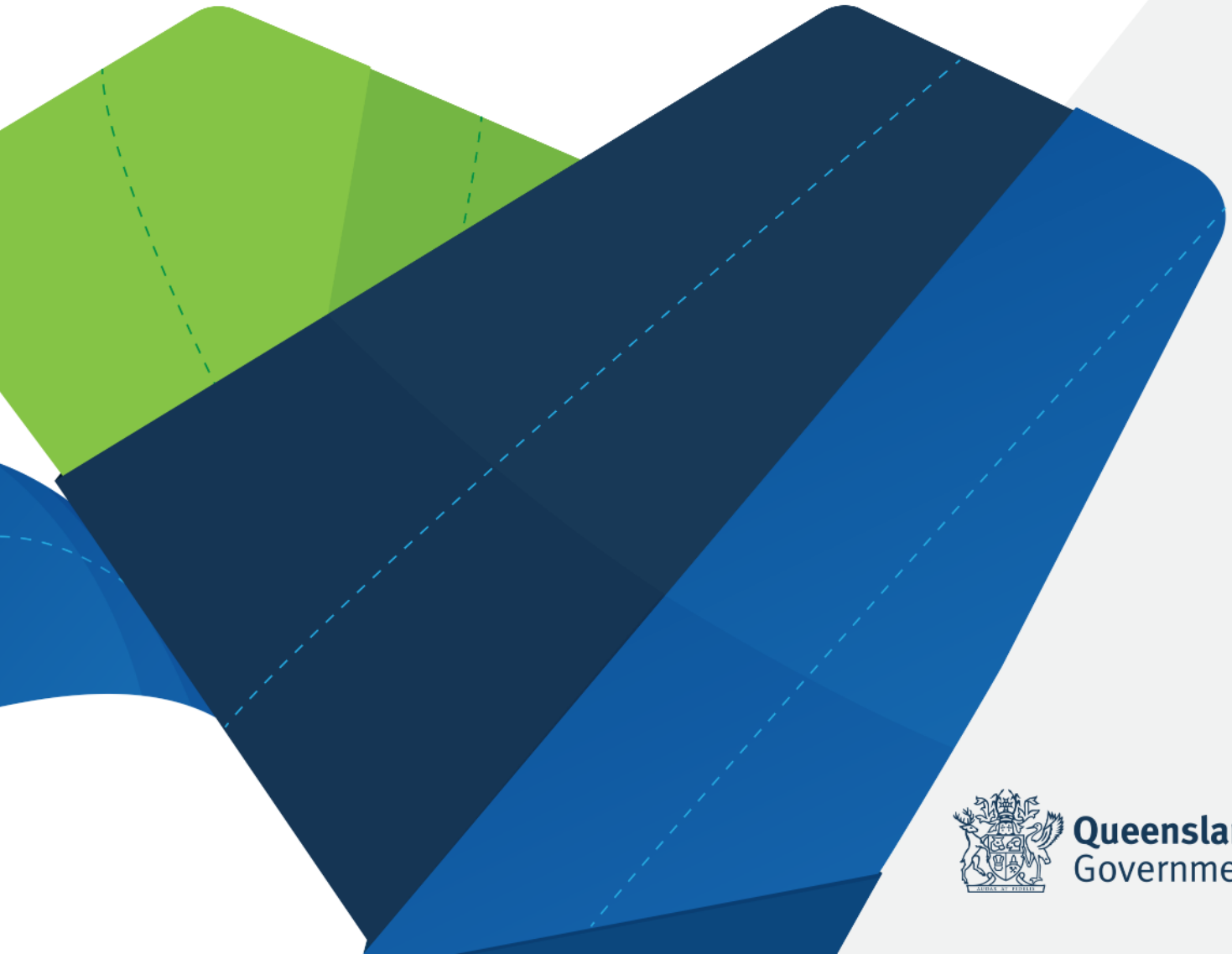
Health-related quality of life in Queensland

Relationship with risk factors and hospitalisations



Queensland Government

Health-related quality of life in Queensland - Relationship with risk factors and hospitalisations

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Summary

What is already known about this topic?

Health-related quality of life (HRQoL) is an important measure for public health monitoring as it provides a more holistic assessment of the population's health than objective health measures such as hospitalisation rates, disease prevalence and mortality rates.

The Centers for Disease Control and Prevention (CDC) in the United States of America (US) proposed, validated and continues the use of healthy days measures to measure population HRQoL, as reflected in their national health promotion and disease prevention framework (with the latest iteration being Healthy People 2030). In US populations, healthy days have been shown to exhibit notable variations by sociodemographic characteristics, behavioural risk factors, health conditions and adverse events.

There is currently limited reporting of population-level HRQoL in Queensland, and the healthy days measures in particular.

What this report adds?

For the Queensland adult population in 2020, the unhealthy days measures showed meaningful differences across:

- Sociodemographic characteristics such as age groups, sex and socioeconomic status
- Self-reported health risk factors such as smoking status, alcohol consumption, body mass index and physical activity levels.

Specific unhealthy day measures were able to account for a small component of the hospitalisation types investigated, namely:

- Total unhealthy days with all-causes hospitalisations
- Mental unhealthy days with mental and behavioural disorder hospitalisations
- Physical unhealthy days with musculoskeletal hospitalisations.
- Limiting unhealthy days with respiratory hospitalisations.

Potential implications for population health

The healthy days measures are useful for monitoring HRQoL of Queensland adults.

The regression analysis findings provide preliminary evidence that the healthy days measures can potentially reflect health utilisations behaviours of the population as well.

There is scope for more detailed analysis to further investigate the relationship between unhealthy days and hospitalisations at the individual-level using data linkage.

Contents

Background

Objective health indicators, such as hospitalisation rates, disease prevalence and mortality rates, provide a useful but narrow perspective of the actual health burden of a population. Such measures do not capture how individuals perceive changes to their health state, nor provide information about individuals who do not engage with health services.

Monitoring health-related quality of life (HRQoL) measures alongside objective health measures provide a more comprehensive assessment of the population's health. HRQoL is a multi-dimensional concept that includes individual's perceived physical, mental, emotional and social functioning over time [1].

From a population health perspective, monitoring HRQoL provides valuable information on subgroups or health conditions associated with relatively poor perceived health. This information can assist targeted public health policy or prevention planning efforts [2], and be used as an effectiveness measure of health initiatives and interventions.

An instrument for measuring HRQoL should be:

- able to accurately measure the concept of HRQoL (validity)
- consistent when administered to participants with similar health characteristics (reliability)
- sensitive to changes over time, relevant characteristics or health policy changes (responsiveness).

In addition, for routine population health monitoring, the instrument needs to be relatively short, acceptable for use across a wide range of population groups, and readily understood by participants to minimise misinterpretation and non- or partial responses.

There are many instruments developed to measure HRQoL. For example, the SF-36 Health Survey is a 36-item questionnaire included in each wave of the national Household, Income and Labour Dynamics in Australia survey to assess general health and well-being of participants as a score between 0 and 100. The EuroQoL's EQ-5D questionnaire is commonly used to quantify HRQoL as an index between 0 and 1 for economic evaluations in health. There are also other similar but less commonly used instruments to derive a HRQoL index, such as the Assessment of Quality of Life (AQoL), health utility index (HUI) and the World Health Organization Quality of Life (WHOQOL) instruments.

In contrast with the HRQoL instruments above which assign an abstract numerical score or index, the Centers for Disease Control and Prevention (CDC) developed the healthy days measure to provide a more readily interpretable HRQoL measure. The healthy days instrument comprises four questions that assess perceived health status and activity limitation [1]. These data are collected and reported in terms of four types of unhealthy days in the past 30 days: physical, mental, total and limiting. Limiting unhealthy days refer to the number of days poor physical or mental health limited the participant's ability to engage in their usual activities, such as self-care, work or recreation. The CDC healthy days has been demonstrated be a valid, reliable and responsive instrument for measuring HRQoL [1].

The healthy day measure has been used predominantly in the US, where it has been included in the Behavioural Risk Factor Surveillance System since 1993. The healthy days

measure is one of the leading health indicators for their Healthy People framework which guides national health promotion and disease prevention policies in the US [3].

In the US adult population, the healthy days measure has shown to:

- Capture differences across demographic factors [4, 5], behavioural risk factors [6, 7] and disease groups [8, 9]
- Be associated with physician visits, hospitalisations and mortality among older adults [10]
- Be used in evaluating impacts of health interventions [11]
- Capture temporal trends across long time periods corresponding to changes in population health, such as changes in smoking and obesity [12]
- Change as a result of significant personal or public adverse events, such abuse and serious psychological distress [13], and natural disasters [14].

As such, the healthy days measure has potential to be a valuable population health measure. There is currently limited reporting of the healthy days measure for the Queensland population. An example of its use was in a Queensland Health public report on sociodemographic characteristics and behavioural risk factors of public sector workers in which public sector workers reported fewer physical unhealthy days than the adult Queensland population [15].

Aim

This report will investigate the utility of the healthy days measure for population health monitoring in Queensland by:

- describing the general patterns of self-reported unhealthy days by sociodemographic characteristics, health behavioural risk factors, and hospital and health service regions
- exploring whether self-reported unhealthy days were related to population-level health service utilisation, specifically hospitalisation rates.

Data

Queensland Health conducts an annual preventive health survey to monitor the prevalence of health behavioural risk factors. The survey is conducted by computer-assisted telephone interviews using a near-complete Queensland list-based sampling frame of both landline and mobile numbers. Adults 18 years and older from residential households who speak English sufficiently well for telephone interviewing are eligible to participate in the survey. Detailed survey methodology is available from the Queensland Health website [16, 17]. The CDC healthy days measure was collected as part of this survey since 2017.

Hospitalisations data were extracted from the Queensland Health Admitted Patient Data Collection. In addition to all-cause hospitalisation, six hospitalisation broad causes which plausibly relate to unhealthy days and usual activity limitation were extracted: mental and

behavioural disorders, musculoskeletal, coronary heart disease, respiratory, chronic obstructive pulmonary disease (COPD), and pneumonia and influenza. Extracted data were aggregate data for combinations of year, sex, age group, and Hospital and Health Service (HHS) regions.

Methods

Descriptive summaries

Summary tables for the unhealthy days measure by sociodemographic characteristics and behavioural risk factors were generated for state-level estimates using the 2020 survey data of Queensland adults (18 years and older). HHS estimates were calculated using the 2017–18 pooled survey data, which were the most recent available pooled data at the time of investigation. The latest year of data collection will be available through the Queensland survey analytic system (QSAS) [17]. Each unhealthy day type was summarised by sex, age group, remoteness, socioeconomic status, health risk factors and HHS.

Association with hospitalisations

Regression analyses were used to investigate the relationship between unhealthy days and hospitalisations at the population level for Queensland adults using aggregated summary data. The analyses also accounted for the effects of age, sex, calendar year and HHS as these factors are known to affect hospitalisation rates. The analyses used three years of data from 2017 to 2019 (Table A.1 in Appendix). Data linkage between the two data sources for individual-level analysis was not available for this analysis.

For each hospitalisation type, the associated type of unhealthy days investigated was pre-specified based on clinical plausibility and expected relationships (Table 1). For example, it was hypothesized that mental and behavioural hospitalisations would be related to mental unhealthy days. Other unhealthy day types were investigated in sensitivity analyses in the Appendix.

Table 1: Pre-specified unhealthy day types to be modelled for each hospitalisation type in the regression analyses

Hospitalisation type	Type of unhealthy days
All causes	Total
Mental and behavioural disorders	Mental
Musculoskeletal	Physical, Limiting
Respiratory	Physical, Limiting
COPD (subset of Respiratory)	Physical, Limiting
Pneumoniae and influenza (subset of Respiratory)	Physical, Limiting

Table 2: Summary measures of hospitalisation rates for Queenslanders adults

Hospitalisation type	Measures	2017	2018	2019
	Estimated resident population ('000)	3,710.7	3,776.4	3,844.8
All causes	Counts ('000)	2,238.8	2,357.0	2,461.5
	Crude rate per 100,000	60,332.7	62,415.4	64,021.6
Mental and behavioural disorders	Counts ('000)	336.6	364.2	398.6
	Crude rate per 100,000	9,071.6	9,643.5	10,367.0
Musculoskeletal	Counts ('000)	855.9	918.2	968.7
	Crude rate per 100,000	23,066.2	24,313.7	25,195.9
Respiratory	Counts ('000)	185.7	198.8	202.5
	Crude rate per 100,000	5,003.8	5,263.2	5,267.2
COPD (subset of Respiratory)	Counts ('000)	36.0	37.8	38.3
	Crude rate per 100,000	969.0	1,001.6	997.0
Pneumoniae and influenza (subset of Respiratory)	Counts ('000)	36.5	43.3	39.0
	Crude rate per 100,000	984.8	1,146.7	1,013.7

Descriptive results

Population subgroups

Queensland adults reported an average of 7.8 unhealthy days over the past 30 days in 2020 (Table 3). This included an average of:

- 4.1 physical unhealthy days
- 4.9 mental unhealthy days.

Additionally, an average of 2.7 days where poor physical or mental health kept them from doing their usual activities (limiting unhealthy days) were reported.

Compared with men, Queensland women reported an average of:

- 1 additional mental unhealthy day (5.4 days compared with 4.4 days)
- 1.4 additional total unhealthy days (8.5 days compared with 7.1 days).

As age increases, Queensland adults reported:

- more physical unhealthy days, increasing from 2.5 days among 18–29 year olds to 6.1 days among 65 years and older
- fewer mental unhealthy days, decreasing from 6.6 days among 18–29 year olds to 2.8 days among 65 years and older.

The average unhealthy days were similar across remoteness categories.

Queenslanders in socioeconomically disadvantaged areas reported more unhealthy days than those in more advantaged areas, increasing from an average of

- 3.1 days to 5.9 days for physical unhealthy days
- 3.8 days to 6.5 days for mental unhealthy days
- 6.4 days to 10.3 days for total unhealthy days
- 1.7 days to 4.2 days for limiting unhealthy days.

Table 3: Average unhealthy days in the past 30 days by sociodemographic characteristics, Queensland adults, 2020

	Mean unhealthy days (95% confidence interval)			
	Physical	Mental	Total	Limiting
Persons	4.1 (3.9–4.3)	4.9 (4.6–5.2)	7.8 (7.5–8.1)	2.7 (2.5–2.9)
Sex				
Male	3.7 (3.4–4.0)	4.4 (4.0–4.7)	7.1 (6.6–7.5)	2.5 (2.3–2.8)
Female	4.5 (4.2–4.8)	5.4 (5.1–5.8)	8.5 (8.1–9.0)	2.8 (2.6–3.1)
Persons				
18–29 years	2.5 (2.0–3.1)	6.6 (5.7–7.5)	8.4 (7.5–9.4)	2.6 (2.0–3.1)
30–44 years	3.2 (2.8–3.6)	5.3 (4.9–5.8)	7.5 (6.9–8.0)	2.3 (1.9–2.6)
45–64 years	4.7 (4.3–5.1)	4.7 (4.4–5.1)	7.8 (7.4–8.3)	2.9 (2.6–3.2)
65 years and older	6.1 (5.7–6.5)	2.8 (2.5–3.1)	7.7 (7.3–8.1)	2.9 (2.6–3.2)
Males				
18–29 years	1.9 (1.4–2.5)	5.3 (4.1–6.4)	6.9 (5.6–8.3)	1.9 (1.3–2.6)
30–44 years	3.0 (2.4–3.5)	5.3 (4.6–6.0)	7.1 (6.3–8.0)	2.5 (1.9–3.0)
45–64 years	4.1 (3.5–4.6)	4.0 (3.5–4.5)	6.8 (6.2–7.5)	2.6 (2.2–3.0)
65 years and older	6.1 (5.5–6.7)	2.7 (2.3–3.1)	7.5 (6.9–8.2)	3.2 (2.7–3.7)
Females				
18–29 years	3.2 (2.3–4.0)	8.0 (6.7–9.3)	10.0 (8.5–11.4)	3.2 (2.3–4.2)
30–44 years	3.4 (2.9–3.9)	5.4 (4.8–5.9)	7.8 (7.0–8.5)	2.1 (1.7–2.4)
45–64 years	5.3 (4.7–5.9)	5.4 (4.9–5.9)	8.8 (8.1–9.4)	3.3 (2.8–3.7)
65 years and older	6.1 (5.6–6.6)	2.9 (2.5–3.3)	7.9 (7.3–8.5)	2.7 (2.3–3.1)
Remoteness				
Major cities	3.7 (3.4–4.0)	4.7 (4.3–5.1)	7.4 (7.0–7.9)	2.5 (2.2–2.8)
Inner regional	4.9 (4.5–5.2)	4.9 (4.6–5.3)	8.4 (7.9–8.8)	3.1 (2.8–3.4)
Outer regional	4.8 (4.3–5.2)	5.8 (5.3–6.3)	8.9 (8.3–9.5)	3.0 (2.7–3.4)
Remote/very remote	4.1 (3.5–4.7)	4.9 (4.1–5.8)	7.9 (7.0–8.9)	2.4 (2.0–2.8)
Socioeconomic status				
Disadvantaged	5.9 (5.4–6.3)	6.5 (5.9–7.0)	10.3 (9.7–11.0)	4.2 (3.7–4.6)
Quintile 2	4.5 (4.1–5.0)	5.4 (4.9–5.8)	8.5 (8.0–9.1)	3.1 (2.7–3.4)
Quintile 3	3.9 (3.4–4.4)	4.8 (4.2–5.4)	7.5 (6.8–8.2)	2.3 (1.9–2.7)
Quintile 4	3.5 (3.0–4.0)	4.4 (3.8–4.9)	6.9 (6.2–7.6)	2.4 (1.9–2.8)
Advantaged	3.1 (2.7–3.6)	3.8 (3.2–4.4)	6.4 (5.6–7.1)	1.7 (1.4–2.1)

Health behavioural risk factors

There were notable differences in self-reported unhealthy day averages by health behavioural risk factors (Table 4).

Daily smokers reported more unhealthy days compared with non-daily smokers across all unhealthy day types. Compared with non-smokers and non-daily smokers, the average unhealthy days for daily smokers was:

- 1.9 days higher for physical unhealthy days (5.8 days compared with 3.9 days)
- 4.7 days higher for mental unhealthy days (9.1 days compared with 4.4 days)
- 4.8 days higher for total unhealthy days (12.1 days compared with 7.3 days)
- 2 days higher for limiting unhealthy days (4.5 days compared with 2.5 days).

Queenslanders' self-reported unhealthy days varied across different alcohol consumption behaviours:

- Abstainers reported the highest averages for physical and limiting unhealthy days (5.7 days compared with averages ranging from 3.4 to 3.9 days, and 3.5 days compared with averages ranging from 2.5 to 2.7 days, respectively)
- Lifetime risky and single occasion risky drinkers reported higher average mental unhealthy days (5.9 days and 5.8 days, respectively) than abstainers and lifetime low risk drinkers (4.6 days for both groups)
- Lifetime low risk drinkers reported the lowest average total unhealthy days (7.3 days compared with averages ranging from 8.1 to 8.6 days).

Queensland adults who were obese reported more unhealthy days compared with those who were of healthy weight or overweight:

- 6.1 days compared with 3.1 days and 3.6 days for physical unhealthy days
- 6.5 days compared with 4.5 days and 4.2 days for mental unhealthy days
- 10.6 days compared with 6.8 days and 6.9 days for total unhealthy days
- 3.9 days compared with 2.1 days and 2.3 days for limiting unhealthy days.

Queenslanders who were more physically active reported fewer unhealthy days, where the averages decrease from:

- 8.6 days among physically inactive adults to 2.7 days among those with sufficient physical activity for physical unhealthy days
- 6.8 days among physically inactive adults to 4.5 days among those with sufficient physical activity for mental unhealthy days
- 12 days among physically inactive adults to 6.6 days among those with sufficient physical activity for total unhealthy days
- 5.6 days among physically inactive adults to 1.9 days among those with sufficient physical activity for limiting unhealthy days.

Table 4: Average unhealthy days in the past 30 days by health risk factors, Queensland adults, 2020

Health risk factors	Mean unhealthy days (95% confidence interval)			
	Physical	Mental	Total	Limiting
Daily smoking				
Daily smokers	5.8 (5.1–6.6)	9.1 (8.0–10.2)	12.1 (10.9–13.2)	4.5 (3.9–5.1)
Non-smokers and non-daily smokers	3.9 (3.7–4.2)	4.4 (4.2–4.7)	7.3 (7.0–7.7)	2.5 (2.3–2.7)
Alcohol consumption				
Abstainers	5.7 (5.1–6.2)	4.6 (4.0–5.1)	8.6 (7.9–9.3)	3.5 (3.0–3.9)
Lifetime low risk	3.8 (3.5–4.0)	4.6 (4.3–4.9)	7.3 (7.0–7.7)	2.5 (2.2–2.7)
Lifetime risky	3.9 (3.4–4.4)	5.9 (5.2–6.5)	8.6 (7.8–9.3)	2.7 (2.3–3.0)
Single occasion risky (monthly)	3.4 (3.0–3.8)	5.8 (5.2–6.3)	8.1 (7.5–8.8)	2.6 (2.2–2.9)
Body mass index				
Underweight	4.0 (2.6–5.5)	5.2 (3.2–7.2)	8.3 (6.0–10.7)	4.3 (2.3–6.3)
Healthy Weight	3.1 (2.8–3.5)	4.5 (4.0–4.9)	6.8 (6.2–7.3)	2.1 (1.8–2.4)
Overweight	3.6 (3.3–4.0)	4.2 (3.8–4.5)	6.9 (6.4–7.4)	2.3 (2.0–2.5)
Obese	6.1 (5.7–6.6)	6.5 (5.9–7.0)	10.6 (10.0–11.2)	3.9 (3.5–4.2)
Overweight & obese	4.7 (4.4–5.0)	5.1 (4.8–5.4)	8.4 (8.0–8.8)	2.9 (2.7–3.2)
Physical activity				
Inactive	8.6 (7.7–9.4)	6.8 (6.0–7.6)	12.0 (11.0–13.0)	5.6 (4.9–6.3)
Insufficient	4.5 (4.1–4.9)	5.6 (5.1–6.1)	8.6 (8.1–9.2)	3.1 (2.6–3.5)
Sufficient	2.7 (2.5–3.0)	4.5 (4.1–4.9)	6.6 (6.2–7.0)	1.9 (1.6–2.1)

The average physical, mental, total and limiting unhealthy days were similar across HHS regions *(Figure 1)*, ranging from

- 2.9 days (Torres and Cape HHS) to 5.5 days (Wide Bay HHS) for physical unhealthy day.
- 2.6 days (Torres and Cape HHS) to 5.5 days (Wide Bay HHS) for mental unhealthy day.
- 5.2 days (Torres and Cape HHS) to 9.2 days (Wide Bay HHS) for total unhealthy day.
- 1.8 days (Torres and Cape HHS) to 3.4 days (Wide Bay HHS) for limiting unhealthy day.

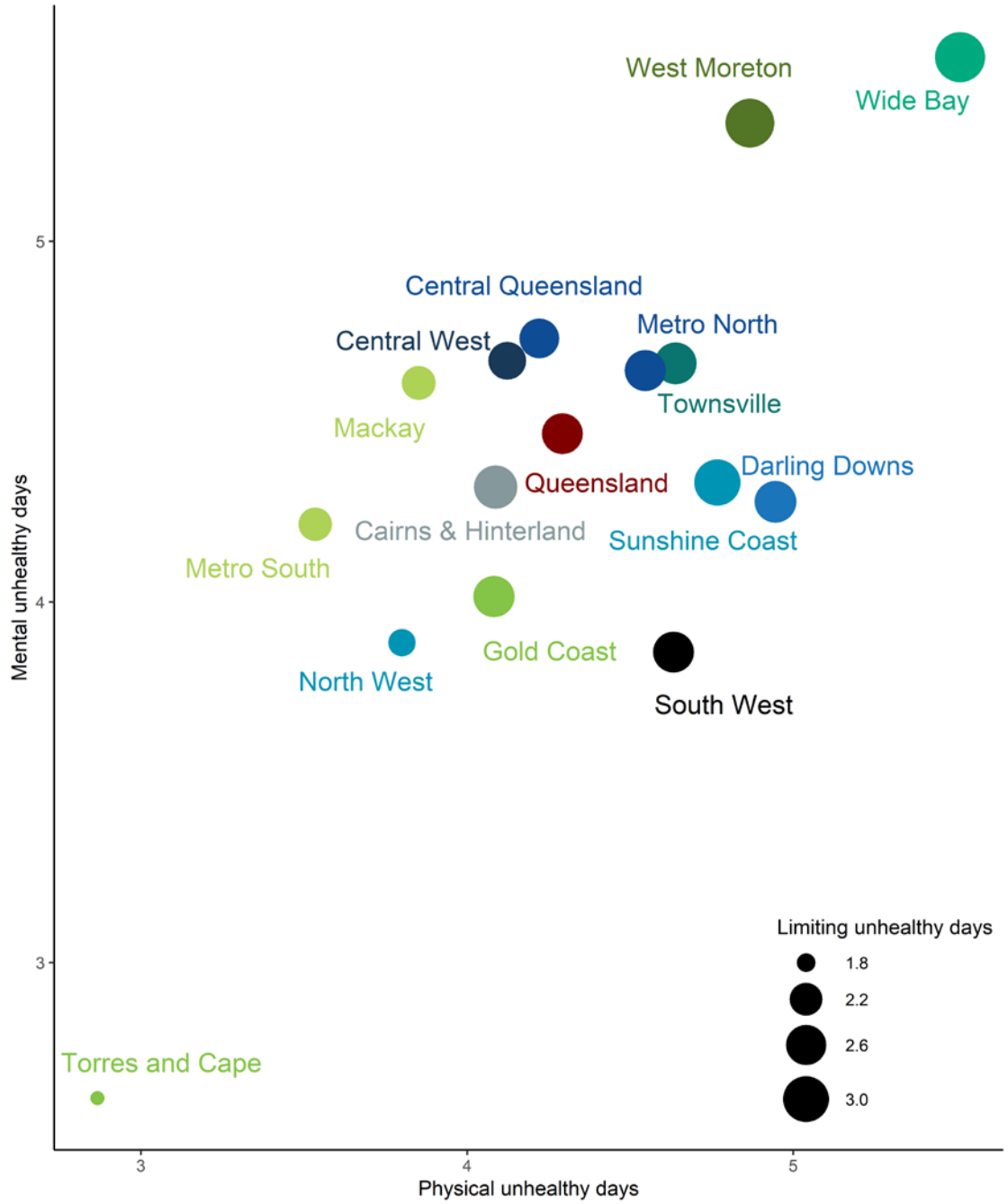

Figure 1: Average unhealthy days in the past 30 days by HHS, Queensland adults, 2017-18

Association with hospitalisations

This section presents results from the regression analyses of the different hospitalisation types on unhealthy days averages accounting for the effects of year, sex, age group and HHS on hospitalisation rates.

Across all analyses presented, hospitalisation rates:

- increased with age
- increased over time
- varied by HHS regions.

Additionally, all-causes hospitalisation rates were higher in women than men, while the rates were lower in women for mental and behavioural disorder related hospitalisations.

All-causes hospitalisations

The total unhealthy days average was associated with an increase in all-causes hospitalisations.

A one-day increase in the total unhealthy days average was associated with a 1.56% increase in all-causes hospitalisations, or 38,312 additional all-causes hospitalisations in 2019 across Queensland.

Mental and behavioural disorder hospitalisations

The mental unhealthy days average was associated with an increase in mental and behavioural disorder related hospitalisations.

A one-day increase in the mental unhealthy days average was associated with a 0.95% increase in mental and behavioural disorder hospitalisations, or 3,800 additional mental and behaviour disorder hospitalisations in 2019 across Queensland.

Musculoskeletal hospitalisations

The physical unhealthy days average was associated with an increase in musculoskeletal hospitalisation rates, accounting additionally for the limiting unhealthy days average.

A one-day increase in the physical unhealthy days average was associated with a 0.92% increase in musculoskeletal hospitalisations, or 8,881 additional musculoskeletal hospitalisations in 2019 across Queensland.

Respiratory hospitalisations

The limiting unhealthy days average was associated with an increase in respiratory hospitalisations, accounting additionally for the physical unhealthy days average.

A one-day increase in limiting unhealthy days average was associated with a 1.93% increase in respiratory hospitalisations, or 3,912 additional respiratory hospitalisations in 2019 across Queensland.

For the two Respiratory hospitalisations subsets investigated (COPD, and pneumonia and influenza hospitalisations), the pre-specified unhealthy days averages (physical and limiting) were not associated with changes in the observed hospitalisation rates.

Limitations and future directions

There are limitations with the regression analyses results presented above:

- Data from different sources were not linked at the persons level, necessitating use of aggregate data (group summaries) to combine the datasets for analysis
- Timing of data collection differed slightly between different data sources, potentially obscuring the cause-effect relationship between unhealthy days and hospitalisations

These limitations adversely impact the strength and quality of evidence developed from the analysis between unhealthy days and hospitalisations rates presented.

One potential improvement for future investigations would be to link individual-level data from the two data sources. This data linkage would allow for a more detailed investigation into the relationship between unhealthy days and hospitalisations. Stronger evidence generated from such future investigation will enhance the value of the healthy days measure to monitor health-related quality of life.

Appendix – Additional unhealthy days data summaries

Distribution of unhealthy days

The distributions of the self-reported unhealthy days exhibit a notable peak at zero. In other words, a large proportion of the population reported not having any unhealthy days. It would be of interest to investigate if the health status of those who did and did not report any unhealthy days in the past 30 days differed. For example, a future investigation could compare health system utilisation of the two groups using individual-level data linkage.

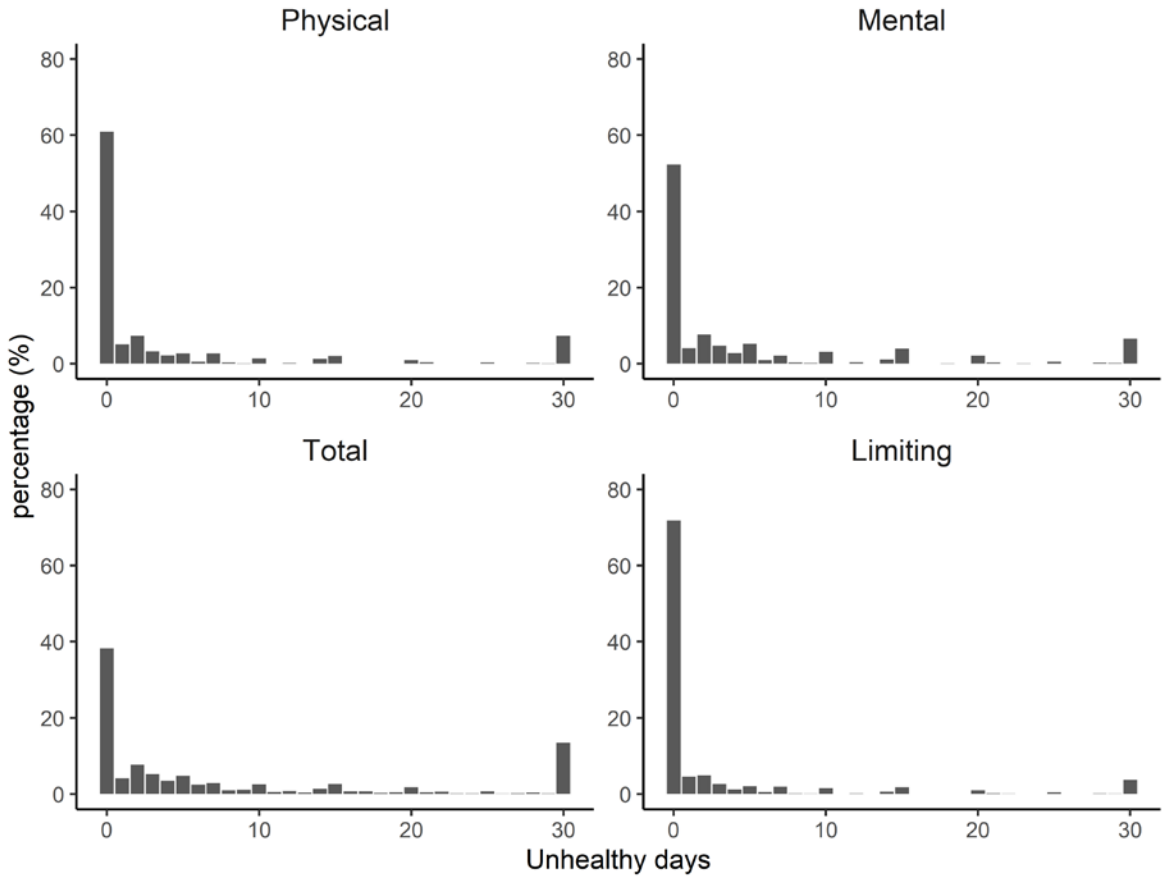

Figure A.1: Distribution of unhealthy days in the past 30 days, Queensland adults, 2020

Temporal patterns in unhealthy days by age

The unhealthy days trends over age groups were similar across the four years of data collections (Figure A.2). Specifically,

- More physical unhealthy days were reported as age increases
- Fewer mental unhealthy days were reported as age increases
- Total unhealthy days were broadly similar across age groups
- People aged 45 year or older reported more limiting unhealthy days than the adult population under 45 years olds.

There were some small, non-statistically significant, variations over time within individual age groups and unhealthy day types:

- Averages of mental and total unhealthy days among 18–29 year olds increased over time
- Average mental unhealthy days among 30–44 year olds increased over time.

For Queensland men (Figure A.3):

- Average mental unhealthy days among 30–44 year olds was higher in 2020
- Average physical unhealthy days among 45–64 year olds was lower in 2020
- Average mental unhealthy days among 65 year olds and older increased over time.

For Queensland women (Figure A.4):

- Averages of mental and total unhealthy days among 18–29 year olds were notably lower in 2017
- Average mental unhealthy days among 65 year olds and older decreased over time.

With only four annual data points, it is too early to determine if these patterns reflect sustained change over time.

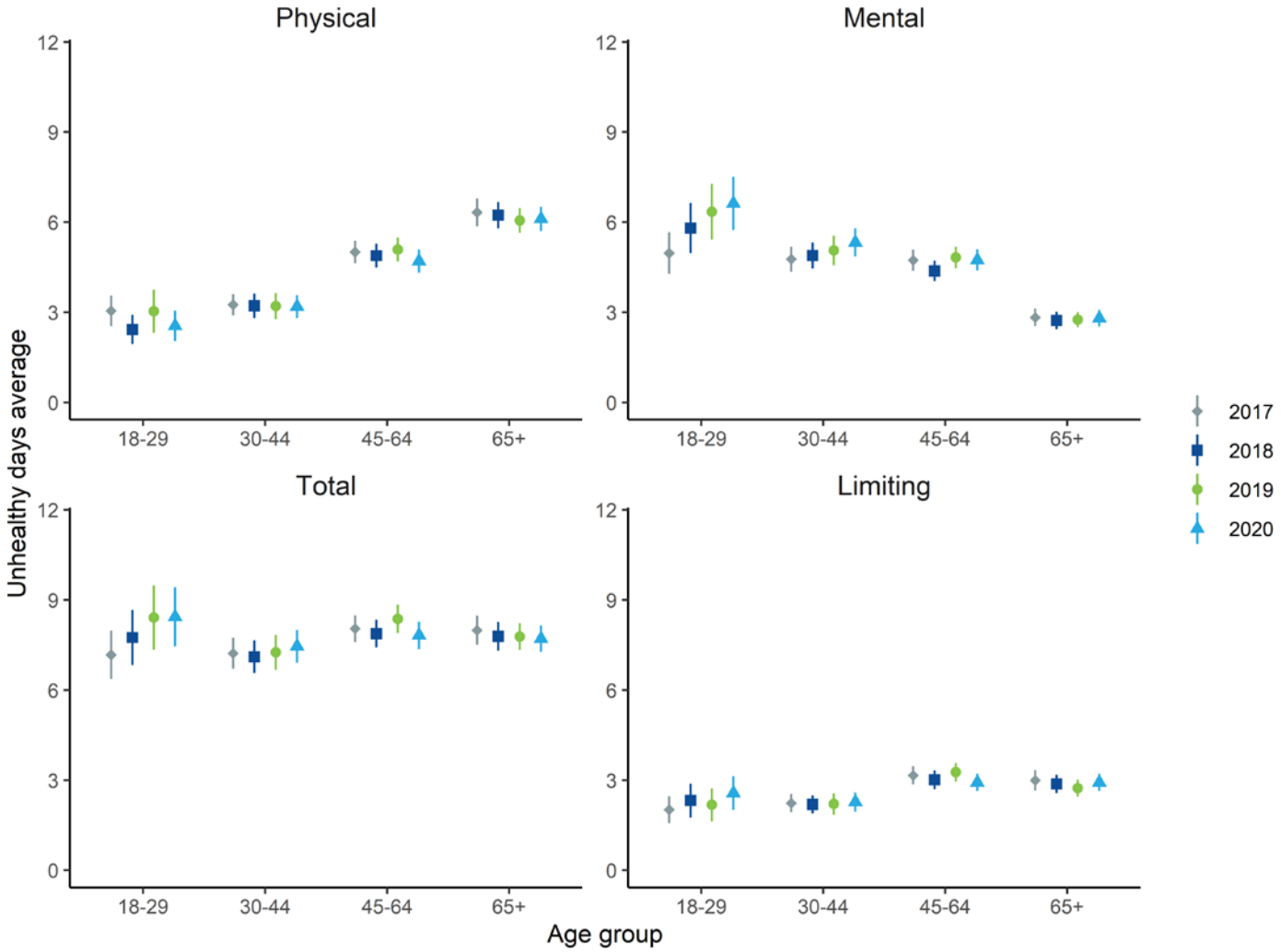

Figure A.2: Average unhealthy days by age groups, Queensland adults, 2017 to 2020

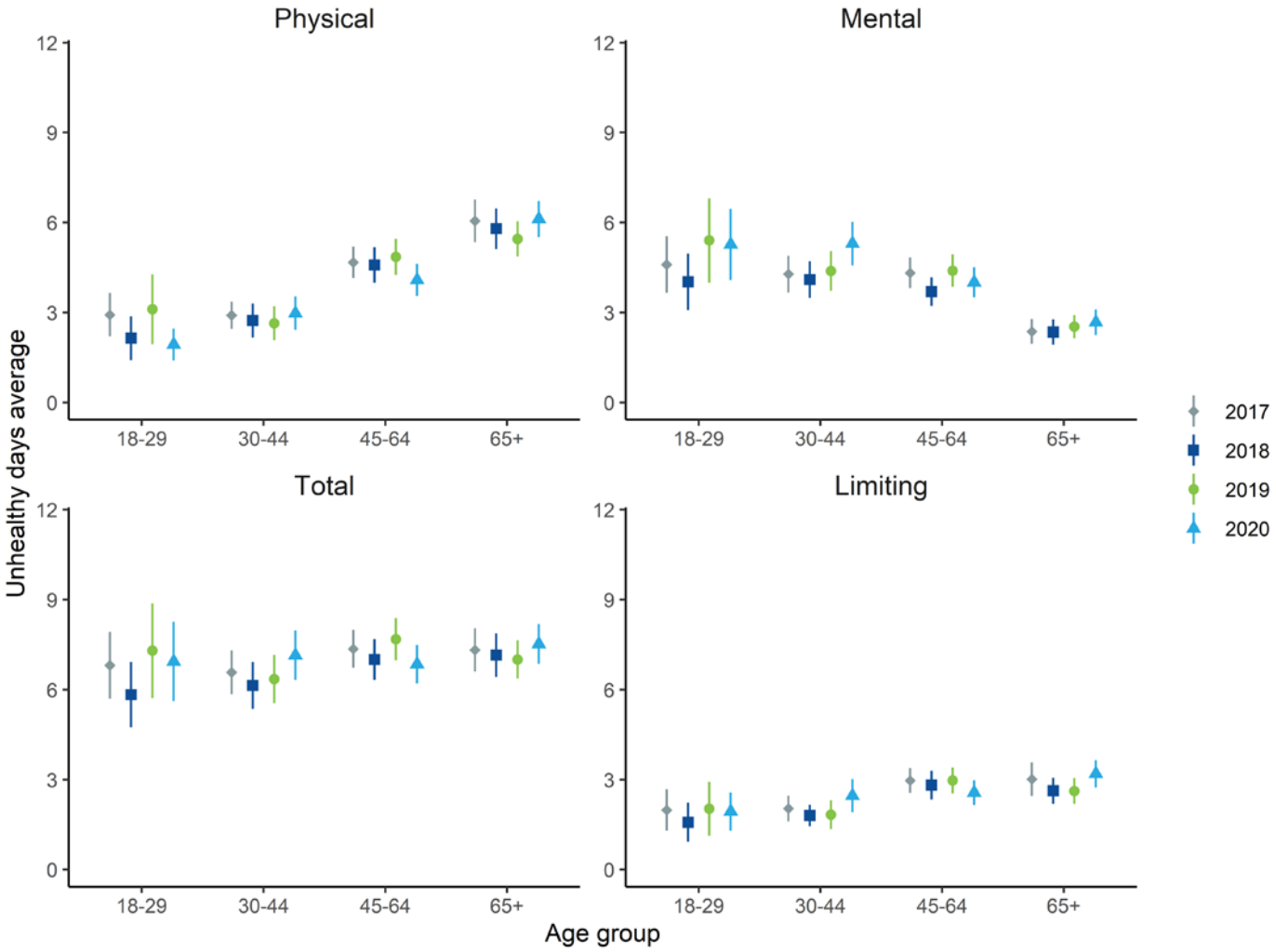

Figure A.3: Average unhealthy days by age groups, Queensland men, 2017 to 2020

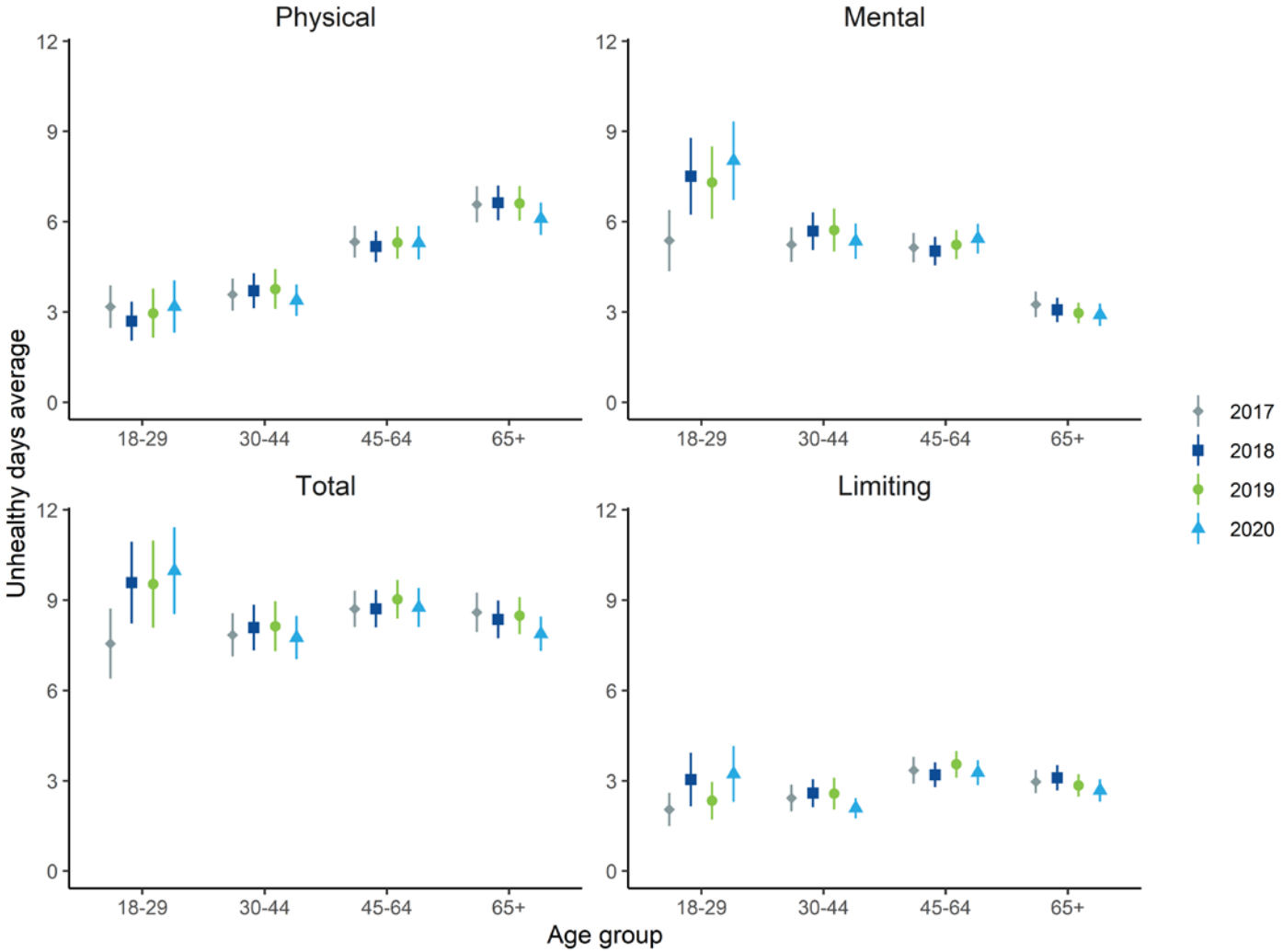

Figure A.4: Average unhealthy days by age groups, Queensland women, 2017 to 2020

Appendix – Technical details of analysis method

Regression analysis plan

The regression analysis used aggregated summary data for combinations of year, sex, age group, and HHS to combine the unhealthy days dataset with the hospitalisations dataset.

Regression analyses used the number of hospitalisations as the outcome variable with the estimated resident populations as the exposure variable. The potential explanatory variables included are the specified unhealthy day type averages, age group, sex, year of data collection and Hospital and Health Service (HHS) regions.

Table A.1: Years of data collection for data analysed in the regression models

Data	Year 1	Year 2	Year 3
Healthy Days	2017	2018	2019
Hospitalisations	2016-17	2017-18	2018-19
Estimated resident populations	2016	2017	2018

Distributional assumption

As our outcome of interest is a count measure (number of hospitalisations), the appropriate regression analysis is either a Poisson or negative Binomial regression. Negative Binomial models allows for overdispersion at the expense of fitting an additional model parameter.

For each hospitalisation type analysed, a Poisson model was first fitted and its model fit assessed, specifically checking for patterns of overdispersion in the model residuals. If there was evidence of overdispersion, the negative Binomial model is warranted.

For all hospitalisation type investigated, there were clear indications of strong overdispersion in the Poisson model residuals. As such, only the fitted negative Binomial model results are presented in this report.

Model coefficient interpretation

For each fitted model, results of the unhealthy day coefficients are presented as a percentage change of the outcome which is more readily interpreted by a general audience. The percentage change is a straightforward calculation from the fitted coefficient value. Specifically, the percentage change is calculated as $(\exp(b) - 1) \times 100\%$ where "b" the is the coefficient value, and "exp(b)" is referred to as the incidence rate ratio (IRR) presented in tables below.

The percentage change calculated was additionally applied to the number of hospitalisations across Queensland in 2019 for the specific hospitalisation type as an example to aid interpretation.

Sensitivity analyses

Two sensitivity analyses were performed to assess the robustness of the model results for the pre-specified unhealthy day type. It is important to note that these sensitivity analyses were conducted from a statistical robustness perspective. As the regression analyses were based on aggregate data rather than individual data, results should be used with caution. Analyses based on individual-level linked data are needed to confirm the findings reported.

The two sensitivity analyses conducted were:

- Removing each variable singly in the regression model and quantifying the change in model performance using a model fit summary measure (McFadden pseudo R^2). This measure provides estimates of the relative importance of each variable in the model.
- Substituting the specified unhealthy days with other unhealthy day types and assessing the change in model inference. This investigation evaluates how sensitive the different unhealthy day types are to the different hospitalisation types.

The model fit summaries used in these investigations are summarised Table A.2. The "% importance" measure was predominantly used in the results texts comparing different model specifications. Similar inferences were obtained using the likelihood-ratio test and Bayesian information criterion to compare models.

Table A.2: Description of statistical model goodness-of-fit summary measures used

Model fit summary	Description
Likelihood-ratio test (LR test) p-value	p-value of the likelihood-ratio test comparing the fitted model against the original specified model. The likelihood-ratio test is only applicable when comparing nested models, and is the uniformly most powerful test for such cases based on the Neyman-Pearson lemma [18]. The calculated p-value can be interpreted as the p-value for testing the null hypothesis that the coefficients omitted in the nested model is equal to zero. The LR test is not an appropriate statistical test when assessing the unhealthy day type substitutions as the models being compared are not nested.
McFadden pseudo R^2	Summary measure of model goodness-of-fit based on fitted log-likelihood values of the specified model and an intercept-only model. Values between 0.2 to 0.4 indicate excellent model fit [19].
% importance	Percentage decrease in the McFadden pseudo R^2 value compared with the original specified model.

Model fit summary	Description
Bayesian information criterion (BIC)	Model goodness-of-fit summary measure based on the model's log-likelihood value with a penalty term for model complexity (to avoid overfitting). Smaller BIC values are statistically preferred.
Change in BIC	Decrease in BIC value of the fitted model and the original specified model. Conventionally, differences smaller than 2 are not statistically meaningful.

Appendix – Technical results

All-causes hospitalisations

The estimated regression coefficients for the all-causes hospitalisation model are tabulated in Table A.3.

The total unhealthy days average variable was a statistically meaningful component of the model and cannot be omitted without adverse effect on the model's statistical performance (Table A.4). Removing the total unhealthy days variable from the model was associated with 1.3% decrease in pseudo R^2, which was the second smallest percentage decrease after the year variable (0.44% decrease). The fitted model can be simplified by removing year from the model specification only without notable loss in statistical fit based on likelihood-ratio test p-value.

Substitution of total unhealthy days variable with any other unhealthy day types were associated with decreases in model performance (decreases in pseudo R^2 and increases in BIC in Table A.4). This indicated that total unhealthy days was the best-fitting unhealthy days (UHD) type to include in the model for all-causes hospitalisations.

Table A.3: All-causes hospitalisation regression coefficient estimates, adjusting for year and HHS

Variables	Estimate	SE	p-value	IRR
Male	(reference)			
Female	0.20	0.02	<0.001	1.22
18-24 years	(reference)			
25-34 years	0.17	0.04	<0.001	1.19
35-44 years	0.27	0.04	<0.001	1.32
45-54 years	0.55	0.04	<0.001	1.74
55-64 years	0.96	0.04	<0.001	2.61
65-74 years	1.40	0.04	<0.001	4.07
75 years and older	1.74	0.04	<0.001	5.70
Total unhealthy days average	0.02	0.004	<0.001	1.02

Table A.4: Statistical model fit summaries for all-causes hospitalisation regression analysis

Model	LR test p-value	BIC	McFadden pseudo R^2	% importance	Change in BIC
Specified model	-	11002.52	0.1020	0	0
Model without total unhealthy days average	<0.001	11012.37	0.1006	1.32	-9.85
Model without HHS	<0.001	11064.55	0.0894	12.37	-62.03
Model without age group	<0.001	12168.34	0.0022	97.87	-1165.83
Model without sex	<0.001	11075.13	0.0954	6.42	-72.61
Model without year	0.067	10995.02	0.1016	0.44	7.49
Model substituting total UHD with physical UHD	-	11015.87	0.1009	1.09	-13.35
Model substituting total UHD with mental UHD	-	11004.36	0.1018	0.15	-1.84
Model substituting total UHD with limiting UHD	-	11016.15	0.1009	1.11	-13.64

Mental and behavioural disorder hospitalisations

The mental unhealthy days average was a statistically meaningful model component (Table A.5). The likelihood-ratio test result indicated that the coefficient associated with mental unhealthy days average is statistically different from zero (p-value = 0.04 in Table A.6). Removing the mental unhealthy days from the model specification was associated with a 0.43% decrease in pseudo R^2.

The effect of mental unhealthy days average on mental and behavioural disorder hospitalisations was not observed when using physical and limiting unhealthy days averages in place of mental unhealthy days average. A smaller effect was obtained with total unhealthy days substituting mental unhealthy days, likely representing the dilution of the mental unhealthy days component in total unhealthy days with physical unhealthy days (which was not associated with mental and behavioural disorder hospitalisations).

These findings are important as they indicate that mental unhealthy days average is a useful measure for monitoring mental health at the population level, as shown by its association with mental and behavioural disorder hospitalisations. Additionally, this effect is specific to mental unhealthy days and was not observed with other unhealthy day types.

Table A.5: Mental and behavioural disorder related hospitalisation regression coefficient estimates, adjusting for year and HHS

Variables	Estimate	SE	p-value	IRR
Male	(reference)			
Female	-0.13	0.02	<0.001	0.88
18-24 years	(refence)			
25-34 years	0.05	0.03	0.123	1.05
35-44 years	0.26	0.03	<0.001	1.30
45-54 years	0.31	0.03	<0.001	1.36
55-64 years	0.23	0.03	<0.001	1.25
65-74 years	0.23	0.04	<0.001	1.26
75 years and older	0.95	0.04	<0.001	2.59
Mental unhealthy days average	0.01	0.005	0.04	1.01

Table A.6: Statistical model fit summaries for mental and behavioural disorder related hospitalisation regression analysis

Model	LR test p-value	BIC	McFadden pseudo R^2	% importance	Change in BIC
Specified model	-	8489.94	0.1019	0	0
Model without mental unhealthy days	0.04	8487.57	0.1015	0.43	2.37
Model without HHS	<0.001	8967.65	0.0406	60.14	-477.71
Model without age group	<0.001	9023.66	0.0401	60.62	-533.72
Model without sex	<0.001	8527.86	0.0971	4.70	-37.92
Model without year	<0.001	8553.64	0.0936	8.11	-63.70
Model substituting mental UHD with physical UHD	-	8491.19	0.1018	0.13	-1.25
Model substituting mental UHD with total UHD	-	8486.16	0.1023	-0.40	3.78
Model substituting mental UHD with limiting UHD	-	8492.83	0.1016	0.31	-2.89

Musculoskeletal hospitalisations

Removing the physical unhealthy days average variable from the model resulted in a 0.21% decrease in model performance (Table A.8). While this decrease was the third smallest decrease after limiting unhealthy days average (0.03%) and sex (0.14%), physical unhealthy days average was a statistically significant model component as opposed to limiting unhealthy days and sex (Table A.7). The fitted model can potentially be simplified by removing limiting unhealthy days average and sex from the model specification without notable loss in statistical fit based on likelihood-ratio test p-value and change in BIC.

Using physical or limiting unhealthy days average singly in place of both measures in the model for musculoskeletal hospitalisations resulted in statistically significant estimates for the respective unhealthy day type (0.01 (SE: 0.004), p-value = 0.005 for physical singly, and 0.01 (SE:0.006), p-value = 0.05 for limiting singly) . This indicates that both unhealthy day types are potentially quantifying the same underlying physical fitness level related to musculoskeletal hospitalisations. As such, only one of the two unhealthy day types was required in the model.

In contrast, mental unhealthy days average was not associated with musculoskeletal hospitalisations (estimate was 0.001 (SE: 0.005) with p-value 0.77). Substituting physical and

limiting unhealthy days average with mental or total unhealthy days average did not improve the model's statistical fit based on the change in BIC values (Table A.8).

Table A.7: Musculoskeletal-related hospitalisation regression coefficient estimates, adjusting for year and HHS

Variables	Estimate	SE	p-value	IRR
Male	(reference)			
Female	0.03	0.02	0.076	1.03
18-24 years	(refence)			
25-34 years	0.51	0.03	<0.001	1.67
35-44 years	1.23	0.03	<0.001	3.41
45-54 years	1.83	0.03	<0.001	6.25
55-64 years	2.48	0.03	<0.001	11.91
65-74 years	3.00	0.03	<0.001	20.10
75 years and older	3.17	0.04	<0.001	23.81
Physical unhealthy days average	0.01	0.004	0.032	1.01
Limiting unhealthy days average	0.01	0.01	0.393	1.01

Table A.8: Statistical model fit summaries for musculoskeletal-related hospitalisation regression analysis

Model	LR test p-value	BIC	McFadden pseudo R^2	% importance	Change in BIC
Specified model	-	9063.87	0.1926	0	0
Model without limiting UHD	0.40	9058.15	0.1925	0.03	5.73
Model without physical UHD	0.03	9061.98	0.1922	0.21	1.89
Model without physical and limiting UHDs	0.01	9059.41	0.1918	0.40	4.46
Model without HHS	<0.001	9164.89	0.1752	9.02	-101.02
Model without age group[1]	-	-	-	-	-
Model without sex	0.08	9060.50	0.1923	0.14	3.37

Model	LR test p-value	BIC	McFadden pseudo R^2	% importance	Change in BIC
Model without year	<0.001	9074.68	0.1904	1.12	-10.80
Model substituting physical and limiting UHDs with mental UHD	-	9065.77	0.1918	0.39	-1.90
Model substituting physical and limiting UHDs with total UHD	-	9061.44	0.1922	0.19	2.43

1. Model does not converge when age group variable was removed

Respiratory hospitalisations

Both physical unhealthy days average and sex were not associated with respiratory hospitalisation rates (Table A.9). Removing limiting unhealthy days average from the model specification for respiratory hospitalisations resulted in 0.44% decrease in model performance (Table A.10). Smaller model performance decrements were observed for physical unhealthy days averages (0.003%) and sex (0.03%). The fitted model specification can be simplified by removing these two variables based on the likelihood-ratio test p-value and nearly identical pseudo R^2 values for the simpler models compared with the full model.

Substituting physical and limiting unhealthy days averages with either mental or total unhealthy days averages resulted in notable improvement in statistical fit based on the reductions in BIC values (Table A.10). This finding indicates that there could be a potential relationship between mental unhealthy days and respiratory hospitalisations for this data set, as the effect of physical unhealthy days was not statistically meaningful. A potential investigation which was outside of the scope of this investigation could be the assessing if a model using both mental and limiting unhealthy days would be statistically preferred over the models tested here.

Table A.9: Respiratory hospitalisation regression coefficient estimates, adjusting for year and HHS

Variables	Estimate	SE	p-value	IRR
Male	(reference)			
Female	-0.01	0.01	0.392	0.99
18-24 years	(refence)			
25-34 years	-0.15	0.03	<0.001	0.86
35-44 years	0.06	0.03	0.03	1.06
45-54 years	0.36	0.03	<0.001	1.43
55-64 years	0.85	0.03	<0.001	2.35
65-74 years	1.52	0.03	<0.001	4.56
75 years and older	2.35	0.03	<0.001	10.45
Physical unhealthy days average	0.001	0.004	0.794	1.00
Limiting unhealthy days average	0.02	0.01	0.002	1.02

Table A.10: Statistical model fit summaries for respiratory related hospitalisation regression analysis

Model	LR test p-value	BIC	McFadden pseudo R^2	% importance	Change in BIC
Specified model	-	7431.87	0.2243	0	0
Model without limiting UHD	0.0023	7434.73	0.2233	0.44	-2.86
Model without physical UHD	0.80	7425.50	0.2243	0.0032	6.38
Model without physical and limiting UHDs	0.0018	7431.58	0.2230	0.60	0.29
Model without HHS	<0.001	7831.94	0.1719	23.36	-400.06
Model without age group[1]	-	-	-	-	-
Model without sex	0.40	7426.15	0.2242	0.03	5.72
Model without year	<0.001	7435.96	0.2225	0.81	-4.09

Model	LR test p-value	BIC	McFadden pseudo R^2	% importance	Change in BIC
Model substituting physical and limiting UHDs with mental UHD	-	7409.66	0.2260	-0.75	22.21
Model substituting physical and limiting UHDs with total UHD	-	7417.09	0.2252	-0.40	14.79

1. Model does not converge when age group variable was removed

Coronary obstructive pulmonary disorder hospitalisations

The coefficients of physical and limiting unhealthy days averages were not statistically different from zero for the coronary obstructive pulmonary disorder hospitalisations model (Table A.11). Removing both unhealthy days averages and year resulted in the smallest decreases in statistical performance for this model (based on the % importance and likelihood-ratio tests in Table A.12). As such, these variables can potentially be omitted from the model specification with minimal decrements in the model's statistical performance.

While substituting the physical and limiting unhealthy days averages with either mental or total unhealthy days averages resulted in smaller BIC values (Table A.12), none of the estimated coefficients were statistically different from zero. These findings imply that none of the unhealthy day types were associated with coronary obstructive pulmonary disorder hospitalisations in this data set.

Table A.11: Coronary obstructive pulmonary disorder hospitalisation regression coefficient estimates, adjusting for year and HHS

Variables	Estimate	SE	p-value	IRR
Male	(reference)			
Female	-0.10	0.03	<0.001	0.90
18-24 years	(refence)			
25-34 years	0.47	0.12	<0.001	1.60
35-44 years	2.10	0.11	<0.001	8.20
45-54 years	3.65	0.11	<0.001	38.59
55-64 years	4.76	0.11	<0.001	116.87
65-74 years	5.68	0.11	<0.001	293.48
75 years and older	6.48	0.11	<0.001	649.10
Physical unhealthy days average	0.00	0.01	0.845	1.00
Limiting unhealthy days average	0.02	0.01	0.18	1.02

Table A.12: Statistical model fit summaries for coronary obstructive pulmonary disorder related hospitalisation regression analysis

Model	LR test p-value	BIC	McFadden pseudo R^2	% importance	Change in BIC
Specified model	-	5040.33	0.2914	0	0
Model without limiting UHD	0.19	5035.63	0.2912	0.09	4.71
Model without physical UHD	0.85	5033.93	0.2914	0.0018	6.41
Model without physical and limiting UHDs	0.39	5029.35	0.2912	0.09	10.99
Model without HHS	<0.001	5385.17	0.2281	21.73	-344.83
Model without age group[1]	-	-	-	-	-
Model without sex	<0.001	5046.84	0.2896	0.65	-6.51
Model without year	0.95	5027.54	0.2914	0.0047	12.80

Model	LR test p-value	BIC	McFadden pseudo R^2	% importance	Change in BIC
Model substituting physical and limiting UHDs with mental UHD	-	5032.17	0.2917	-0.09	8.16
Model substituting physical and limiting UHDs with total UHD	-	5034.02	0.2914	0.01	6.31

1. Model does not converge when age group variable was removed.

Pneumonia and influenza hospitalisations

The coefficients of physical and limiting unhealthy days averages were not statistically different from zero for the pneumonia and influenza hospitalisations model (Table A.13). Removing the unhealthy days averages were associated with the smallest decreases in model performance (0.12% decrease when removing limiting, 0.04% decrease when removing physical, and 0.13% decrease when removing both) (Table A.14). As such, the specified model could potentially be simplified by removing both unhealthy days averages.

Substituting the physical and limiting unhealthy days averages with mental unhealthy days average resulted in improvements in both pseudo R^2 and BIC for the pneumonia and influenza hospitalisations model. Additionally, the associated coefficient for mental unhealthy days average was statistically significant (0.016 (SE: 0.006), p-value = 0.008), implying a potential association between mental unhealthy days and pneumonia and influenza related hospitalisations that could be more closely examined in future investigations.

Table A.13: Pneumonia and influenza related hospitalisation regression coefficient estimates, adjusting for year and HHS

Variables	Estimate	SE	p-value	IRR
Male	(reference)			
Female	-0.06	0.02	<0.001	0.94
18-24 years	(refence)			
25-34 years	0.14	0.04	<0.001	1.15
35-44 years	0.51	0.04	<0.001	1.67
45-54 years	0.88	0.04	<0.001	2.42
55-64 years	1.48	0.04	<0.001	4.39
65-74 years	2.20	0.04	<0.001	9.00
75 years and older	3.31	0.04	<0.001	27.47

Variables	Estimate	SE	p-value	IRR
Physical unhealthy days average	-0.005	0.005	0.327	1.00
Limiting unhealthy days average	0.01	0.01	0.103	1.01

Table A.14: Statistical model fit summaries for pneumonia and influenza related hospitalisation regression analysis

Model	LR test p-value	BIC	McFadden pseudo R^2	% importance	Change in BIC
Specified model	-	5643.03	0.2753	0	0
Model without limiting UHD	0.11	5639.15	0.2749	0.12	3.88
Model without physical UHD	0.35	5637.45	0.2752	0.04	5.59
Model without physical and limiting UHDs	0.27	5632.76	0.2749	0.13	10.27
Model without HHS	<0.001	6385.59	0.1649	40.09	-742.56
Model without age group[1]	-	-	-	-	-
Model without sex	<0.001	5648.77	0.2737	0.59	-5.74
Model without year	<0.001	5695.05	0.2667	3.12	-52.02
Model substituting physical and limiting UHDs with mental UHD	-	5632.20	0.2759	-0.21	10.83
Model substituting physical and limiting UHDs with total UHD	-	5637.73	0.2751	0.06	5.30

1. Model does not converge when age group variable was removed.

Appendix – Summary HHS tables

The HHS regions exhibited similar physical, mental, total and limiting unhealthy days averages (Table A.15). The age-standardised averages for the HHSs (Table A.16) were similar to the crude averages. The most up-to-date information will be available on QSAS [17].

Table A.15: Average unhealthy days in the past 30 days by HHS, Queensland adults, 2017-18

HHS	Mean unhealthy days (95% confidence intervals)			
	Physical	Mental	Total	Limiting
Cairns and Hinterland	4.1 (3.7–4.5)	4.3 (3.8–4.8)	7.5 (6.8–8.1)	2.8 (2.4–3.3)
Central Queensland	4.2 (3.8–4.6)	4.7 (4.3–5.2)	7.9 (7.3–8.4)	2.6 (2.2–2.9)
Central West	4.1 (3.2–5.1)	4.7 (3.3–6.0)	8.0 (6.6–9.4)	2.5 (1.7–3.2)
Darling Downs	4.9 (4.5–5.4)	4.3 (3.9–4.7)	7.9 (7.4–8.5)	2.7 (2.4–3.0)
Gold Coast	4.1 (3.6–4.6)	4.0 (3.5–4.5)	7.2 (6.6–7.8)	2.7 (2.3–3.1)
Mackay	3.9 (3.4–4.3)	4.6 (4.1–5.1)	7.5 (6.9–8.1)	2.2 (1.9–2.6)
Metro North	4.5 (4.1–5.0)	4.6 (4.2–5.1)	8.0 (7.4–8.5)	2.7 (2.3–3.0)
Metro South	3.5 (3.2–3.9)	4.2 (3.8–4.6)	6.9 (6.4–7.4)	2.2 (1.9–2.5)
North West	3.8 (3.0–4.6)	3.9 (3.1–4.7)	6.6 (5.6–7.6)	2.0 (1.5–2.5)
South West	4.6 (3.9–5.3)	3.9 (3.3–4.4)	7.4 (6.6–8.2)	2.6 (2.1–3.1)
Sunshine Coast	4.8 (4.2–5.3)	4.3 (3.8–4.8)	7.9 (7.2–8.6)	3.0 (2.6–3.5)
Townsville	4.6 (4.0–5.3)	4.7 (4.1–5.3)	8.0 (7.2–8.7)	2.7 (2.3–3.2)
Wide Bay	5.5 (5.0–6.0)	5.5 (5.0–6.1)	9.2 (8.5–9.8)	3.4 (2.9–3.8)
West Moreton	4.9 (4.4–5.4)	5.3 (4.8–5.9)	8.5 (7.8–9.2)	3.2 (2.8–3.7)
Torres and Cape	2.9 (1.8–4.0)	2.6 (1.8–3.5)	5.2 (3.9–6.6)	1.8 (0.9–2.6)
Queensland[1]	**4.3 (4.1–4.4)**	**4.5 (4.3–4.6)**	**7.6 (7.4–7.9)**	**2.6 (2.5–2.8)**

1. For Queensland data by single year, refer to QSAS.

Table A.16: Age-standardised average unhealthy days in the past 30 days by HHS, Queensland adults, 2017-18

HHS	Mean unhealthy days (95% confidence intervals)			
	Physical	Mental	Total	Limiting
Cairns and Hinterland	3.9 (3.5–4.4)	4.3 (3.8–4.8)	7.3 (6.7–7.9)	2.7 (2.3–3.1)
Central Queensland	4.3 (3.8–4.7)	4.8 (4.3–5.3)	7.9 (7.4–8.5)	2.6 (2.3–3.0)
Central West	4.2 (3.1–5.2)	4.6 (3.5–5.8)	8.0 (6.6–9.4)	2.4 (1.6–3.2)
Darling Downs	4.8 (4.3–5.2)	4.4 (4.0–4.9)	7.9 (7.3–8.5)	2.6 (2.3–3.0)
Gold Coast	4.0 (3.6–4.5)	4.1 (3.6–4.6)	7.2 (6.6–7.8)	2.7 (2.2–3.1)
Mackay	3.9 (3.5–4.4)	4.6 (4.1–5.1)	7.5 (6.9–8.2)	2.3 (1.9–2.6)
Metro North	4.6 (4.1–5.0)	4.6 (4.2–5.0)	8.0 (7.4–8.5)	2.7 (2.3–3.0)
Metro South	3.6 (3.3–4.0)	4.1 (3.7–4.5)	6.9 (6.5–7.4)	2.2 (1.9–2.5)
North West	4.2 (3.3–5.1)	3.8 (3.1–4.6)	6.9 (5.9–7.9)	2.2 (1.6–2.8)
South West	4.4 (3.7–5.1)	3.9 (3.3–4.5)	7.3 (6.4–8.1)	2.5 (2.0–3.0)
Sunshine Coast	4.6 (4.0–5.2)	4.5 (3.9–5.1)	7.9 (7.1–8.7)	2.9 (2.5–3.4)
Townsville	4.6 (4.0–5.2)	4.7 (4.1–5.3)	8.0 (7.2–8.7)	2.7 (2.3–3.1)
Wide Bay	5.1 (4.5–5.7)	6.0 (5.3–6.8)	9.3 (8.5–10.1)	3.3 (2.8–3.8)
West Moreton	4.9 (4.4–5.4)	5.2 (4.7–5.8)	8.4 (7.8–9.1)	3.2 (2.8–3.7)
Torres and Cape	3.1 (1.9–4.2)	2.7 (1.8–3.6)	5.5 (4.1–6.9)	*1.9 (1.0–2.8)
Queensland[1]	**4.3 (4.1–4.4)**	**4.5 (4.3–4.7)**	**7.6 (7.4–7.9)**	**2.6 (2.5–2.8)**

* Estimates have a relative standard error of 25% to 50% and should be used with caution.
1. For Queensland data by single year, refer to QSAS.

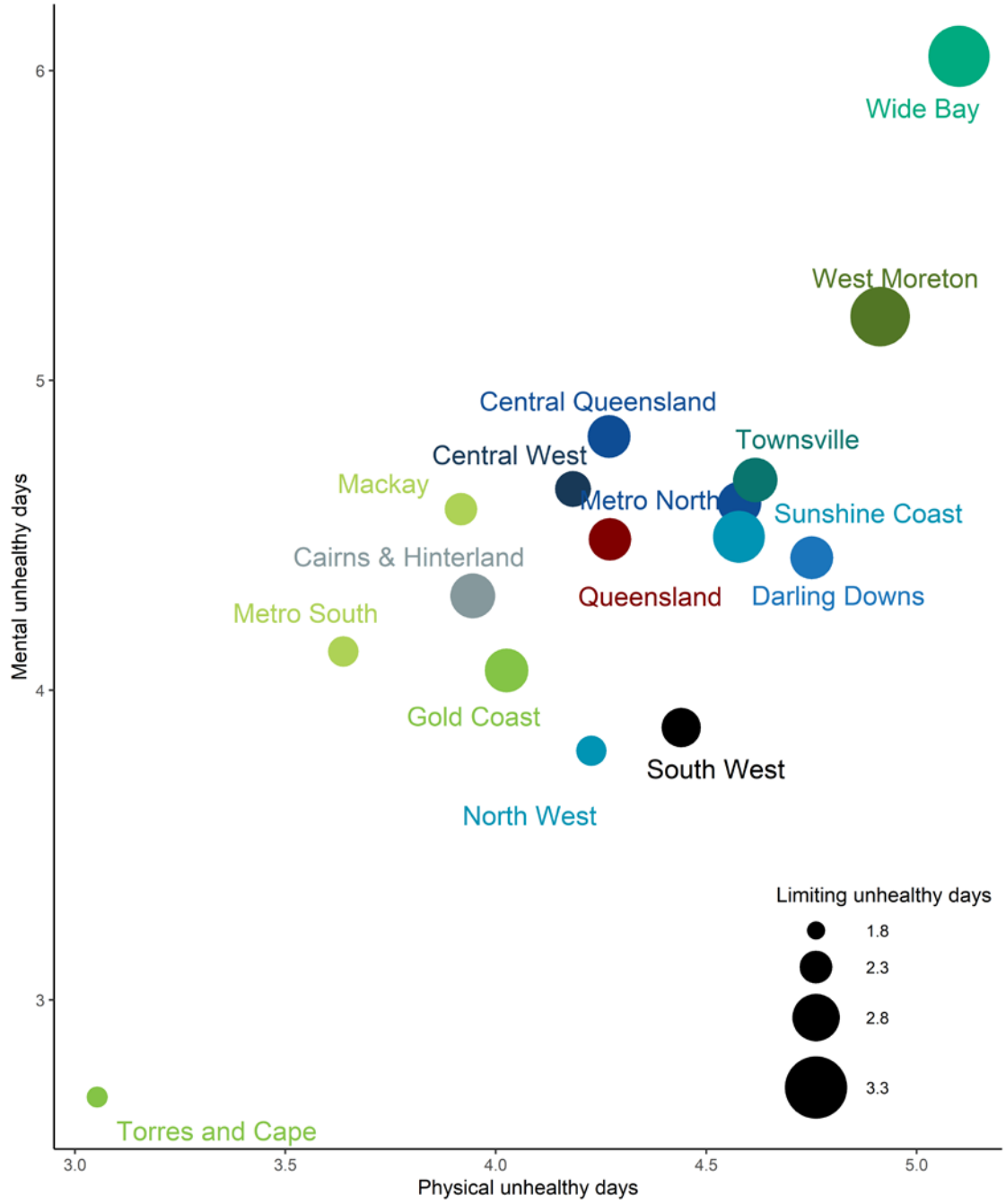

Figure A.5: Age-standardised average unhealthy days in the past 30 days by HHS, Queensland adults, 2017-18

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