67)
Country of birth		
Australia	509 (100)	12645 (68.92)
Other	0 (0)	3595 (31.08)
Private health		
No	423 (78.36)	7672 (46.54)
Yes	86 (21.64)	8568 (53.46)

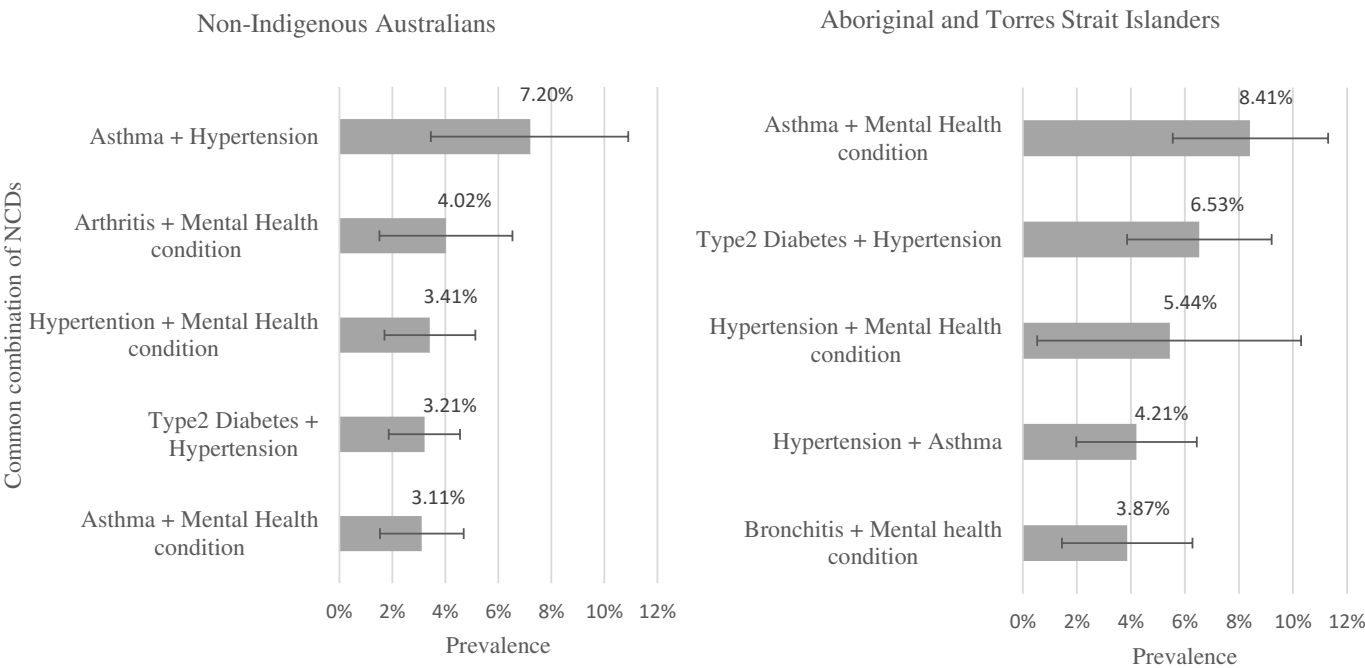
Note: authors estimates; proportions were calculated using weights

Appendix Figure 2. Prevalence of multimorbidity by type and Indigenous status



Note: authors estimates; proportions were calculated using weights

Appendix Figure 3. Common combinations of NCDs by indigenous status



Note: authors estimates; proportions were calculated using weights

Appendix Table 4. Health service use and multimorbidity

	Pooled sample			Non-Indigenous		Aboriginal and Torres Strait Islander	
	OR (95%CI)		Interaction term	OR (95%CI)		OR (95%CI)	
Any GP visit	2.70***	(2.50, 2.92)	0.92	2.70***	(2.50, 2.93)	3.34***	(2.15, 5.17)
Any specialist appointment	1.62***	(1.48, 1.77)	0.85**	1.62***	(1.48, 1.77)	1.64***	(1.32, 2.04)
Any day hospital admit	1.28***	(1.22, 1.35)	0.92	1.28***	(1.22, 1.35)	1.32	(0.93, 1.88)
Any overnight hospital admit	1.52***	(1.46, 1.58)	0.97	1.52***	(1.46, 1.58)	1.65**	(1.17, 2.32)
Polypharmacy	2.86***	(2.75, 2.97)	1.21	2.87***	(2.76, 2.99)	3.81***	(2.50, 5.80)
	Coef. (95%CI)		Interaction term	Coef. (95%CI)		Coef. (95%CI)	
Number of GP visit	0.37***	(0.30, 0.44)	-0.06	0.37***	(0.30, 0.44)	0.39**	(0.13, 0.64)
Number of day hospital admit	0.37***	(0.21, 0.53)	0.69	0.37***	(0.23, 0.52)	0.37**	(0.09, 0.66)
Number of overnight hospital admit	0.40***	(0.38, 0.43)	-0.02	0.40***	(0.37, 0.43)	0.49***	(0.31, 0.67)
Number of nights inpatient	0.52***	(0.43, 0.61)	-0.31***	0.52***	(0.43, 0.60)	0.64***	(0.41, 0.86)
Number of prescription medication	0.55***	(0.45, 0.65)	0.01	0.55***	(0.45, 0.65)	0.55**	(0.13, 0.96)

Note: *** p<0.01, ** p<0.05

OR = Odds Ratio, Coef. = Coefficient

authors estimates; ORs and Coefficients were calculated using weights

Interaction of number of multimorbidity and Indigenous status

Appendix Table 5. Productivity loss and multimorbidity

	Pooled sample			Non-Indigenous		Aboriginal and Torres Strait Islander	
	OR (95%CI)		Interaction term	OR (95%CI)		OR (95%CI)	
Labour force participation	0.61***	(0.58, 0.65)	1.08	0.61***	(0.58, 0.65)	0.67	(0.44, 1.01)
Reduced work hours	1.08	(0.95, 1.23)	0.96	1.08	(0.95, 1.23)	1.15	(0.65, 2.01)
	Coef. (95%CI)		Interaction term	Coef. (95%CI)		Coef. (95%CI)	
Number of sick leave	0.25***	(0.19, 0.31)	-0.12	0.25***	(0.19, 0.31)	0.21	(-0.14, 0.55)
Number of unpaid leave	0.10***	(0.06, 0.15)	0.19	0.10***	(0.06, 0.14)	0.80**	(0.08, 1.53)

Note: *** p<0.01, ** p<0.05

OR = Odds Ratio, Coef. = Coefficient

authors estimates; ORs and Coefficients were calculated using weights

Appendix Table 6. Multimorbidity and health, disability, wellbeing

	Pooled sample			Non-Indigenous		Aboriginal and Torres Strait Islander	
	OR (95%CI)		Interaction term	OR (95%CI)		OR (95%CI)	
Self-recorded health	2.06***	(1.99, 2.12)	1.03	2.06***	(1.99, 2.12)	2.36**	(1.35, 4.13)
Disability support pension	1.39***	(1.31, 1.48)	0.92	1.40***	(1.30, 1.51)	1.60	(0.66, 3.86)
Health problem/disabilities	2.61***	(2.31, 2.95)	1.16	2.61***	(2.31, 2.95)	4.13**	(1.76, 9.70)
Raised psychological risk	1.79***	(1.50, 2.14)	0.92	1.80***	(1.49, 2.16)	1.77**	(1.18, 2.68)
	Coef. (95%CI)		Interaction term	Coef. (95%CI)		Coef. (95%CI)	
Sf6D score	-0.04***	(-0.05, -0.04)	0.01	-0.04***	(-0.05, -0.04)	-0.04***	(-0.06, -0.02)

Note: *** p<0.01, ** p<0.05
OR = Odds Ratio, Coef. = Coefficient
authors estimates; ORs and Coefficients were calculated using weights