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Geographic distribution of asthma and chronic obstructive pulmonary disease hospitalisations in Australia 2007–08 to 2009–10

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Authoritative information and statistics to promote better health and wellbeing

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Contents

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Abbreviations

ABS	Australian Bureau of Statistics
AIHW	Australian Institute of Health and Welfare
ARIA	Accessibility/Remoteness Index of Australia
ASGC	Australian Standard Geographical Classification
COPD	chronic obstructive pulmonary disease
ERP	Estimated Resident Population
ICD-10	International Statistical Classification of Diseases and Related Health Problems, 10th revision
ICD-10-AM	International Statistical Classification of Diseases and Related Health Problems, 10th revision, Australian Modification
IRSAD	Index of Relative Socio-economic Advantage and Disadvantage
NHMD	National Hospital Morbidity Database
NHS	National Health Survey
SES	socioeconomic status
SLA	Statistical Local Area
SSD	Statistical Sub-division
WHO	World Health Organization

Summary

This report shows how asthma and chronic obstructive pulmonary disease (COPD) hospitalisations vary across Australia. It also examines the association between these hospitalisation rates and socioeconomic status (SES), remoteness and the proportion of Indigenous Australians in different locations across Australia.

Maps presented in this report show higher hospitalisation rates for both asthma and COPD in inland Australia and rural areas. Asthma hospitalisation rates are also higher in certain coastal areas in Queensland, in south-east South Australia and in south Western Australia. In comparison, COPD hospitalisation rates are higher in much of the Northern Territory and north-west Western Australia.

Further investigation found that SES, remoteness and the proportion of the population that identifies as Indigenous all had a significant association with the hospitalisation rates for asthma and COPD by area.

There may be further reasons for the variation in hospitalisation rates for asthma and COPD, such as:

- location specific factors, such as air pollution and allergic triggers
- access to hospital and primary care services
- variation in smoking rates.

These issues could be explored in further studies.

1 Introduction

This report investigates the geographic distribution of hospitalisation for asthma and chronic obstructive pulmonary disease (COPD) in Australia.

Asthma is a chronic inflammatory condition of the airways associated with episodes of wheezing, breathlessness and chest tightness. The symptoms of asthma are usually reversible, either spontaneously or with treatment.

There is evidence that environmental and lifestyle factors, as well as genetic factors (such as an allergic tendency) increase the risk of developing asthma (GINA 2011).

Among those with asthma, symptoms can be triggered by exposure to allergens such as house dust mites, pollens and mould spores. Symptoms can also be triggered by viral infections, exercise, air pollutants, tobacco smoke and occupational allergens or irritants.

COPD is a serious long-term lung disease that mainly affects middle-aged to older adults. The term COPD encompasses bronchitis and emphysema. It is characterised by airflow limitation that is not fully reversible with treatment. People with the disease may experience shortness of breath as well as cough, phlegm and wheeze.

Tobacco smoking is the predominant cause of COPD (Forey et al. 2011). However, there is evidence that genetic and/or other environmental factors are involved. Exposure to outdoor air pollution, occupational fumes and dusts, as well as a history of pulmonary tuberculosis, childhood respiratory infections, or chronic asthma are all associated with an increased risk of COPD (Salvi & Barnes 2009).

Among those with COPD, exacerbations can be triggered by viral or bacterial infections as well as exposure to environmental pollutants (Celli & Barnes 2007).

It is estimated that nearly 10% of the Australian population have asthma. Prevalence data for COPD is less clear, however, it is believed that among those aged 55 and over, at least 5% have COPD (AIHW: ACAM 2011).

1.1 What do we already know about the distribution of asthma and COPD?

Many studies have suggested that asthma and COPD have a greater impact on particular population groups (AIHW: ACAM 2011).

The prevalence of asthma (estimated from self-reported data from the 2007–08 National Health Survey, or NHS) tends to be significantly higher in people living in areas with lower socioeconomic status (SES) than in people living in areas with higher SES. The prevalence of asthma is also significantly higher in people living in *Inner regional* areas than in those living in *Major cities* (AIHW: ACAM 2011).

Similar disparities have been noted in relation to hospitalisations for asthma, which are higher for:

- people living in areas with lower SES compared with those living in areas with higher SES
- adults living in *Remote* areas compared with adults living in *Major cities*

- Aboriginal and Torres Strait Islander people compared with Other Australians (for ages 5 and over)
- people from an English-speaking background compared with those from a non-English-speaking background (AIHW: ACAM 2011).

The prevalence of COPD (estimated from self-reported data from the 2007–08 NHS) among people aged 55 and over does not differ between people living in *Major cities*, *Inner regional* areas or *Other* areas (covering *Outer regional* and *Remote* categories of remoteness) (AIHW: ACAM 2011).

COPD hospitalisations are higher for:

- people living in areas with lower SES compared with those living in areas with higher SES
- people living in *Remote* areas compared with *Major cities*
- Indigenous Australians compared with Other Australians
- people from an English-speaking background compared with those from a non-English-speaking background (AIHW: ACAM 2011).

The variation in the impact of the disease between population groups noted for asthma and COPD is similar to that for many health conditions. For example, in 2007–08, overall hospitalisation rates were higher for Indigenous Australians than Other Australians. Hospitalisation rates were higher in the fifth of the population with the lowest SES compared with the fifth of the population with the highest SES, and in more remote areas compared with urban areas (AIHW 2009).

1.2 Purpose of this report

This report aims to provide information about how asthma and COPD hospitalisations vary across Australia. It looks at the role played in this variation by socioeconomic status, remoteness and proportion of Indigenous Australians in different locations across Australia.

2 Methods

2.1 Data

Regions investigated

The report investigates regions in Australia called Statistical Sub-divisions (SSDs). There are 217 SSDs in Australia with population numbers ranging from 280 to 517,000 and with an average population of 99,000. In aggregate, SSDs cover the whole of Australia without gaps or overlays. The SSD boundaries were calculated by the Australian Bureau of Statistics (ABS) (ABS 2006b). Eight SSDs covering offshore and migratory areas were excluded from the analysis.

Hospitalisation data

Hospital separations for asthma and COPD were extracted from the Australian Institute of Health and Welfare (AIHW) National Hospital Morbidity Database (NHMD) for July 2007 to June 2010. A hospital separation is defined as an episode of care for an admitted patient, which can be a total hospital stay or a portion of a hospital stay beginning or ending in a change of type of care (AIHW 2011).

Hospital separations were extracted from the NHMD when asthma or COPD was the principal diagnosis (the diagnosis of the problem that was the main reason for admission). Hospital separations were also extracted from the NHMD for all causes combined for comparison purposes.

In the NHMD, the hospital separation records contain information about the Statistical Local Area (SLA) of usual residence of the patient (where the patient usually lives, not where they were treated). This information can be used to identify the SSD of usual residence of the patient, as SLAs are smaller areas that fit within SSDs.

See Appendix B Section B.1 for the codes used and a further discussion of SLA information.

Age ranges

This report focuses on asthma hospitalisations for people aged 5–34 and COPD hospitalisations for people aged 55+. The diagnosis of asthma is most certain in the age range 5–34 and COPD is an uncommon cause of hospitalisation in people aged under 55.

Time period

Due to the small numbers involved, 3 years of hospital separation data were combined to create larger, more stable numbers and allow analysis for small geographic areas. This report combined data from the 2007–08, 2008–09 and 2009–10 financial years.

2.2 Calculating and interpreting hospitalisation rates

Calculation of hospital separation rates

Hospital separation rates for asthma and COPD were calculated by dividing the average yearly number of hospital separations in each SSD by the estimated SSD population within the specified age range. The hospital separations were taken from 2007–08 to 2009–10, and this number was divided by three to give the average yearly number of hospital separations across this 3-year period. The rate for hospital separations is different to a rate for the number of people hospitalised, as in some cases one person's stay in hospital will generate multiple separations. Estimated resident populations (ERPs) based on the mid-year 2006 Census of Population of Housing provided the most recent Census-based estimates of SSD population size. All data in this report were based on the 2006 SSD boundaries set by the ABS.

The hospital separation rates by SSD were not age-standardised, however, the rates were limited to ages 5–34 for asthma and 55+ for COPD.

Exclusion of SSDs with unstable rates due to low populations

SSDs with fewer than 1,000 people in the age range of interest were not presented. The low hospital separation numbers in these SSDs gave rise to rates that were unstable and subject to higher uncertainty.

For the asthma analysis, two SSDs had fewer than 1,000 people in the 5–34 age range. For the COPD analysis, eight SSDs had fewer than 1,000 people in the 55+ age range. These SSDs are listed in Appendix B, Section B.2.

How can SSDs with high or low rates be interpreted?

Hospitalisation rates can reflect demand, supply and admission practices.

A higher rate of hospital separations for a particular condition in a SSD may indicate:

- a higher prevalence of the more severe cases of the condition that require hospital treatment
- a higher prevalence of comorbidities that increase the likelihood of hospitalisation
- a higher level of access to hospital (including different thresholds for admission)
- less or poorer quality care available within the primary health care setting
- a higher rate of re-admission to hospital due to poorer management of the condition across the hospital and non-hospital settings
- a greater propensity of doctors to use diagnostic terms that are coded as asthma or COPD.

2.3 Investigating how the hospitalisation rates vary by location

This report tests the hypothesis that the variation in hospitalisation rates for asthma and COPD is significantly affected by location.

Strictly speaking, any variation between SSDs could be taken as an influence of location. It is assumed, however, that some variation will occur between SSDs due to random factors and factors unrelated or partially related to location, such as SES and the proportion of the SSD population that identifies as Indigenous.

It is also assumed that the degree of this variation will be influenced by the volume of hospitalisations for the condition. That is, if a condition has a high rate of hospitalisation, we expect to see more variation in the hospitalisation rates for the condition between SSDs, due to a larger scope for random effects. Therefore, because hospitalisations for COPD are far more common than for asthma, we assume that the variation in hospitalisation rates for COPD will be greater than for asthma.

This raises a question of how the variation in hospital separation rates by SSD can be tested, to ascertain if location is a statistically significant predictor of SSD separation rates. Four methods for interpreting this variation were used.

Mapping the data

The hospitalisation rates for asthma and COPD by SSD are presented on a map of Australia (Chapter 3). The hospitalisation rates by SSD are also shown for the five most highly populated cities in Australia, and surrounding regions, as well as the Australian Capital Territory and Tasmania (Appendix A). The hospitalisation rates were divided into quartiles and each quartile is shown in a different colour. SSDs with fewer than 1,000 people in the age range of interest were not used in the analysis, and are shown on the maps in white.

These maps give an overview of the range of asthma and COPD hospitalisation rates in Australia, however, larger SSDs are given more prominence when the data are displayed in this form, and smaller SSDs are given less prominence.

Measuring the variation in the data

Interdecile range method

The variation in hospitalisation rates by SSD for asthma or COPD was measured using the 'interdecile range'. Deciles divide a data set into 10 parts, each containing an equal number of observations. The interdecile range is the difference between the first and the tenth deciles. Thus, the interdecile range covers the inner 80% of the spread of a data set. This measure was chosen because it takes into account the spread of the majority of the data, but is not influenced by outlying values. If the variation in hospitalisation rates by SSD is high, the interdecile range will be large.

Coefficient of variation method

The coefficient of variation is another measure of the variation present in a data set. It has the advantage over the interdecile range that it corrects for the magnitude of the values in the data set. This is useful because when a condition is common, it is more likely to have a wide

distribution of hospitalisation rates. Thus, when comparing the variation in hospitalisations for conditions that differ in prevalence, it is desirable to correct for this effect.

The coefficient of variation is calculated by taking a measure of the spread of a data set and dividing it by a measure of the magnitude of the values in the data set. Specifically, it is calculated by dividing the standard deviation of the data set by the mean of the data set.

In this report, the coefficient of variation was calculated for the asthma and COPD hospitalisations by SSD, and compared with the distribution of hospitalisations for all causes by SSD, for the corresponding age ranges. The distribution of all-cause hospitalisations by SSD is a useful data set for comparison to assess the relative degree of variability between conditions.

Poisson regression method

A regression model was used to investigate the extent to which variation in hospitalisation rates by SSD could be explained by variation in SES, remoteness and the proportion of Indigenous Australians in the SSD. A regression model was fitted to the hospitalisation data for asthma, and a separate regression model was fitted to the hospitalisation data for COPD. A Poisson model was chosen for the analysis because this model gave a better fit to the data than a multiple linear model.

The generalised coefficient of determination, also called the generalised R^2, is the proportion of variability in a data set that is accounted for by the statistical model. Once the Poisson regression model has been fitted, this measure indicates how much of the variation in hospitalisations by SSD can be accounted for by variation in SES, remoteness and the proportion of Indigenous Australians. This measure is expressed as a percentage. A result of 0% means that none of the variation can be explained by the chosen variables, and a result of 100% means that all of the variation can be explained by the chosen variables. The method used to calculate the generalised R^2 in this report is in Appendix C, Section C.1.

The SES and remoteness of the SSD, as well as the proportion of Indigenous Australians in the SSD, were considered as explanatory variables in the regression models. There is good reason to expect that these variables are correlated (an issue called 'collinearity'), so the model with the greatest R^2 may not include all three variables. For information about these three measures, see Appendix B, Section B.3.

The three explanatory variables were run in separate Poisson models. A final model was chosen by testing all possible models using the three explanatory variables and choosing the combination of variables that gave the highest explanatory power (R^2), where each included variable was required to make a statistically significant contribution to the model.

The statistical significance of the Poisson model was tested using a goodness-of-fit chi-squared test (UCLA 2012b). If this test returns a P value that is greater than 0.05, it can be concluded that the regression model fits the data well.

Appendix C contains a discussion of three technical issues related to the regression: overdispersion, collinearity and spatial autocorrelation.

Investigation of the top 10 SSDs

The 10 SSDs with the highest hospitalisation rates for asthma or COPD are presented. The median SES, median remoteness and average proportion of Indigenous Australians for the 10 SSDs were compared with the corresponding values for the full set of SSDs under study

(the set of SSDs under study excludes SSDs with fewer than 1000 population in the age range). It was necessary to use the median rather than the average for SES and remoteness, as the intervals between the values of these variables are not evenly spaced.

2.4 Data quality statements

A data quality statement for the National Hospital Morbidity Database can be found at the following location:

<http://www.aihw.gov.au/WorkArea/DownloadAsset.aspx?id=10737421911>.

A data quality statement for the 2006 ABS Census of Population and Housing can be found at the following location:

<http://www.abs.gov.au/websitedbs/D3310114.nsf/home/Census+Data+Quality#Relevance>.

2.5 Computer packages

The results for this report were extracted and analysed using SAS Enterprise Guide Version 4.3, Microsoft Excel 2010 and MapInfo Professional Version 11.0.

3 Results

3.1 Hospitalisation rates

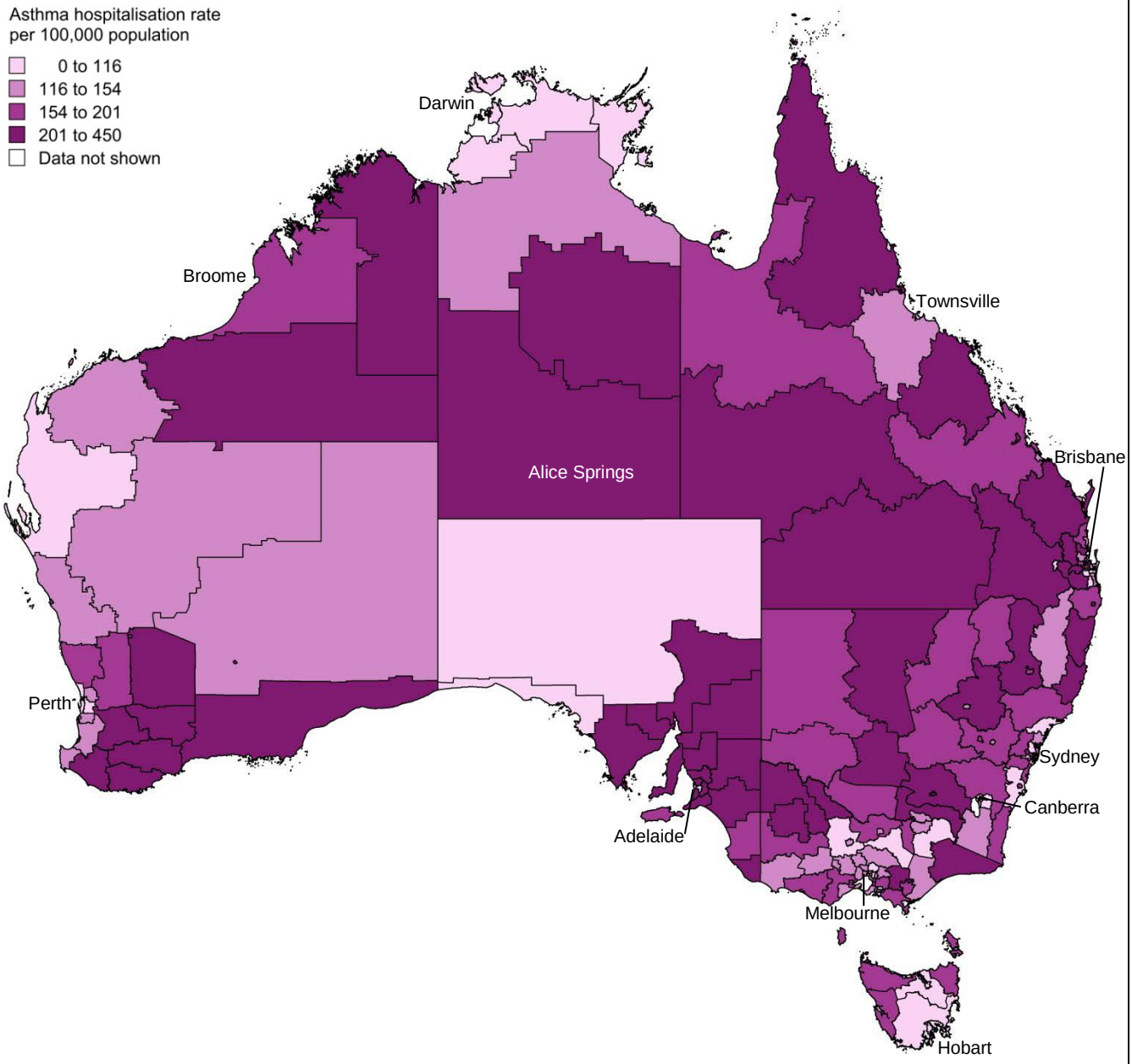
Asthma hospitalisations

A map of the asthma hospitalisation rates by SSD for Australia is shown in Figure 3.1.

Portions of this map have been enlarged in Appendix A, which includes images of the five most populous Australian cities, as well as the Australian Capital Territory and Tasmania.

The map of asthma hospitalisation rates by SSD in Australia shows clusters of SSDs with high hospitalisation rates in inland Australia. The map also shows high hospitalisation rates in certain coastal areas of Queensland, as well as in the south-east corner of South Australia, and the southern part of Western Australia. The additional maps in Appendix A show clusters of SSDs with lower asthma hospitalisation rates in urban areas.

There are a range of reasons why a particular SSD may have a higher rate of hospitalisations. See Section 2.2 for an overview of these issues.



Notes

1. This analysis is limited to ages 5–34.
2. The rates presented here are the average yearly rates for 2007–08 to 2009–10.
3. SSDs with populations of fewer than 1,000 in the age range 5–34 were not presented.
4. This analysis is based on 2006 SSD boundaries.
5. Data extracted using the principal diagnosis of J45–J46 for asthma.
6. Hospital separations for which the care type was reported as *Newborn* with no qualified days, *Hospital boarders* or *Posthumous organ procurement* have been excluded.

Source: AIHW analysis of the AIHW National Hospital Morbidity Database and ABS ERPs from the 2006 Census of Population and Housing.

Figure 3.1: Asthma hospitalisation rates by SSD, 2007–08 to 2009–10

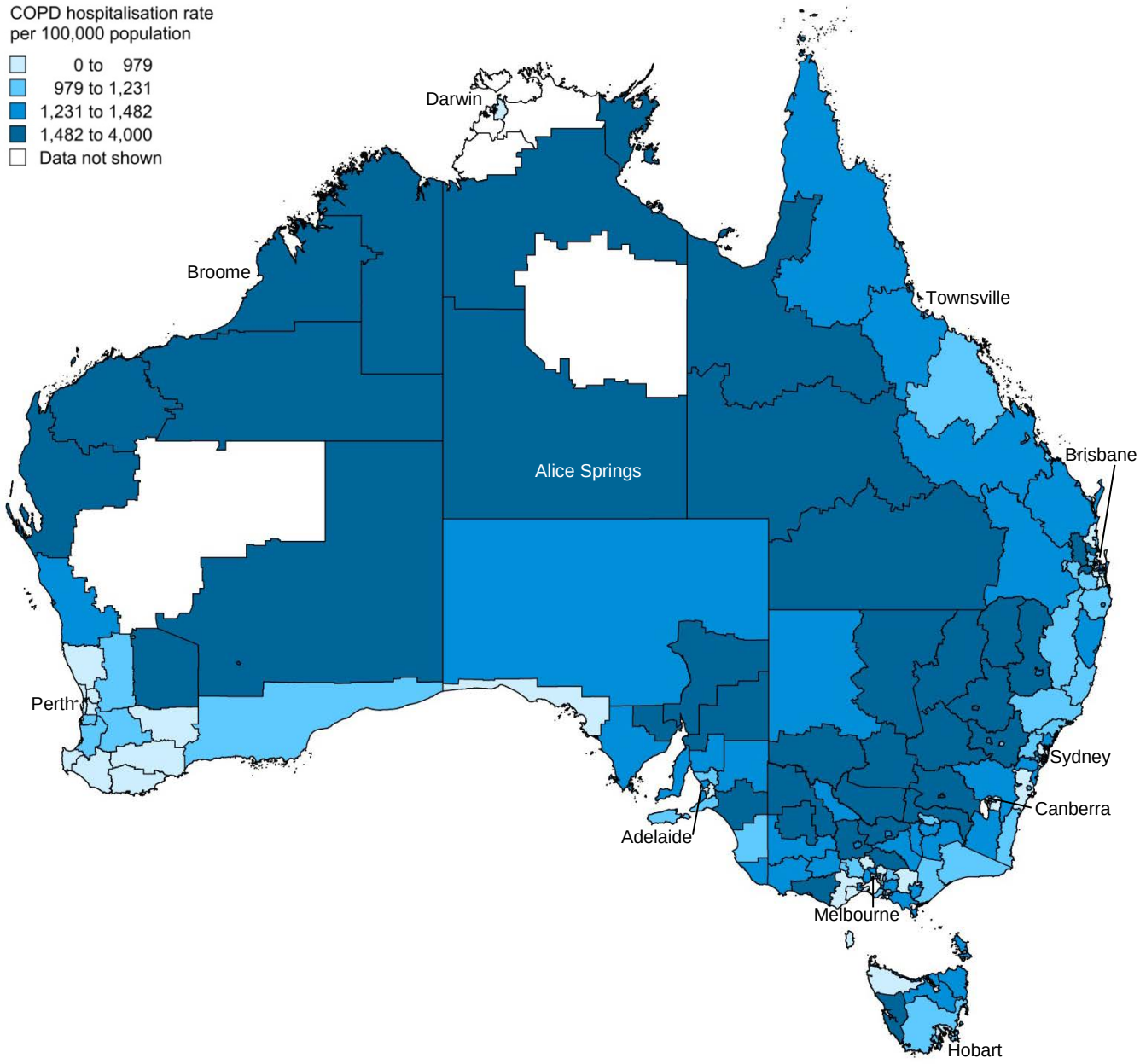
COPD hospitalisations

A map of the COPD hospitalisation rates by SSD for Australia is shown in Figure 3.2.

Portions of this map have been enlarged in Appendix A, which includes images of the five most populous Australian cities, as well as the Australian Capital Territory and Tasmania.

The map of COPD hospitalisation rates by SSD in Australia shows a band of SSDs with high hospitalisation rates in inland areas, much of the Northern Territory and the north-west corner of Western Australia. The additional maps in Appendix A show a pattern of lower COPD hospitalisation rates in urban areas compared with rural areas.

An overview of the reasons why a particular SSD may have a higher rate of hospitalisations is in Section 2.2.



Notes

1. This analysis is limited to ages 55+.
2. The rates presented here are the average yearly rates for 2007–08 to 2009–10.
3. SSDs with populations of fewer than 1,000 in the age range 55+ were not presented.
4. This analysis is based on 2006 SSD boundaries.
5. Data extracted using the principal diagnosis of J40–J44 for COPD.
6. Hospital separations for which the care type was reported as *Newborn* with no qualified days, *Hospital boarders* or *Posthumous organ procurement* have been excluded.

Source: AIHW analysis of the AIHW National Hospital Morbidity Database and ABS ERPs from the 2006 Census of Population and Housing.

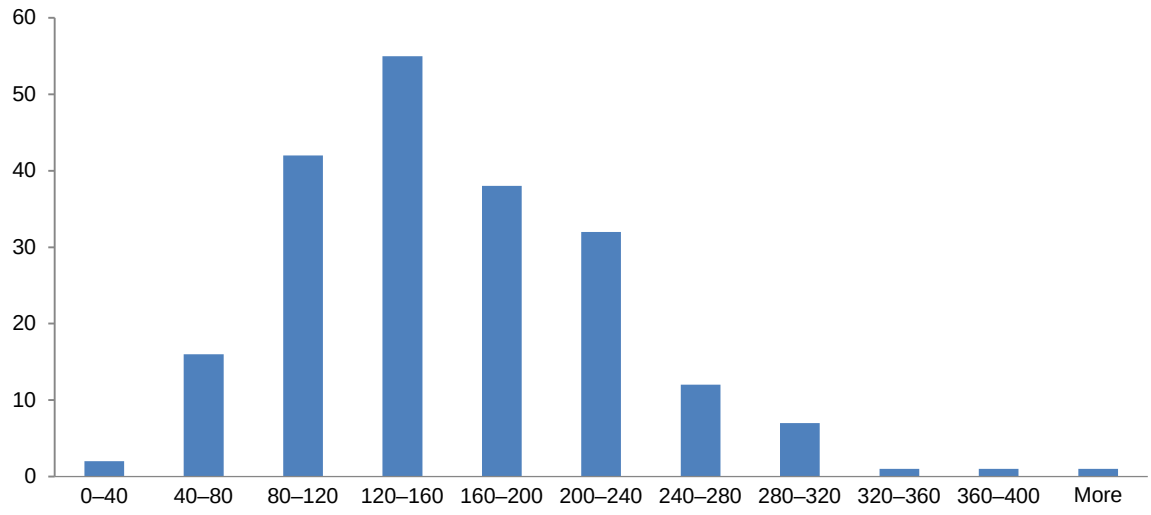
Figure 3.2: COPD hospitalisation rates by SSD, 2007–08 to 2009–10

3.2 Variation in the hospitalisation rates

Asthma hospitalisations

The range of hospitalisation rates for asthma across the different SSDs in Australia is presented in Figure 3.3. Eighty per cent of the SSDs had between 86 and 248 hospitalisations per 100,000 population per year. The interdecile range in this case was 162 hospitalisations per 100,000 population per year (see Section 2.3).

The coefficient of variation was 0.40 for the asthma hospitalisations and 0.22 for all-cause hospitalisations (see Section 2.3). This result shows that once the magnitude of the hospitalisation rates is corrected for, asthma hospitalisations show far greater variation (almost double) by SSD than all cause hospitalisations. This suggests that location factors play a more important role for asthma hospitalisations than for all-cause hospitalisations.



Notes

1. This analysis is limited to ages 5–34.
2. The rates presented here are the average yearly rates for 2007–08 to 2009–10.
3. SSDs with populations of fewer than 1,000 in the age range 5–34 were not presented.
4. This analysis is based on 2006 SSD boundaries.
5. Data extracted using the principal diagnosis of J45–J46 for asthma.
6. Hospital separations for which the care type was reported as *Newborn* with no qualified days, *Hospital boarders* or *Posthumous organ procurement* have been excluded.

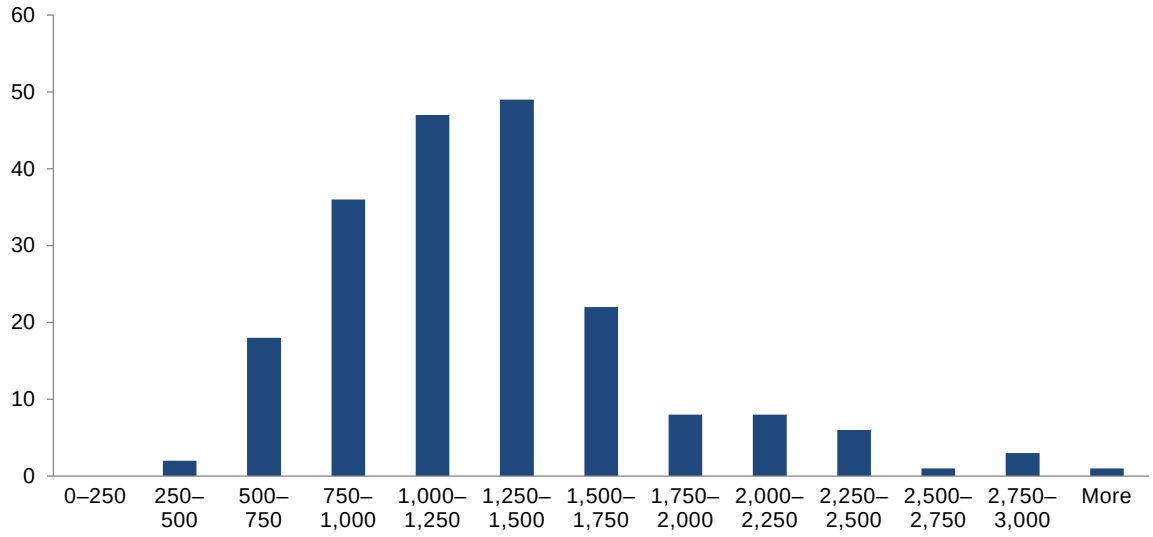
Source: AIHW analysis of the AIHW National Hospital Morbidity Database and ABS ERPs from the 2006 Census of Population and Housing.

Figure 3.3: Distribution of hospitalisation rates for asthma by SSD, 2007–08 to 2009–10

COPD hospitalisations

Figure 3.4 shows the range of hospitalisation rates for COPD across the different SSDs in Australia. Eighty per cent of the SSDs had between 751 and 1,987 hospitalisations per 100,000 population per year. Therefore, the interdecile range was 1,236 hospitalisations per 100,000 population per year (see Section 2.3).

The coefficient of variation was 0.38 for the COPD hospitalisations and 0.24 for all-cause hospitalisations (see Section 2.3). This result shows that once the magnitude of the hospitalisation rates is corrected for, COPD hospitalisations show far greater variation by SSD than all-cause hospitalisations. This suggests that location factors play a more important role for COPD hospitalisations than for all-cause hospitalisations.



Notes

1. This analysis is limited to ages 55+.
2. The rates presented here are the average yearly rates for 2007–08 to 2009–10.
3. SSDs with populations of fewer than 1,000 in the age range 55+ were not presented.
4. This analysis is based on 2006 SSD boundaries.
5. Data extracted using the principal diagnosis of J40–J44 for COPD.
6. Hospital separations for which the care type was reported as *Newborn* with no qualified days, *Hospital boarders* or *Posthumous organ procurement* have been excluded.

Source: AIHW analysis of the AIHW National Hospital Morbidity Database and ABS ERPs from the 2006 Census of Population and Housing.

Figure 3.4: Distribution of hospitalisation rates for COPD by SSD, 2007–08 to 2009–10

3.3 Poisson regression models

Asthma hospitalisations

A Poisson regression model was fitted to the hospitalisation data for asthma by SSD. Three variables were considered—the SES of the SSD, the remoteness of the SSD and the proportion of the SSD population who were Indigenous Australians.

To explore the possible contribution of each of the variables to a model, the three variables were each used as the only explanatory variable in a Poisson model. The model using the SES of the SSD had a generalised R^2 value of 45%, and therefore this variable accounted for 45% of the variation in asthma hospitalisations by SSD. The model using the remoteness of the SSD had a generalised R^2 value of 10%. The model using the proportion of Indigenous Australians in the SSD had a generalised R^2 value of 2%.

The model using the SES of the SSD found that the asthma hospitalisation rate was twice as high for SSDs in the lowest SES quintile as SSDs in the highest SES quintile.

No conclusions could be drawn about the relationship between remoteness and hospitalisation rates because, although the model was statistically significant as a whole, the comparisons of hospitalisation rates between the five different remoteness areas were not significant.

According to the model using the proportion of Indigenous Australians in the SSD, the asthma hospitalisation rate was higher in SSDs with a higher proportion of Indigenous Australians. The model predicted an increase in the hospitalisation rate by a factor of 1.01 for every percentage increase in the proportion of the SSD population who were Indigenous Australians.

The proportion of Indigenous Australians in each SSD and the remoteness of the SSD were not included in the final model for asthma hospitalisations because, likely due to correlations with SES of the SSD, neither variable made a statistically significant contribution to the model once the SES of the SSD was included. The final model for asthma hospitalisations used one explanatory variable—the SES of the SSD. This model accounted for 45% of the variation in asthma hospitalisations by SSD. (This value—45%—is the generalised R^2.) This R^2 value indicates that this model accounts for a reasonable proportion of the variation in asthma hospitalisations by SSD. However, it also suggests that it is likely that there are additional explanatory variables, not investigated in this work, that would explain some of the variation in hospitalisations.

Based on this model, as previously mentioned, the asthma hospitalisation rate was larger by a factor of 2 in SSDs in the lowest SES quintile compared with SSDs in the highest SES quintile. The model was found to be statistically significant at the 95% confidence level.

The details of these models are in Appendix D, Section D.1.

COPD hospitalisations

A Poisson regression model was fitted to the hospitalisation data for COPD by SSD. Three variables were considered—the SES of the SSD, the remoteness of the SSD and the proportion of Indigenous Australians in the SSD.

To explore the possible contribution of each of the variables to a model, the three variables were each used as the only explanatory variable in a Poisson model. The model using the SES of the SSD had a generalised R^2 value of 50%. The model using the remoteness of the SSD had a generalised R^2 value of 21%, and the model using the proportion of Indigenous Australians in the SSD had a generalised R^2 value of 18%.

The model using the SES of the SSD found that the COPD hospitalisation rate was larger by a factor of 2 in SSDs in the lowest SES quintile compared with SSDs in the highest SES quintile.

As was the case for asthma, no conclusions could be drawn about the relationship between remoteness and hospitalisation rates because, although the model was statistically significant as a whole, the comparisons of hospitalisation rates between the five different remoteness areas were not significant.

According to the model using the proportion of Indigenous Australians in the SSD, the COPD hospitalisation rate was higher in SSDs with a higher proportion of Indigenous Australians. The model predicted an increase in the hospitalisation rate by a factor of 1.03 for every percentage increase in the proportion of the SSD population who were Indigenous Australians.

The final model for COPD hospitalisations used two explanatory variables—the SES and the proportion of Indigenous Australians in the SSD. The remoteness of the SSD was removed from the model because it did not make a statistically significant contribution to the model, likely due to a correlation with the other two variables. This model accounted for 55% of the variation in COPD hospitalisations by SSD (This value—55%—is the generalised R^2). This R^2 value indicates that this model accounts for a reasonable proportion of the variation in COPD hospitalisations by SSD, but it is likely that other factors not investigated here also play a role.

The model was found to be statistically significant at the 95% confidence level.

Based on this model, COPD hospitalisation rates were higher in SSDs with a higher proportion of Indigenous Australians by a factor of 1.02 for every percentage increase in the proportion of Indigenous Australians. The model also found that COPD hospitalisation rates were larger by a factor of 1.8 in SSDs in the lowest SES quintile compared with SSDs in the highest SES quintile. These findings differ slightly from the findings for the single variable models due to the interaction between the two variables.

The details of these models are in Appendix D, Section D.2.

3.4 Characteristics of the top 10 SSDs

Asthma hospitalisations

The 10 SSDs with the highest rates of asthma hospitalisation for July 2007 to June 2010 had between 282 and 438 asthma hospitalisations per 100,000 population per year. The average asthma hospitalisation rate for the full asthma data set of SSDs was 161 per 100,000 population per year.

The top 10 SSDs had a lower median SES than the SSDs in the full asthma data set. The top 10 SSDs had a median SES that fell in the lowest SES group, and the full asthma data set had a median SES that fell in the second-lowest SES group.

The top 10 SSDs had a higher median remoteness than the SSDs in the full asthma data set. The top 10 SSDs had a median level of remoteness between *Inner regional* and *Outer Regional*, compared with the median level of remoteness for the full asthma data set of *Inner Regional*. The remoteness index is based on how distant a place is by road from urban centres of varying sizes, and therefore provides a relative indication of how difficult it might be for residents to access certain services, such as health care and education.

The average proportion of Indigenous Australians for the top 10 SSDs was 5.1%, slightly lower than the average proportion in the full asthma data set of 6.7%.

COPD hospitalisations

The 10 SSDs with the highest rates of COPD hospitalisation from July 2007 to June 2010 had between 2,949 and 7,384 COPD hospitalisations per 100,000 population per year. The average COPD hospitalisation rate for the full COPD data set of SSDs was 1,181 per 100,000 population per year.

The top 10 SSDs had a lower median SES and higher median remoteness than the SSDs in the full COPD data set. The top 10 SSDs had a median SES that fell in the lowest SES group, and the full COPD data set had a median SES that fell in the second-lowest SES group. The top 10 SSDs had a median level of remoteness of *Remote,* compared with the median level of remoteness for the full COPD data set of *Inner Regional*.

Many of the top 10 SSDs had a high proportion of Indigenous Australians. The average proportion of Indigenous Australians for these top 10 SSDs was 23.4%. The average proportion of Indigenous Australians in the full COPD data set was 5.2%.

4 Discussion

This report presents information about the variation in asthma and COPD hospitalisations across Australia. A regression model was used to show that SES, remoteness and the proportion of the population that identifies as Indigenous had a statistically significant effect on hospitalisation rates for these conditions.

There are many additional reasons why hospitalisations for asthma or COPD may be higher in one SSD compared with another. The hospitalisation rates in an SSD may be affected by various factors, including the prevalence of the condition, the management of the condition (for example, access to non-hospital health care) as well as the presence of comorbidities that increase the likelihood of hospitalisation. Environmental factors such as air pollution or the presence of allergic triggers may also play a role.

In future, other measures of the impact of asthma and COPD at SSD level could be used in combination with hospitalisations information. For example, emergency department presentations or pharmaceutical use for these conditions could be taken into account. Analysis of pharmaceutical use will be more feasible in the future, due to substantial improvements from 1 April 2012 in the coverage of national prescription data available as a by-product of the Pharmaceutical Benefits Scheme (which will now include information about all prescriptions filled regardless of whether they were under or over a copayment threshold).

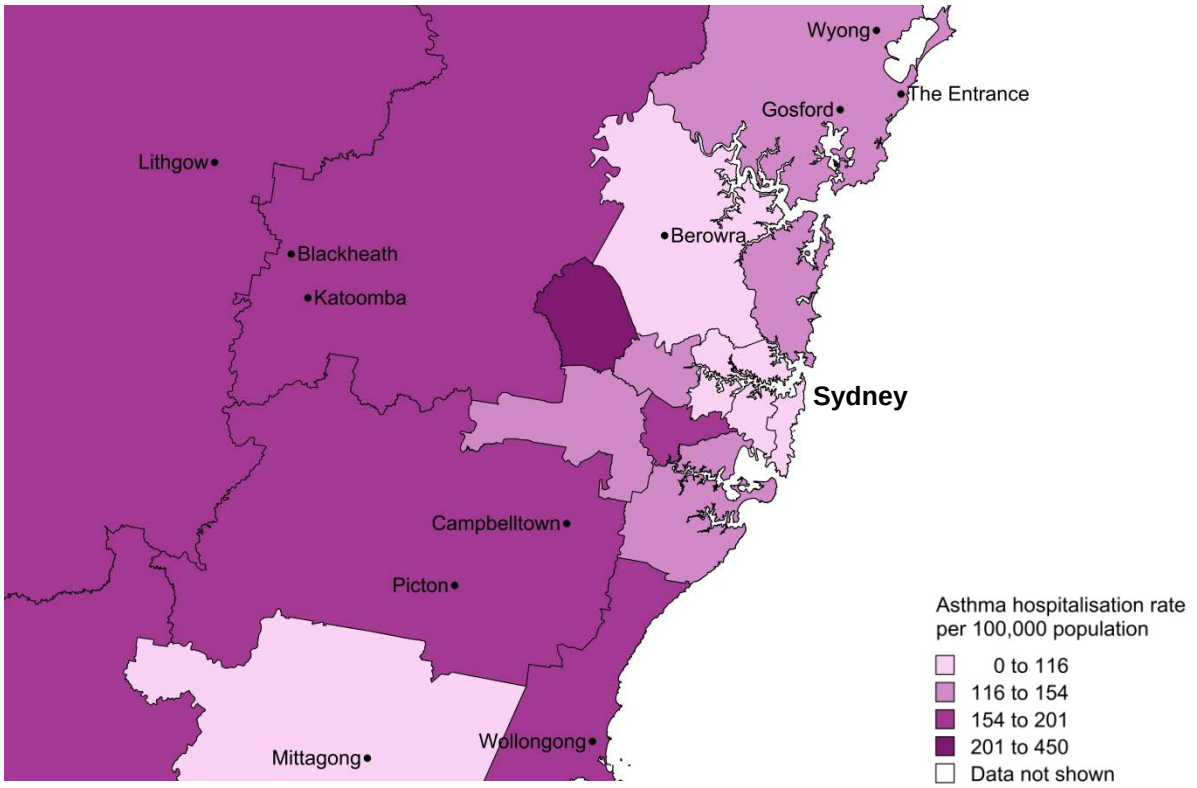
It would also be useful to identify the proportion of hospital separations due to re-admissions. This can be an indicator of poor health system management of a condition. This type of analysis is feasible in a technical sense and opportunities for such analysis are likely to improve in the future, building on the development of hospital readmission indicators for the National Healthcare Agreement and the National Health Reform Agreement's Performance and Accountability Framework.

It may also be possible to identify other location factors that contributed to the variation in asthma or COPD hospitalisation rates. In particular, it would be interesting to investigate the impact of environmental factors such as pollens, moulds, outdoor air pollution and seasonal weather events. Additionally, social determinants of health could be further investigated.

Finally, investigation of the association between smoking rates and hospitalisation rates for asthma and COPD would be an interesting area for future analysis.

Appendix A Additional maps

Asthma hospitalisations

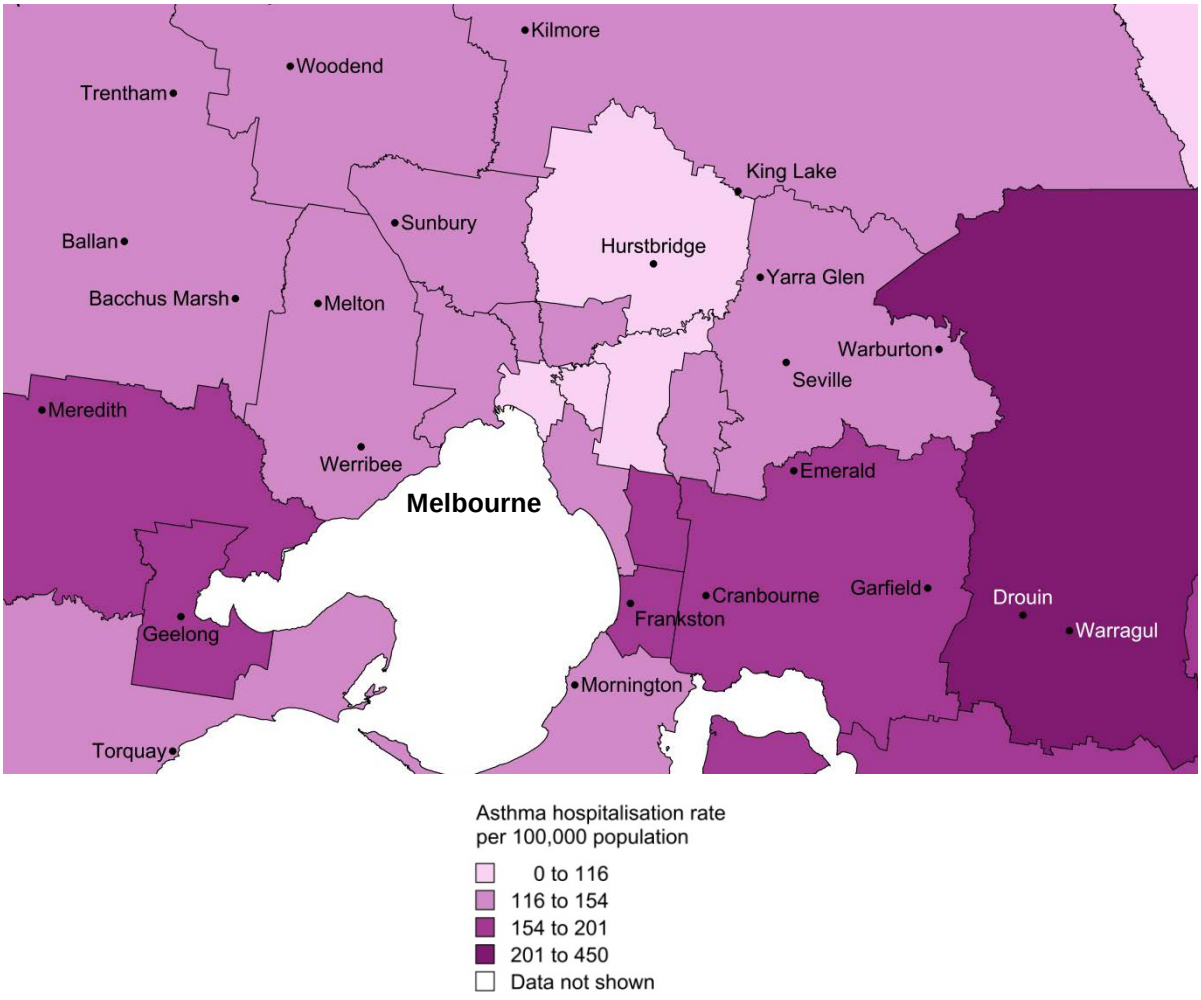


Notes

1. This analysis is limited to ages 5–34.
2. The rates presented here are the average yearly rates for 2007–08 to 2009–10.
3. SSDs with populations of fewer than 1,000 in the age range 5–34 were not presented.
4. This analysis is based on 2006 SSD boundaries.
5. Data extracted using the principal diagnosis of J45–J46 for asthma.
6. Hospital separations for which the care type was reported as *Newborn* with no qualified days, *Hospital boarders* or *Posthumous organ procurement* have been excluded.

Source: AIHW analysis of the AIHW National Hospital Morbidity Database and ABS ERPs from the 2006 Census of Population and Housing.

Figure A1: Asthma hospitalisation rates by SSD, Sydney and surrounds, 2007–08 to 2009–10

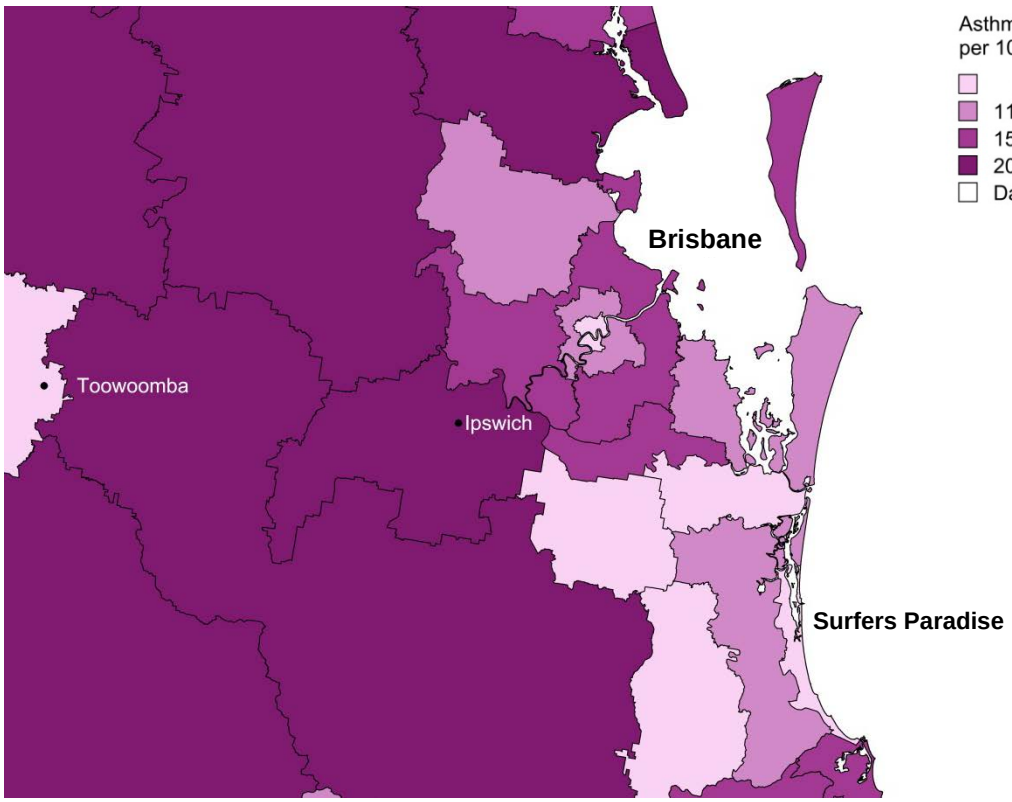


Notes

1. This analysis is limited to ages 5–34.
2. The rates presented here are the average yearly rates for 2007–08 to 2009–10.
3. SSDs with populations of fewer than 1,000 in the age range 5–34 were not presented.
4. This analysis is based on 2006 SSD boundaries.
5. Data extracted using the principal diagnosis of J45–J46 for asthma.
6. Hospital separations for which the care type was reported as *Newborn* with no qualified days, *Hospital boarders* or *Posthumous organ procurement* have been excluded.

Source: AIHW analysis of the AIHW National Hospital Morbidity Database and ABS ERPs from the 2006 Census of Population and Housing.

Figure A2: Asthma hospitalisation rates by SSD, Melbourne and surrounds, 2007–08 to 2009–10

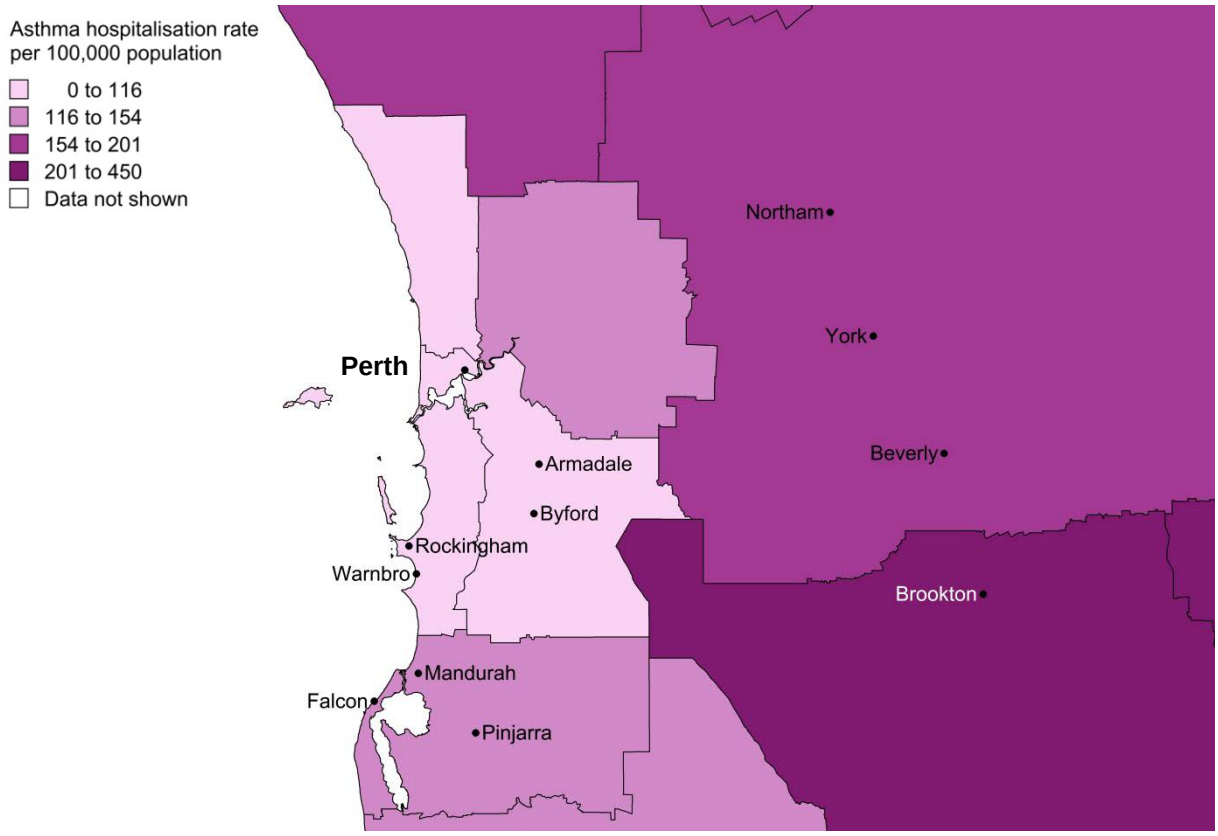


Notes

1. This analysis is limited to ages 5–34.
2. The rates presented here are the average yearly rates for 2007–08 to 2009–10.
3. SSDs with populations of fewer than 1,000 in the age range 5–34 were not presented.
4. This analysis is based on 2006 SSD boundaries.
5. Data extracted using the principal diagnosis of J45–J46 for asthma.
6. Hospital separations for which the care type was reported as *Newborn* with no qualified days, *Hospital boarders* or *Posthumous organ procurement* have been excluded.

Source: AIHW analysis of the AIHW National Hospital Morbidity Database and ABS ERPs from the 2006 Census of Population and Housing.

Figure A3: Asthma hospitalisation rates by SSD, Brisbane and surrounds, 2007–08 to 2009–10

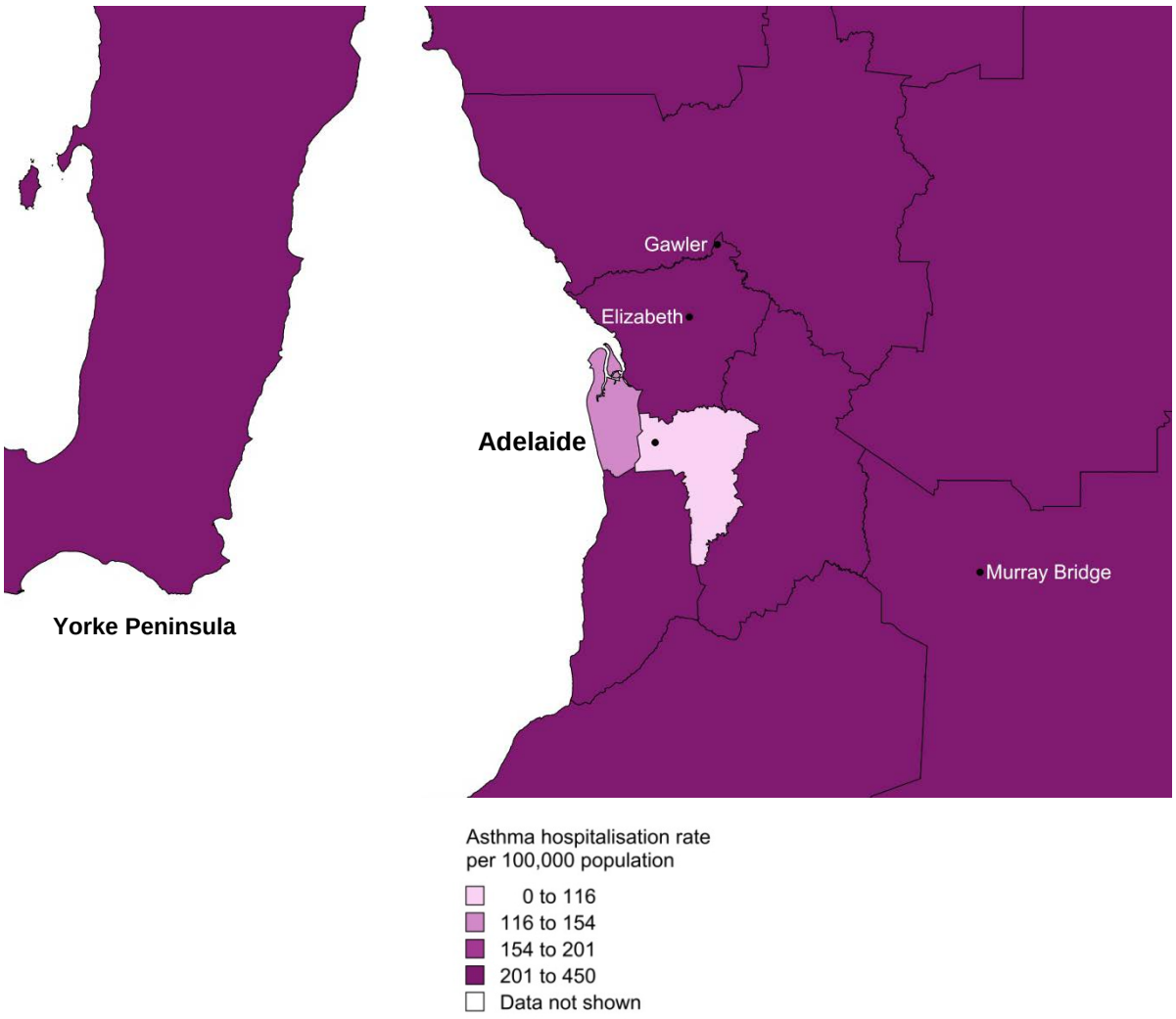


Notes

1. This analysis is limited to ages 5–34.
2. The rates presented here are the average yearly rates for 2007–08 to 2009–10.
3. SSDs with populations of fewer than 1,000 in the age range 5–34 were not presented.
4. This analysis is based on 2006 SSD boundaries.
5. Data extracted using the principal diagnosis of J45–J46 for asthma.
6. Hospital separations for which the care type was reported as *Newborn* with no qualified days, *Hospital boarders* or *Posthumous organ procurement* have been excluded.

Source: AIHW analysis of the AIHW National Hospital Morbidity Database and ABS ERPs from the 2006 Census of Population and Housing.

Figure A4: Asthma hospitalisation rates by SSD, Perth and surrounds, 2007–08 to 2009–10

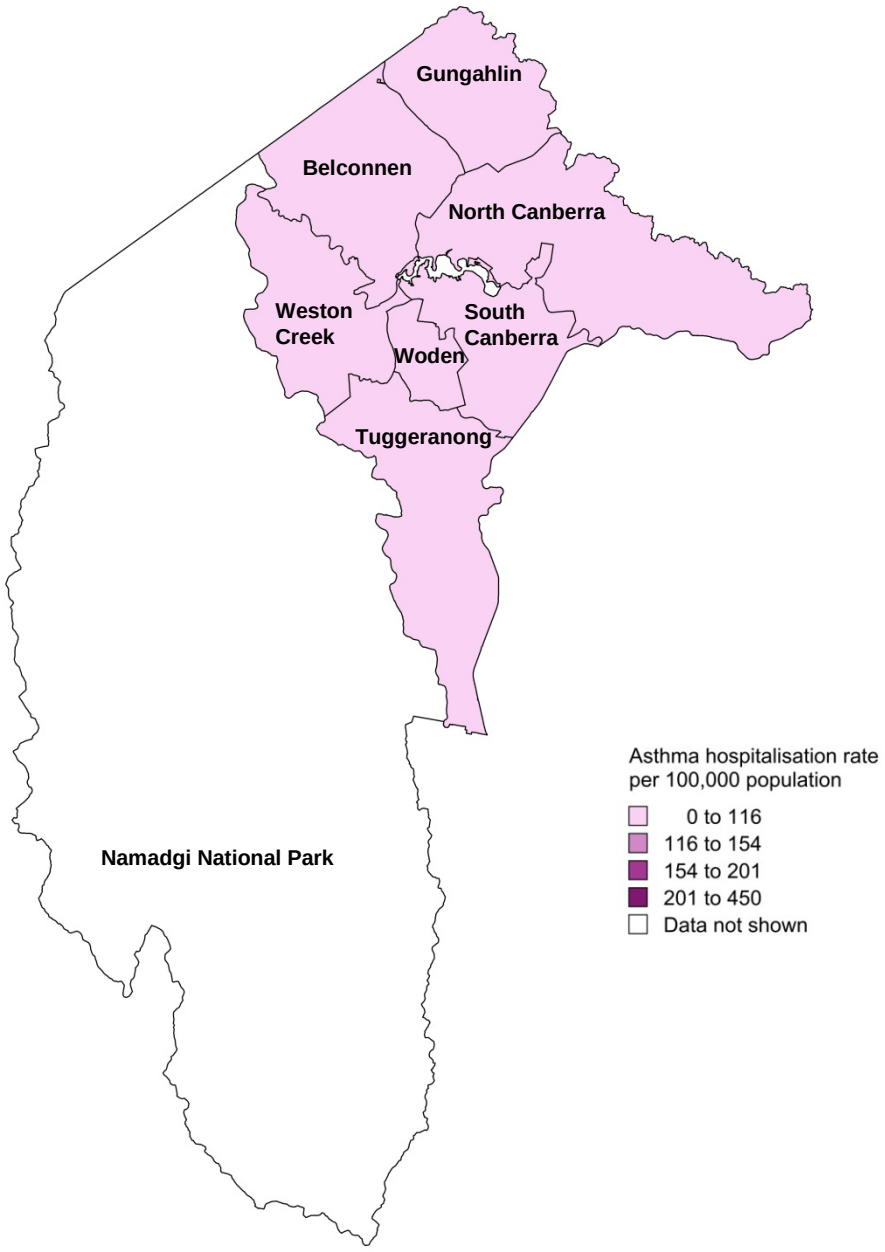


Notes

1. This analysis is limited to ages 5–34.
2. The rates presented here are the average yearly rates for 2007–08 to 2009–10.
3. SSDs with populations of fewer than 1,000 in the age range 5–34 were not presented.
4. This analysis is based on 2006 SSD boundaries.
5. Data extracted using the principal diagnosis of J45–J46 for asthma.
6. Hospital separations for which the care type was reported as *Newborn* with no qualified days, *Hospital boarders* or *Posthumous organ procurement* have been excluded.

Source: AIHW analysis of the AIHW National Hospital Morbidity Database and ABS ERPs from the 2006 Census of Population and Housing.

Figure A5: Asthma hospitalisation rates by SSD, Adelaide and surrounds, 2007–08 to 2009–10

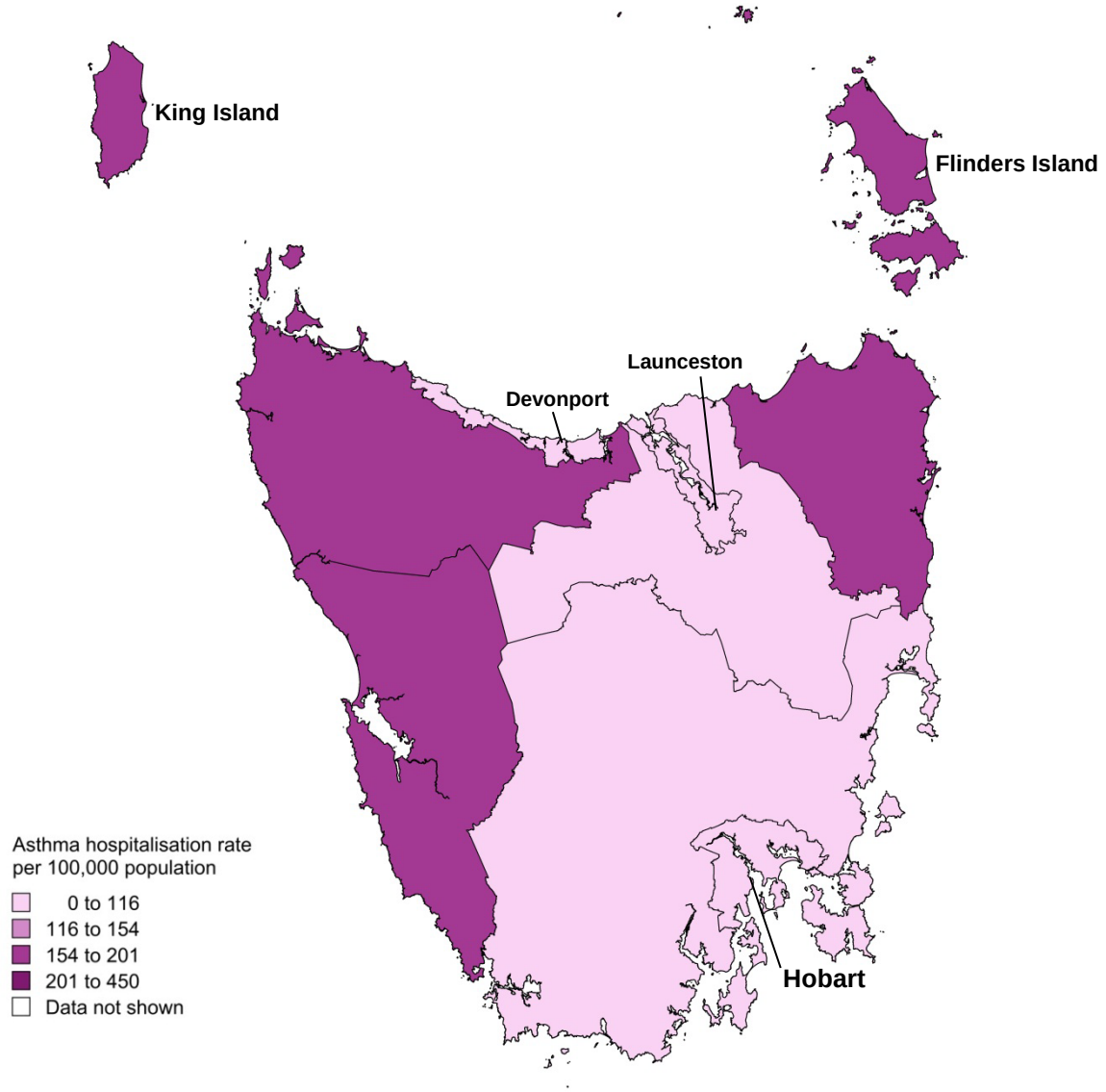


Notes

1. This analysis is limited to ages 5–34.
2. The rates presented here are the average yearly rates for 2007–08 to 2009–10.
3. SSDs with populations of fewer than 1,000 in the age range 5–34 were not presented.
4. This analysis is based on 2006 SSD boundaries.
5. Data extracted using the principal diagnosis of J45–J46 for asthma.
6. Hospital separations for which the care type was reported as *Newborn - unqualified days only*, *Hospital boarders* or *Posthumous organ procurement* have been excluded.

Source: AIHW analysis of the AIHW National Hospital Morbidity Database and ABS ERPs from the 2006 Census of Population and Housing.

Figure A6: Asthma hospitalisation rates by SSD, Australian Capital Territory, 2007–08 to 2009–10



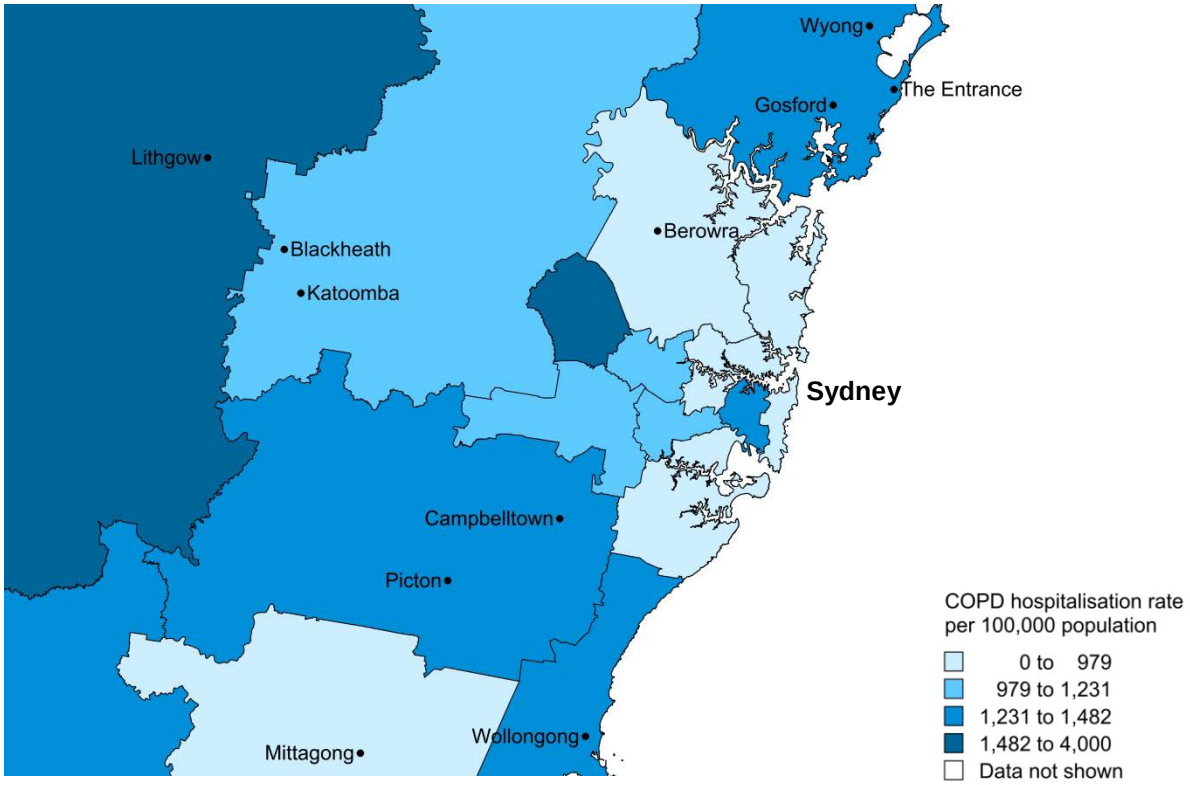
Notes

1. This analysis is limited to ages 5–34.
2. The rates presented here are the average yearly rates for 2007–08 to 2009–10.
3. SSDs with populations of fewer than 1,000 in the age range 5–34 were not presented.
4. This analysis is based on 2006 SSD boundaries.
5. Data extracted using the principal diagnosis of J45–J46 for asthma.
6. Hospital separations for which the care type was reported as *Newborn* with no qualified days, *Hospital boarders* or *Posthumous organ procurement* have been excluded.

Source: AIHW analysis of the AIHW National Hospital Morbidity Database and ABS ERPs from the 2006 Census of Population and Housing.

Figure A7: Asthma hospitalisation rates by SSD, Tasmania, 2007–08 to 2009–10

COPD hospitalisations

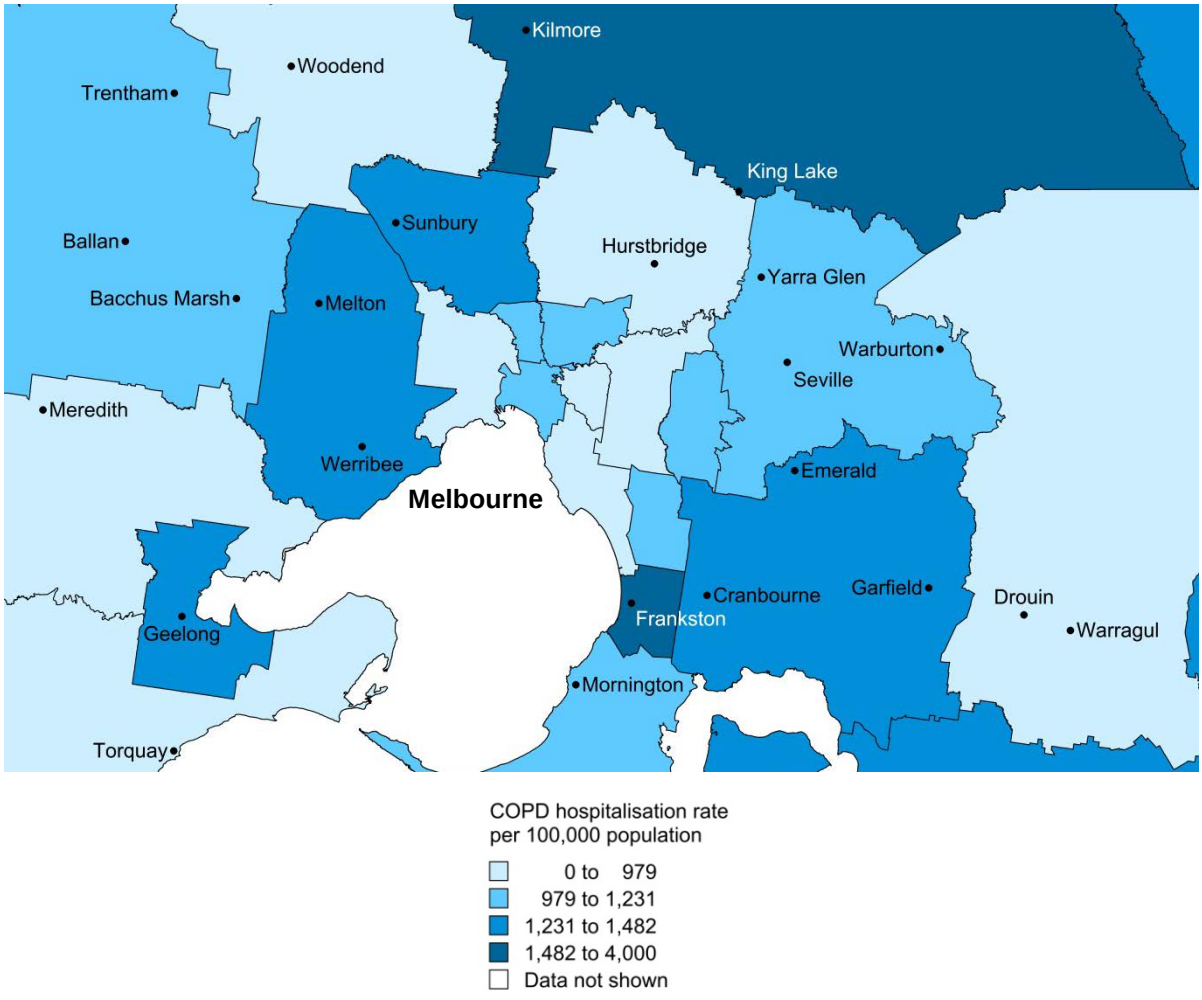


Notes

1. This analysis is limited to ages 55+.
2. The rates presented here are the average yearly rates for 2007–08 to 2009–10.
3. SSDs with populations of fewer than 1,000 in the age range 55+ were not presented.
4. This analysis is based on 2006 SSD boundaries.
5. Data extracted using the principal diagnosis of J40–J44 for COPD.
6. Hospital separations for which the care type was reported as *Newborn* with no qualified days, *Hospital boarders* or *Posthumous organ procurement* have been excluded.

Source: AIHW analysis of the AIHW National Hospital Morbidity Database and ABS ERPs from the 2006 Census of Population and Housing.

Figure A8: COPD hospitalisation rates by SSD, Sydney and surrounds, 2007–08 to 2009–10

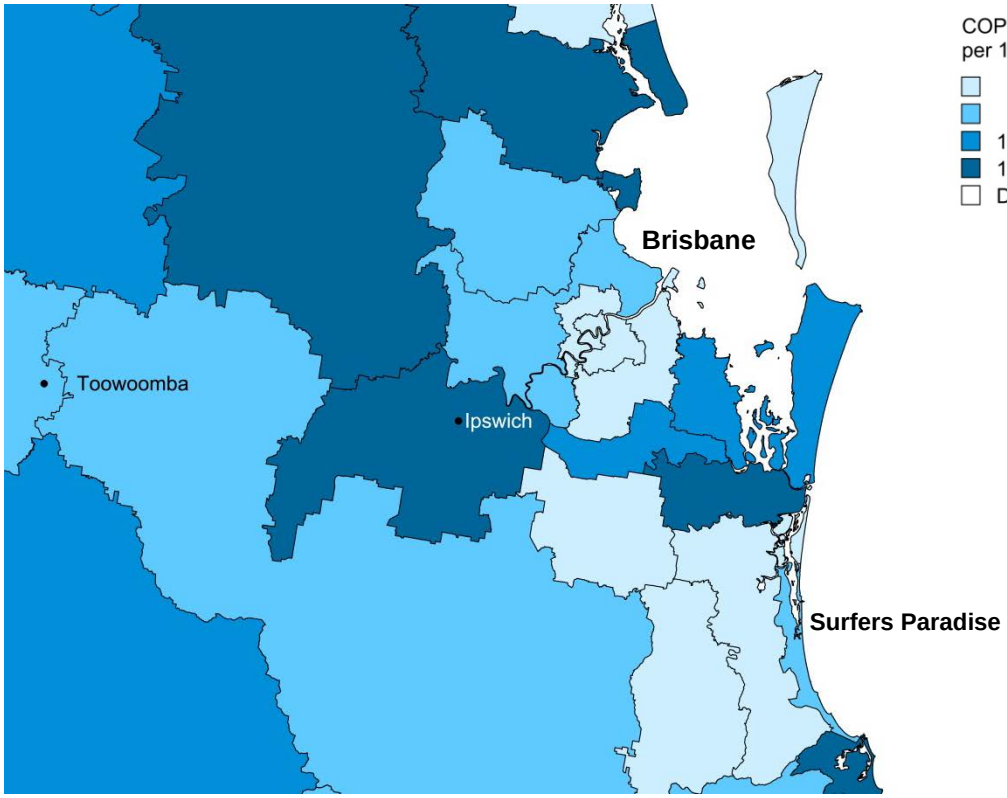


Notes

1. This analysis is limited to ages 55+.
2. The rates presented here are the average yearly rates for 2007–08 to 2009–10.
3. SSDs with populations of fewer than 1,000 in the age range 55+ were not presented.
4. This analysis is based on 2006 SSD boundaries.
5. Data extracted using the principal diagnosis of J40–J44 for COPD.
6. Hospital separations for which the care type was reported as *Newborn* with no qualified days, *Hospital boarders* or *Posthumous organ procurement* have been excluded.

Source: AIHW analysis of the AIHW National Hospital Morbidity Database and ABS ERPs from the 2006 Census of Population and Housing.

Figure A9: COPD hospitalisation rates by SSD, Melbourne and surrounds, 2007–08 to 2009–10

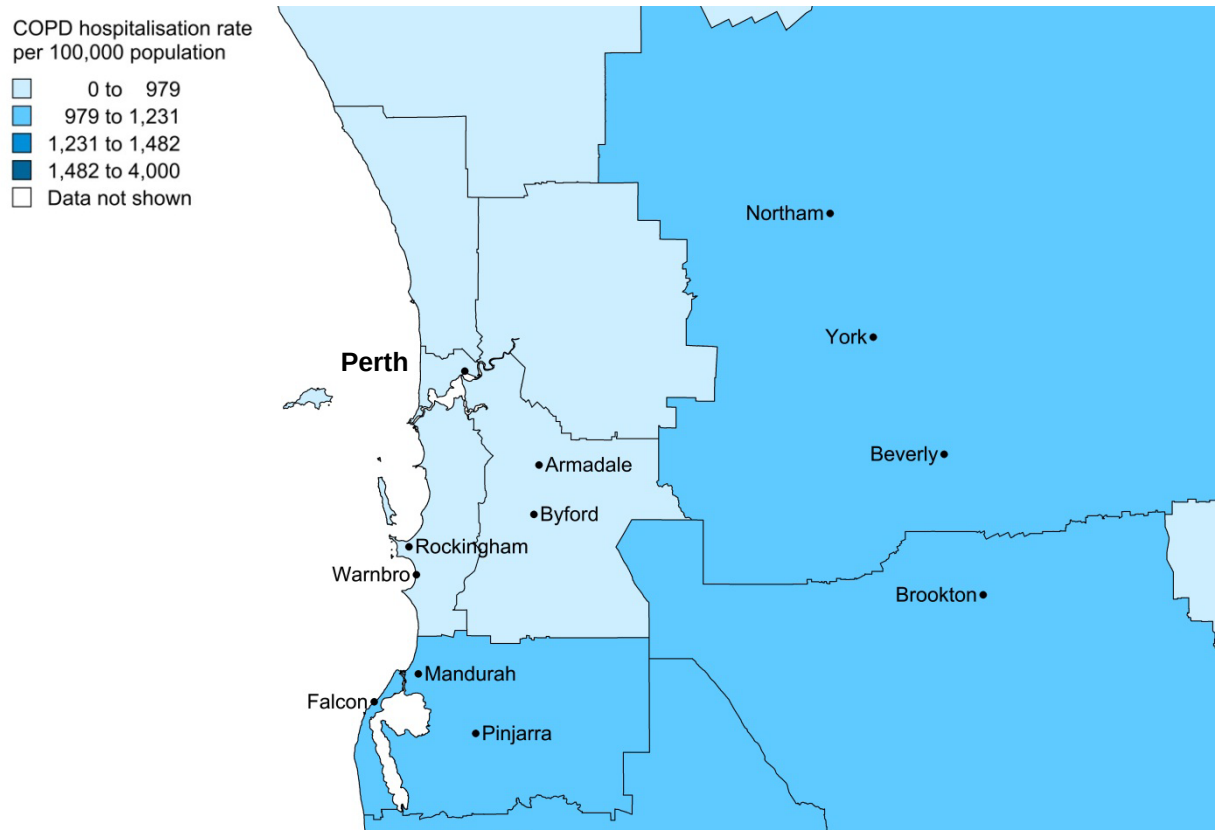


Notes

1. This analysis is limited to ages 55+.
2. The rates presented here are the average yearly rates for 2007–08 to 2009–10.
3. SSDs with populations of fewer than 1,000 in the age range 55+ were not presented.
4. This analysis is based on 2006 SSD boundaries.
5. Data extracted using the principal diagnosis of J40–J44 for COPD.
6. Hospital separations for which the care type was reported as *Newborn* with no qualified days, *Hospital boarders* or *Posthumous organ procurement* have been excluded.

Source: AIHW analysis of the AIHW National Hospital Morbidity Database and ABS ERPs from the 2006 Census of Population and Housing.

Figure A10: COPD hospitalisation rates by SSD, Brisbane and surrounds, 2007–08 to 2009–10

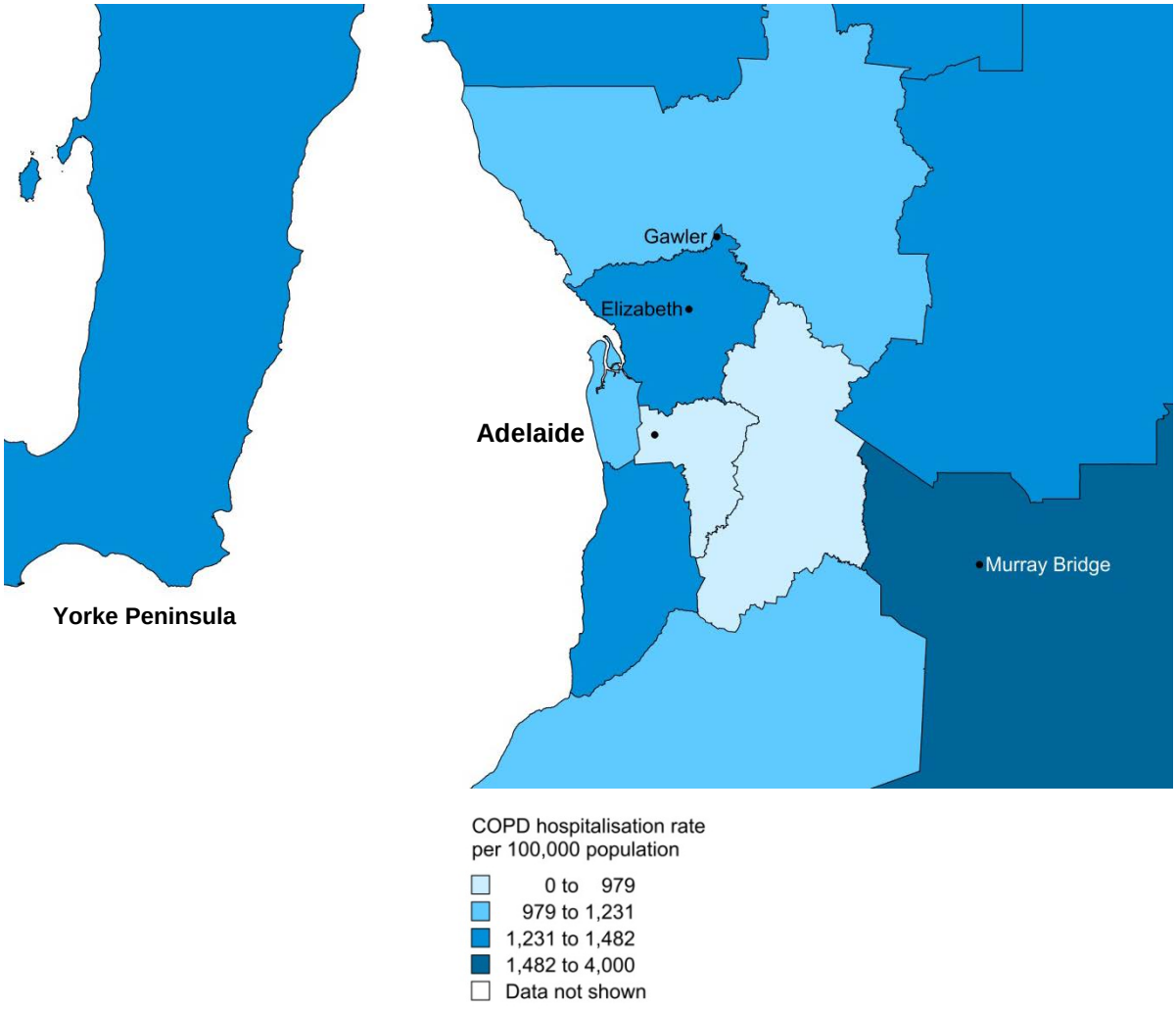


Notes

1. This analysis is limited to ages 55+.
2. The rates presented here are the average yearly rates for 2007–08 to 2009–10.
3. SSDs with populations of fewer than 1,000 in the age range 55+ were not presented.
4. This analysis is based on 2006 SSD boundaries.
5. Data extracted using the principal diagnosis of J40–J44 for COPD.
6. Hospital separations for which the care type was reported as *Newborn* with no qualified days, *Hospital boarders* or *Posthumous organ procurement* have been excluded.

Source: AIHW analysis of the AIHW National Hospital Morbidity Database and ABS ERPs from the 2006 Census of Population and Housing.

Figure A11: COPD hospitalisation rates by SSD, Perth and surrounds, 2007–08 to 2009–10

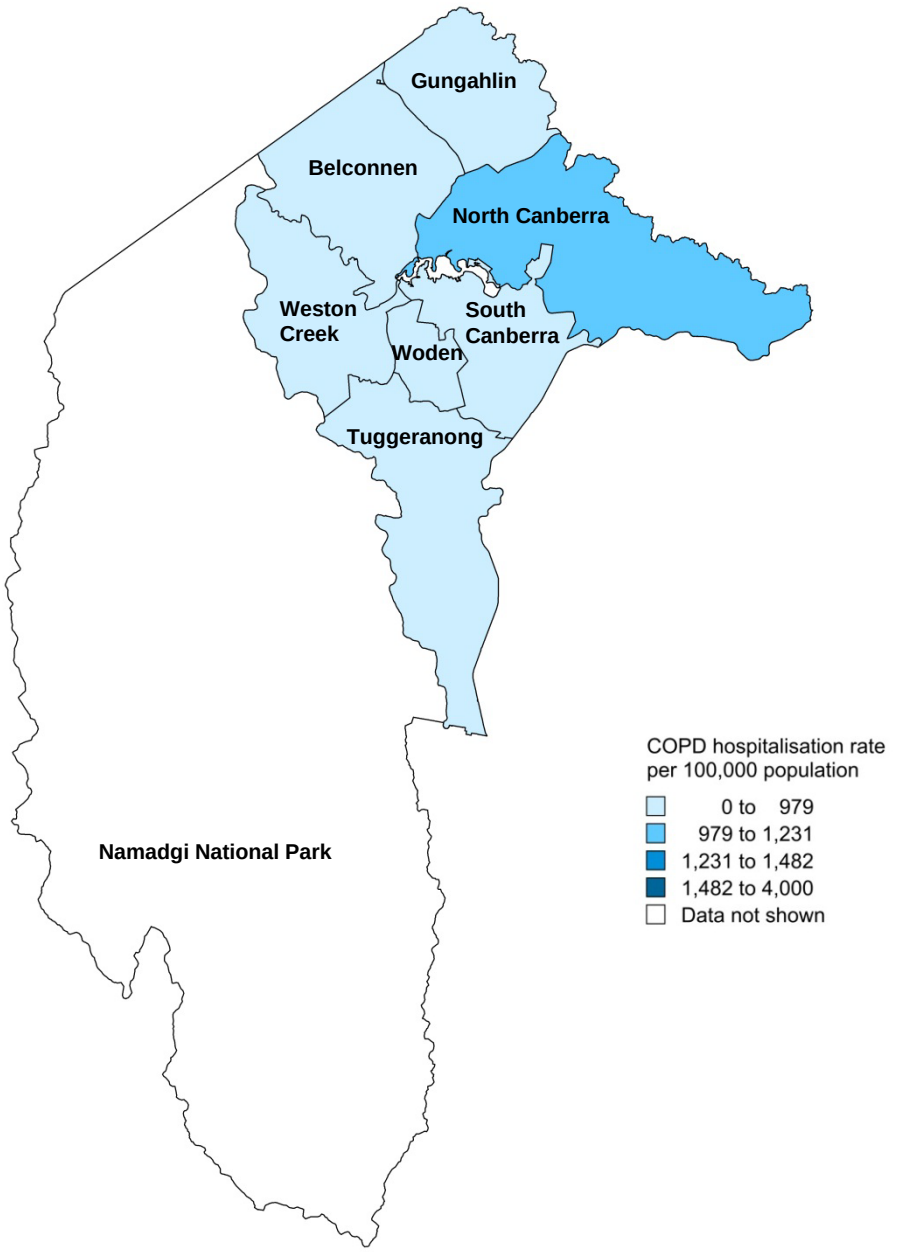


Notes

1. This analysis is limited to ages 55+.
2. The rates presented here are the average yearly rates for 2007–08 to 2009–10.
3. SSDs with populations of fewer than 1,000 in the age range 55+ were not presented.
4. This analysis is based on 2006 SSD boundaries.
5. Data extracted using the principal diagnosis of J40–J44 for COPD.
6. Hospital separations for which the care type was reported as *Newborn* with no qualified days, *Hospital boarders* or *Posthumous organ procurement* have been excluded.

Source: AIHW analysis of the AIHW National Hospital Morbidity Database and ABS ERPs from the 2006 Census of Population and Housing.

Figure A12: COPD hospitalisation rates by SSD, Adelaide and surrounds, 2007–08 to 2009–10

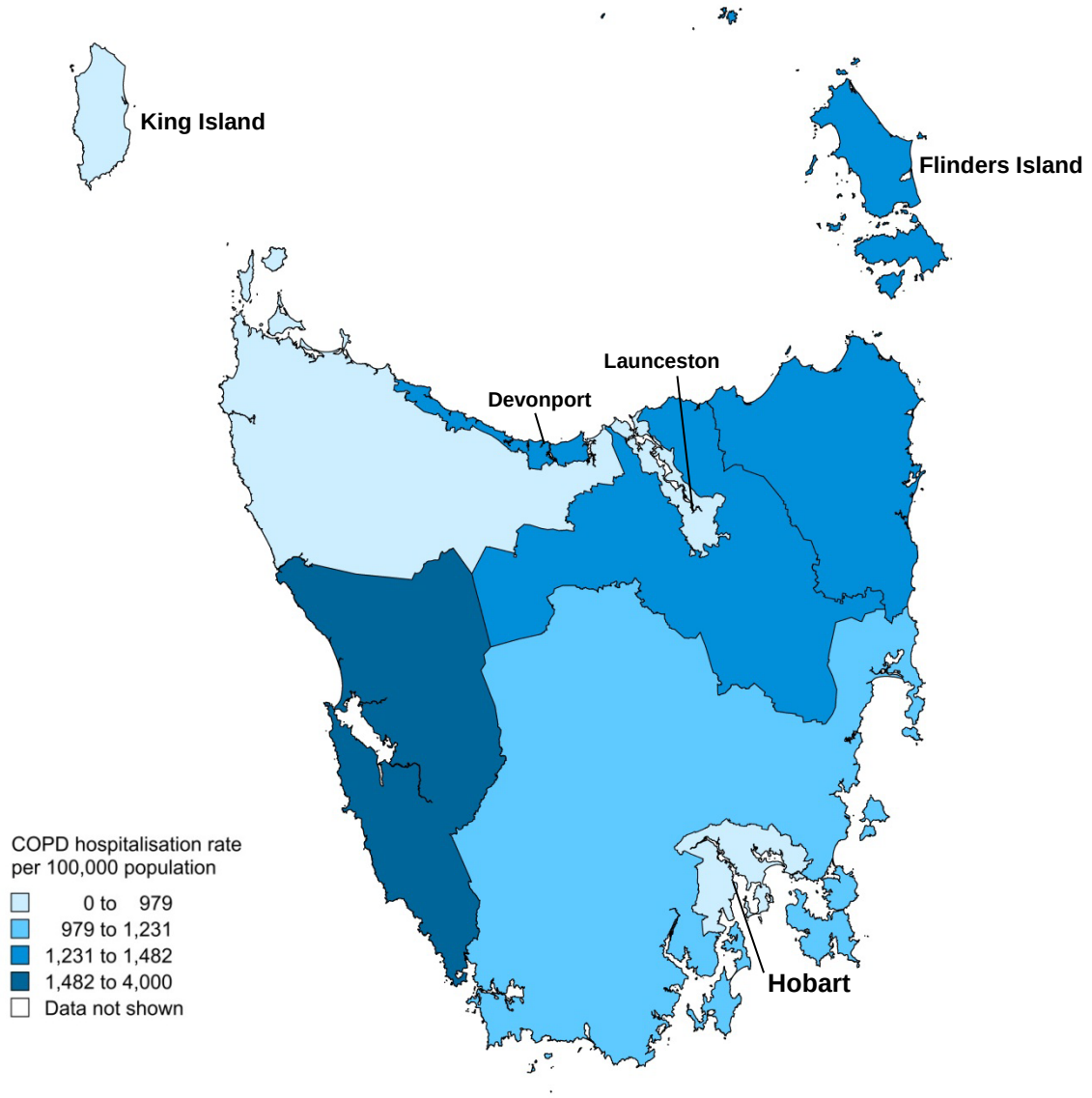


Notes

1. This analysis is limited to ages 55+.
2. The rates presented here are the average yearly rates for 2007–08 to 2009–10.
3. SSDs with populations of fewer than 1,000 in the age range 55+ were not presented.
4. This analysis is based on 2006 SSD boundaries.
5. Data extracted using the principal diagnosis of J40–J44 for COPD.
6. Hospital separations for which the care type was reported as *Newborn* with no qualified days, *Hospital boarders* or *Posthumous organ procurement* have been excluded.

Source: AIHW analysis of the AIHW National Hospital Morbidity Database and ABS ERPs from the 2006 Census of Population and Housing.

Figure A13: COPD hospitalisation rates by SSD, Australian Capital Territory, 2007–08 to 2009–10



Notes

1. This analysis is limited to ages 55+.
2. The rates presented here are the average yearly rates for 2007–08 to 2009–10.
3. SSDs with populations of fewer than 1,000 in the age range 55+ were not presented.
4. This analysis is based on 2006 SSD boundaries.
5. Data extracted using the principal diagnosis of J40–J44 for COPD.
6. Hospital separations for which the care type was reported as *Newborn* with no qualified days, *Hospital boarders* or *Posthumous organ procurement* have been excluded.

Source: AIHW analysis of the AIHW National Hospital Morbidity Database and ABS ERPs from the 2006 Census of Population and Housing.

Figure A14: COPD hospitalisation rates by SSD, Tasmania, 2007–08 to 2009–10

Appendix B Technical information

B.1 Coding information for the NHMD

Asthma was coded as J45–J46 and COPD as J40–J44 using the International Statistical Classification of Diseases and Related Health Problems, 10th revision, Australian Modification (ICD-10-AM) (NCCH 2006; NCCH 2008). This coding scheme was based on the World Health Organization's version of ICD-10. The fifth edition of the Australian Modification was used for 2007–08 and the sixth edition was used for 2008–09 and 2009–10. The classification and coding guidelines for asthma and COPD did not change over this period. Separations with a care type of *Newborn* (without qualified days) and records for *Hospital boarders* and *Posthumous organ procurement* were excluded from the analysis.

The data quality of the diagnosis information in the NHMD is, generally speaking, very good. However, asthma and COPD can be difficult to distinguish. In some cases it is possible that a patient was assigned a principal diagnosis of asthma or COPD when the other condition may have better described the underlying issue.

In the NHMD, the hospital separation records contain information about the SLA of usual residence of the patient (where the patient usually lives, not where they were treated). This information can be used to identify the SSD of usual residence of the patient, as SLAs are smaller areas that fit within SSDs. As with all information in the NHMD, the SLA information was provided to the AIHW by the state and territory health departments. In some cases, the SLA of usual residence was missing or based on outdated codes. Some jurisdictions provided SLA codes for patients usually resident in the jurisdiction, and postcodes for patients not usually resident in the jurisdiction. In these cases an SLA was assigned probabilistically by the AIHW using any available information on area of residence and taking into account ABS data on population distributions (AIHW 2011). Due to the probabilistic nature of this mapping the SLA of usual residence for individual records may, in a small number of cases, not be accurate; however, the overall distribution of records by geographical area is considered suitable for use in analyses of patterns of hospitalisations.

B.2 SSDs not shown

SSDs with fewer than 1,000 people in the age range of interest were not shown on the maps, and were excluded from the analysis in the report.

For the asthma analysis, two SSDs had fewer than 1000 people in the age range 5–34, namely, Finniss in the Northern Territory, and the SSD covering the balance of the Australian Capital Territory.

For the COPD analysis, eight SSDs had fewer than 1,000 people in the 55+ age range, namely, the SSD titled 'Other Territories' covering Jervis Bay, Christmas Island and the Cocos (Keeling) Islands, the SSD covering the balance of the Australian Capital Territory, as well as Carnegie in Western Australia and five SSDs in the Northern Territory: Barkly, Daly, Alligator, Bathurst-Melville and Finniss.

B.3 SSD characteristics

Socioeconomic status of the SSD

This report uses the Index of Relative Socio-economic Advantage and Disadvantage (IRSAD). This index is one of several socioeconomic indexes derived by the ABS from information collected in the 2006 Census of Population and Housing. The IRSAD is an area-based measure that represents the average level of socioeconomic advantage and disadvantage by SLA. SLAs are small geographic areas that can be combined together to form SSDs. The IRSAD is derived from attributes such as income, educational attainment and unemployment (ABS 2006a).

In this report, the IRSAD scores by SLA (provided by the ABS) were used to calculate the IRSAD scores by SSD, as SLAs combine to form SSDs. To account for the varying sizes of the SSDs, the SLA IRSAD scores were weighted by the SLA population size before they were combined. The IRSAD score was then expressed in quintiles (five groups each containing 20% of the SSDs in Australia).

It is important to remember that the IRSAD score for an SSD is only an average score for the SSD. Therefore, an SSD with a low IRSAD score (indicating a high level of socioeconomic disadvantage) is likely to have a high proportion of relatively disadvantaged people. However, such an area will almost certainly include people who are not disadvantaged (ABS 2006a).

Remoteness of the SSD

This report uses the remoteness classification by SSD based on the 2006 Australian Standard Geographical Classification (ASGC). The ASGC was derived by the ABS from information collected in the 2006 Census of Population and Housing. The remoteness classification uses Accessibility/Remoteness Index of Australia (ARIA) scores to determine remoteness areas. This index is calculated based on how distant a place is by road from urban centres of varying sizes, and therefore provides a relative indication of how difficult it might be for residents to access certain services, such as health care and education (ABS 2006b).

There are five remoteness areas in this classification: *Major cities*, *Inner regional*, *Outer regional*, *Remote* and *Very remote* (ABS 2006b). In some cases an SSD fell across the boundary between remoteness areas. In these cases the remoteness area covering the largest portion of the population of the SSD was chosen. This issue affected 70% of the SSDs. For two-thirds of the affected SSDs, the chosen remoteness area covered 80% or more of the SSD population.

Proportion of Indigenous Australians in the SSD

This report uses the proportion of Indigenous Australians in each SSD, estimated by the ABS. The estimated Indigenous population comprises people who are of Aboriginal origin, Torres Strait Islander origin, or both Aboriginal and Torres Strait Islander origin (ABS 2008).

The estimates are based on 2006 Census of Population and Housing counts of Aboriginal and Torres Strait Islander Australians adjusted for net undercount as measured by the Post Enumeration Survey. The extent of under-coverage of Aboriginal and Torres Strait Islander Australians in the 2006 Census and the relatively small sample size of the Post Enumeration Survey to adjust for that under-coverage means the estimates should be interpreted with caution (ABS 2008).

Appendix C Poisson regression

This appendix gives an overview of the technical approach used in fitting Poisson regression models to the hospitalisation data. The fitted models are shown in Appendix D.

When the Poisson model was fitted to the hospitalisation data, there was overdispersion, where the variance of the data was greater than the mean of the data. The overdispersion was addressed by adjusting the statistical tests. The adjustments are outlined in Section C.1. An alternative method to address overdispersion is to use a more complex probability distribution for errors in the model, such as the negative binomial distribution. When a negative binomial model was fitted to the data, the data would not support credible estimation of the additional model parameter, so the Poisson model was a better choice.

Collinearity is present in a regression when the explanatory variables are highly correlated. It is reasonable to expect that the three variables under study will be related to each other to a certain extent. Collinearity can be detected when a variable that was statistically significant in a single variable model does not make a statistically significant contribution to a model with an additional variable. Also, collinearity can be detected if the R^2 for a combined model is smaller than the sum of the R^2 for the variables run in separate models.

SSDs that are close to each other may have more similar hospitalisation rates than SSDs that are further apart. This effect is called spatial autocorrelation. Spatial autocorrelation was not taken into account in the regression calculations in this report.

C.1 Adjusting the Poisson regression statistical tests for overdispersion

Overdispersion (where the variance of the data is greater than the mean of the data) was present when Poisson regression models were run on the data sets for asthma and COPD hospitalisations. This could be seen from the high values of the deviance divided by the degrees of freedom, where a value above 1 indicates overdispersion (UCLA 2012a).

For the asthma data set, when Poisson models were run separately for each explanatory variable, the deviance divided by the degrees of freedom was 4.07 for the model using SES, 6.63 for the model using remoteness and 7.09 for the model using the proportion of Indigenous Australians. The final model used just the SES explanatory variable.

For the COPD data set, when Poisson models were run separately for each explanatory variable, the deviance divided by the degrees of freedom was 13.42 for the model using SES, 21.24 for the model using remoteness and 21.73 for the model using the proportion of Indigenous Australians. The final model used two explanatory variables—SES and the proportion of Indigenous Australians—and the deviance divided by the degrees of freedom was 12.12.

The statistical tests associated with these Poisson regression models were adjusted to account for the overdispersion. These adjustments are outlined here:

Adjusting the standard errors and the test of model significance

The Poisson model was adjusted to account for overdispersion by adding a scale term to the regression. The scale term was calculated using the formula:

$$\text{scale term} = \sqrt{\frac{\text{deviance}}{\text{degrees of freedom}}}$$

(UCLA 2012a). This adjustment meant that the standard errors of the explanatory variables were recalculated by SAS. After the adjustment, SAS provided a scaled deviance, which was used in the place of the deviance in the chi-square goodness-of-fit test, which was used to test the statistical significance of the Poisson model (UCLA 2012b).

Adjusting the generalised R^2

For a Poisson model, the generalised R^2 can be calculated using the formula:

$$\text{generalised } R^2 = 1 - \frac{\text{deviance}}{\text{deviance of the model with all explanatory variables removed}}$$

To account for overdispersion this formula can be adjusted to give:

$$\text{generalised } R^2 = 1 - \frac{\text{deviance} + \text{number of explanatory variables} * \left(\frac{\text{deviance}}{\text{degrees of freedom}}\right)}{\text{deviance of the model with all explanatory variables removed}}$$

(Heinzl & Mittlbock 2003).

C.2 Poisson regression model form:

To fit the Poisson model to rate data (the rate of asthma or COPD hospitalisations by SSD), the number of asthma hospitalisations by SSD was used as the response variable and the population size by SSD was used as an 'offset' term.

The model has three possible explanatory variables: the SES of the SSD, the remoteness of the SSD and the proportion of the SSD population who were Indigenous Australians.

This model can be written as:

$$\log_e(y) = m + n*(\text{ind}(x_1=1)) + o*(\text{ind}(x_1=2)) + p*(\text{ind}(x_1=3)) + q*(\text{ind}(x_1=4))$$
$$+ r*(\text{ind}(x_2=1)) + s*(\text{ind}(x_2=2)) + t*(\text{ind}(x_2=3)) + u*(\text{ind}(x_2=4))$$
$$+ v*x_3$$
$$+ \log_e(z)$$

where:

y = average yearly asthma hospitalisations by SSD, for 2007–08 to 2009–10

z = estimated population size by SSD, included in the regression model as an 'offset' term

x_1 = SES by SSD (measured using IRSAD, used in the model in the form of a categorical variable covering the quintiles 1–5, quintile 1 has the lowest SES, quintile 5 has the highest SES)

x_2 = Remoteness by SSD (used in the model in the form of a categorical variable covering the areas 1–5, where 1 = *Major cities*, 2 = *Inner regional*, 3 = *Outer regional*, 4 = *Remote*, 5= *Very remote*)

x_3 = proportion of Indigenous Australians in the SSD (expressed as a percentage, 0–100)

m = intercept term

n–v = coefficient terms

ind() = This is an indicator term for the expression in the brackets, equal to 1 when the expression is true, and 0 otherwise

This model can be rearranged and exponentiated to give the hospitalisation rate on the left side of the equation:

$$y/z = e^{m} * (e^{n})^{ind(x1=1)} * (e^{o})^{ind(x1=2)} * (e^{p})^{ind(x1=3)} * (e^{q})^{ind(x1=4)} * (e^{r})^{ind(x2=1)} * (e^{s})^{ind(x2=2)} * (e^{t})^{ind(x2=3)} * (e^{u})^{ind(x2=4)} * (e^{v})^{x3}$$

Once the model was fitted in SAS, the terms m–v can be added to the model as needed.

Appendix D Fitted Poisson models

D.1 Asthma hospitalisations

The final model

A Poisson regression model was fitted to the asthma hospitalisations data. All possible models using the three explanatory variables were tested. SES by SSD was used as the explanatory variable in the final model. The two other possible explanatory variables—remoteness of the SSD and the proportion of Indigenous Australians by SSD—were not used in the model because they did not make a statistically significant contribution to the model once SES was included, likely due to the correlations between these variables.

Table D1: The asthma hospitalisation model using SES by SSD as the explanatory variable

Interpretation	Estimated value	Statistically significant?	P value[(a)]	Term[(b)]
The factor increase in the hospitalisation rate for the lowest SES quintile compared with the highest SES quintile.	2.05	Yes	<0.0001	e^n
The factor increase in the hospitalisation rate for the second-lowest SES quintile compared with the highest SES quintile.	1.58	Yes	<0.0001	e^o
The factor increase in the hospitalisation rate for the middle SES quintile compared with the highest SES quintile.	1.64	Yes	<0.0001	e^p
The factor increase in the hospitalisation rate for the second-highest SES quintile compared with the highest SES quintile.	1.30	Yes	<0.0001	e^q
Exponentiated intercept term	0.0010	Yes	<0.0001	e^m

(a) Assuming a chi-square distribution.

(b) For the model form, see Appendix C, Section C.2.

According to this model, the asthma hospitalisation rate was twice as high for SSDs in the lowest SES quintile than for SSDs in the highest SES quintile. The hospitalisation rate generally decreased as the level of advantage increased, with the exception that the asthma hospitalisation rate was higher for SSDs in the middle SES quintile than in the second-lowest SES quintile.

Additional model information:

- Generalised R^2 for the model was 45%.
- The goodness-of-fit chi-square test showed that the model fitted the data well (p=0.46 allows rejection of the null hypothesis that the model does not fit well).
- Scale term added to the model to adjust for overdispersion: 2.01.

The models with each of the explanatory variables run separately

Socioeconomic status by SSD

See above.

Remoteness by SSD

The remoteness term by SSD was statistically significant ($p<0.0002$), but none one of the four remoteness level comparisons were statistically significant (p in the range of 0.45–0.98). Therefore, the full model is not shown here, as the values given to the level comparisons would be misleading.

Additional model information:

- Generalised R^2 for the model was 10%.
- The goodness-of-fit chi-square test showed that the model fitted the data well ($p=0.47$).
- Scale term added to the model to adjust for overdispersion: 2.57.

Proportion of Indigenous Australians by SSD

Table D2: The asthma hospitalisation model using the proportion of Indigenous Australians in the SSD as the explanatory variable

Interpretation	Estimated value	Statistically significant?	P value[(a)]	Term[(b)]
The factor increase in the hospitalisation rate for each percentage increase in the proportion of Indigenous Australians in the SSD	1.01	Yes	<0.0001	e^v
Exponentiated intercept term	0.0014	Yes	<0.0199	e^m

(a) Assuming a chi-square distribution.

(b) For the model form, see Appendix C, Section C.2.

This formula shows that, according to this model, the asthma hospitalisation rate was higher in SSDs with a higher proportion of Indigenous Australians. The model predicts an increase in the hospitalisation rate by a factor of 1.01 for every percentage increase in the proportion of the SSD population who were Indigenous Australians.

Additional model information:

- Generalised R^2 for the model was 2%.
- The goodness-of-fit chi-square test showed that the model fitted the data well ($p=0.48$).
- Scale term added to the model to adjust for overdispersion: 2.66.

D.2 COPD hospitalisations

The final model

A Poisson regression model was fitted to the COPD hospitalisations data. All possible models using the three explanatory variables were tested. SES by SSD and the proportion of Indigenous Australians by SSD were used as the explanatory variables in the final model. The other possible explanatory variable, remoteness of the SSD, was not used in the model because it did not make a statistically significant contribution to the model once the other two variables were included, likely due to correlations with the other two variables.

Table D3: The COPD hospitalisation model using SES and the proportion of Indigenous Australians in the SSD as the explanatory variables

Interpretation	Estimated value	Statistically significant?	P value[(a)]	Term[(b)]
The factor increase in the hospitalisation rate for each percentage increase in the proportion of Indigenous Australians in the SSD	1.02	Yes	<0.0001	e^{v}
The factor increase in the hospitalisation rate for the lowest SES quintile compared with the highest SES quintile.	1.81	Yes	<0.0001	e^{n}
The factor increase in the hospitalisation rate for the second-lowest SES quintile compared with the highest SES quintile.	1.56	Yes	<0.0001	e^{o}
The factor increase in the hospitalisation rate for the middle SES quintile compared with the highest SES quintile.	1.61	Yes	<0.0001	e^{p}
The factor increase in the hospitalisation rate for the second-highest SES quintile compared with the highest SES quintile.	1.28	Yes	<0.0001	e^{q}
Exponentiated intercept term	0.0073	Yes	<0.0001	e^{m}

(a) Assuming a chi-square distribution.

(b) For the model form, see Appendix C, Section C.2.

Based on this model, COPD hospitalisation rates were higher in SSDs with a higher proportion of Indigenous Australians by a factor of 1.02 for every percentage increase in the proportion of Indigenous Australians. The model also found that COPD hospitalisation rates were larger by a factor of 1.8 in SSDs in the lowest SES quintile compared with SSDs in the highest SES quintile. The COPD hospitalisation rate decreased as the level of SES advantage increased, with the exception of quintile 3, the middle quintile, which had a slightly higher hospitalisation rate than quintile 2, the second-lowest SES quintile.

Additional model information:

- Generalised R^2 for the model was 55%.
- The goodness-of-fit chi-square test showed that the model fitted the data well (p=0.48).
- Scale term added to the model to adjust for overdispersion: 3.48.

The models with each of the explanatory variables run separately

SES by SSD

Table D4: The COPD hospitalisation model using SES by SSD as the explanatory variable

Interpretation	Estimated value	Statistically significant?	P value[(a)]	Term[(b)]
The factor increase in the hospitalisation rate for the lowest SES quintile compared with the highest SES quintile.	1.95	Yes	<0.0001	e^{n}
The factor increase in the hospitalisation rate for the second-lowest SES quintile compared with the highest SES quintile.	1.60	Yes	<0.0001	e^{o}
The factor increase in the hospitalisation rate for the middle SES quintile compared with the highest SES quintile.	1.65	Yes	<0.0001	e^{p}
The factor increase in the hospitalisation rate for the second-highest SES quintile compared with the highest SES quintile.	1.30	Yes	<0.0001	e^{q}
Exponentiated intercept term	0.0073	Yes	<0.0001	e^{m}

(a) Assuming a chi-square distribution.

(b) For the model form, see Appendix C, Section C.2.

This model found that COPD hospitalisation rates were larger by a factor of 2 for SSDs in the lowest SES quintile compared with SSDs in the highest SES quintile. The COPD hospitalisation rate decreased as the level of SES advantage increased, with the exception of SSDs in the middle quintile, which had a slightly higher hospitalisation rate than SSDs in the second-lowest SES quintile.

Additional model information:

- Generalised R^2 for the model was 50%.
- The goodness-of-fit chi-square test showed that the model fitted the data well (p=0.48).
- Scale term added to the model to adjust for overdispersion: 3.66.

Remoteness by SSD

The remoteness term by SSD was statistically significant (p<0.0001), but none one of the four remoteness level comparisons were statistically significant (p in the range of 0.07–0.71). Therefore, the full model is not shown here, as the values given to the level comparisons would be misleading.

Additional model information:

- Generalised R^2 for the model was 21%.
- The goodness-of-fit chi-square test showed that the model fitted the data well (p=0.49).
- Scale term added to the model to adjust for overdispersion: 4.61.

Proportion of Indigenous Australians by SSD

Table D5: The COPD hospitalisation model using the proportion of Indigenous Australians in the SSD as the explanatory variable

Interpretation	Estimated value	Statistically significant?	P value[(a)]	Term[(b)]
The factor increase in the hospitalisation rate for each percentage increase in the proportion of Indigenous Australians in the SSD	1.03	Yes	<0.0001	e^v
Exponentiated intercept term	0.010	Yes	<0.0001	e^m

(a) Assuming a chi-square distribution.

(b) For the model form, see Appendix C, Section C.2.

This model found that the COPD hospitalisation rate was higher in SSDs with a higher proportion of Indigenous Australians. The model predicts an increase in the hospitalisation rate by a factor of 1.03 for every percentage increase in the proportion of the SSD population who were Indigenous Australians.

Additional model information:

- Generalised R^2 for the model was 18%.
- The goodness-of-fit chi-square test showed that the model fitted the data well (p=0.48).
- Scale term added to the model: 4.66.

List of figures

List of tables

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This report investigates how hospitalisation rates for asthma and chronic obstructive pulmonary disease (COPD) vary across Australia. Maps in the report show higher hospitalisation rates for both asthma and COPD in inland and rural areas of Australia.

Socioeconomic status, remoteness and the proportion of the population that identifies as Indigenous all have a significant association with the hospitalisation rates for asthma and COPD by area.