Australian Government
Australian Institute of Health and Welfare

Access to primary health care relative to need for Indigenous Australians

Australian Government
Australian Institute of Health and Welfare

Authoritative information and statistics to promote better health and wellbeing

Access to primary health care relative to need for Indigenous Australians

Australian Institute of Health and Welfare
Canberra
Cat. no. IHW 128

The Australian Institute of Health and Welfare is a major national agency which provides reliable, regular and relevant information and statistics on Australia's health and welfare. The Institute's mission is *authoritative information and statistics to promote better health and wellbeing*.

A complete list of the Institute's publications is available from the Institute's website <www.aihw.gov.au>.

ISBN 978-1-74249-586-6

Suggested citation

Australian Institute of Health and Welfare 2014. Access to primary health care relative to need for Indigenous Australians. Cat. no. IHW 128. Canberra: AIHW.

Any enquiries about or comments on this publication should be directed to:
Media and Strategic Engagement Unit
Australian Institute of Health and Welfare
GPO Box 570
Canberra ACT 2601
Tel: (02) 6244 1032
Email: info@aihw.gov.au

Published by the Australian Institute of Health and Welfare

Contents

Acknowledgments

The authors of this paper were Martin Edvardsson, Brett Nebe and Marianna Stylianou from the Indigenous Modelling and Research Unit at the Australian Institute of Health and Welfare. Deanna Pagnini played an important role in the scoping work for this project. Brendan Scott and Jennifer Norton made substantial contributions to the development of the methodology used in this study. Michelle Gourley, Adriana Vanden Heuvel, Louise York and Teresa Dickinson commented on earlier versions of this paper. The authors wish to thank Fadwa Al-Yaman for her ongoing advice and comments on this project and paper.

The authors also gratefully acknowledge the support and advice given by the National Indigenous Reform Agreement Performance Information Management Group (NIRAPIMG). Gavin West (WA Health) kindly provided feedback on a draft report of the pilot study undertaken as part of this project.

Special thanks go to the external reviewers of this paper:

- Nasser Bagheri (Australian National University)
- Matthew McGrail (Monash University)
- Katie Panaretto (NAGATSIHID; Public Health Medical Officer, NACCHO)
- Ian Ring (NAGATSIHID; University of Wollongoing)
- Department of Health
- Department of the Prime Minister and Cabinet.

Partial funding for this project was provided by the former Department of Families, Housing, Community Services and Indigenous Affairs (Performance and Evaluation Branch), which currently sits with the Department of the Prime Minister and Cabinet (Evidence and Evaluation Branch).

Abbreviations

2SFCA	2-step floating catchment area
ABS	Australian Bureau of Statistics
ACSC	ambulatory care sensitive conditions
ADAT	avoidable deaths amenable to treatment
AIHW	Australian Institute of Health and Welfare
AMPCo	Australasian Medical Publishing Company
ARN index	Access Relative to Need index
ASGS	Australian Statistical Geography Standard
FTE	full-time equivalent
GP	general practitioner
ICD-10-AM	International statistical classification of diseases and related health problems, 10th revision, Australian modification
NACCHO	National Aboriginal Community Controlled Health Organisation
NAGATSIHID	National Advisory Group on Aboriginal and Torres Strait Islander Health Information and Data
NATSIHS	National Aboriginal and Torres Strait Islander Health Survey
NIRA	National Indigenous Reform Agreement
NIRAPIMG	National Indigenous Reform Agreement Performance Information Management Group
RFDS	Royal Flying Doctor Service
SA1	Statistical Area Level 1
SA2	Statistical Area Level 2
SEIFA	Socio-Economic Indexes for Areas
WA	Western Australia

Summary

In recent years, the Australian Institute of Health and Welfare (AIHW) has worked towards developing a reliable, valid and meaningful method to measure access to services relative to need as it relates to primary health care for Aboriginal and Torres Strait Islander people. While the aim was clear, finding a way to develop such a measure proved difficult because there was no agreed methodology.

Following a literature review, the AIHW determined that measures of service availability, access and predicted need for primary health care could be incorporated into one reportable indicator by creating a geospatial index of access to health services relative to need for health care. This index could be constructed so it allowed for comparison among and between Indigenous and non-Indigenous communities.

Developing and validating the index

In order to determine the suitability of using a geospatial index to measure access relative to need for the Indigenous population, a pilot study was undertaken using Western Australian data. The pilot study used a similar methodology to that developed by McGrail and Humphreys (2009) for their index of access to primary health care in rural Victoria. Substantial refinements to the methodology were made before expanding the analysis nationally.

The index (Access Relative to Need index, or ARN index) was developed to identify variation in access at the smallest geographical level with available data—Statistical Area Level 1 (SA1). In both the pilot and national studies, access to primary health-care services was estimated based on travel time by road to general practitioners (GPs) and total demand on these GPs from all the populations they serve.

Predicted need for primary health care was calculated using demographic and socioeconomic variables known to be correlated with health outcomes. The index was validated by confirming the association between index scores and health outcomes that reflect unmet health need.

Findings

The results of the national study show that health outcomes improve more dramatically with improved access to GPs in areas with relatively high predicted need for primary health care than in areas with low predicted need. This suggests that access to primary care relative to need is an important factor underlying geographic variation in health outcomes in Australia.

The index suggests that Indigenous people experience a general pattern of worsening access to GPs relative to need with increasing remoteness. This pattern was attributed to relatively poor access to GPs and relatively high predicted need for primary health care in more remote areas.

The index suggests that the non-Indigenous population experiences a less dramatic decrease in access to GPs relative to need with increasing remoteness. Average access to GPs does worsen with increasing remoteness, but non-Indigenous people in *Very remote* areas tend to live in SA1s with higher access to GPs than Indigenous people.

1 Introduction

Measuring access to health care relative to need is inherently complex due to the multidimensional nature of the two concepts—access and need. For example, the concept of access incorporates physical aspects (such as availability and accessibility), financial aspects (affordability) and cultural aspects (acceptability) (Penchansky & Thomas 1981). Similarly, the concept of need can refer to the perceived needs of individuals or their needs as defined by experts, carers or family. While an ideal measure of 'access relative to need' would incorporate all these aspects, such a measure would be complicated to implement and suffer from a lack of robust data (particularly for the Indigenous population).

Service availability, physical access and need can be incorporated into a spatially-based (that is, geospatial) index. Spatial indexes have been used to focus on socioeconomic disadvantage—for example, the Australian Bureau of Statistics' (ABS's) Socio-Economic Indexes for Areas (SEIFA), Indigenous social disadvantage (ABS 2000; Biddle 2009), child social exclusion (McNamara et al. 2008), multidimensional social disadvantage (Vinson 2007) and neighbourhood deprivation (O'Campo et al. 2008). Spatially-based health indexes incorporating supply, access and need have also been developed (Field 2000; McGrail & Humphreys 2009) and have, in some cases, been used to define 'medically underserved' areas (Lee 1979, 1991).

The Australian Institute of Health and Welfare (AIHW) has developed an area-based index of access to primary health care relative to need that can be applied to specific population groups, including Indigenous Australians. The index was developed using the general methodological approach of McGrail and Humphreys (2009), who created an index of access to primary health care for rural Victoria. McGrail and Humphreys' index can be described as an enhanced health service provider-to-population ratio that takes travel distance to providers and varying service demands into account. The AIHW used a modified version of this index as a measure of the capacity of the general practitioners (GPs) accessible to the population residing in a given area to meet the total demand of all the populations they serve. This measure of available GP capacity was then linked to Indigenous-specific predicted need for primary health care and estimated mobility to create an Indigenous-specific index of access relative to need. Available GP capacity was also linked to predicted need for primary health care specific to the non-Indigenous and total populations, creating the same index for these population groups.

Access to GPs was selected as the type of health service to be studied. GPs encompass the prevention, diagnosis and treatment of ill health and are accessed by people for both initial and ongoing management of disease.

This paper outlines findings from a study that uses the AIHW's newly developed geospatial index to report on Indigenous people's access to GPs relative to their predicted need for primary health care across Australia. It also uses the same index to report how access relative to need varies geographically for the non-Indigenous and total populations. Results from the index calculations are presented at the national level, as well as by remoteness areas.

1.1 Data sources

Australasian Medical Publishing Company GP database

Information about GPs was sourced from the Australasian Medical Publishing Company (AMPCo), which provides information on all GPs registered in Australia at the time of its extraction (2013) from AMPCo's database. AMPCo data include GPs working in both public and private health care, and data for GPs employed by Aboriginal Medical Services.

GP data extracted from AMPCo included the following information: GP service addresses, the number of GPs working at each service, and a full-time equivalent (FTE) value for each GP. According to the AIHW (2014b), there were 25,964 employed GPs in Australia in 2012. In 2014, the AMPCo GP database had records for nearly 27,000 GPs; however, not all of these GPs were practising. In this study, the FTE values of GPs working at GP service locations were used rather than specific GP numbers.

Additional GP service data were sourced from the Australian Royal Flying Doctor Service (RFDS), which supplied the AIHW with information regarding location and FTE GPs for community clinics operating in *Remote* and *Very remote* Aboriginal communities.

2011 Census of Population and Housing

Census data were used for population numbers and to calculate the predicted need for primary health care of the populations. The Census of Population and Housing is conducted by the ABS at 5-yearly intervals and is designed to include all Australian households. Data included in this paper were from the 2011 Census and were reported at the Statistical Area Level 1 (SA1) level, which is the smallest unit for which Census data were released for both Indigenous and non-Indigenous Australians.

National Hospital Morbidity Database

Hospitalisation data were used to validate the index. These data were extracted from the AIHW's National Hospital Morbidity Database, which is a compilation of episode-level records from Australian hospitals. These records are provided annually to the AIHW by state and territory health departments. See Appendix C for further information.

National Mortality Database

Mortality data were used to validate the index. These data were extracted from the AIHW's National Mortality Database, which contains information collected on death registrations by the Registrars of Births, Deaths and Marriages in each state and territory and from the National Coronial Information System. The ABS compiles and codes the cause of death and passes the data to the AIHW. See Appendix C for further information.

2 Development of the index

2.1 Background

Reporting on 'access to health care compared to need' has in the past been based on 6-yearly data from the National Aboriginal and Torres Strait Islander Health Survey (NATSIHS) and the following 2 measures:

- the number of people who were admitted to hospital in the past 12 months or who accessed another health service in the past 2 weeks
- the number of people who needed to access health care in the past 12 months but did not.

These 2 measures were not ideal to monitor progress in this area because the first measure captured use of health services rather than access, and new data were available only every 6 years (when the NATSIHS was conducted). The ability of these measures to reflect access relative to need is also debatable. Information recorded in the NATSIHS is essentially 'as reported' by respondents. It may therefore be affected by imperfect recall and individual interpretations of survey questions, which may underestimate health-care use. Also, information on whether a particular respondent accessed a health service in the previous 2 weeks does not indicate how accessible services were for a particular population in terms of both travel time and GP capacity. Furthermore, in the NATSIHS, need is based on the views of the survey respondent, which could be different from those of a health professional.

In 2011, the Council of Australian Governments agreed to review the National Indigenous Reform Agreement (NIRA) under the Intergovernmental Agreement on Federal Financial Reform (NIRA 2011). The NIRA Review Working Group recommended that the 'access to health care compared to need' performance indicator be removed due to conceptual inadequacies in trying to measure both 'access' and 'need'. It also recommended that the then Australian Government Department of Health and Ageing and the AIHW continue to work on determining whether an alternative approach to measuring access to health care compared with need could be found.

Assessment of potential methods

To develop a more robust measure of access relative to need than one based on self-reported survey data from the NATSIHS, the AIHW reviewed the literature on health-care access and needs and found that geospatial indexes had been used in other contexts to describe variation in both access and needs. A geospatial index allows for data to be analysed based on where people live and where services are located. It can also include aspects such as need for services, and population-to-provider ratios. Additionally, geospatial indexes can be used as a summary measure of more than one indicator, they can compare relative inequalities across communities or between populations, and they allow for comparisons between areas that might perform differently on separate components of the index.

Table 2.1 presents examples of geospatial health-care indexes developed in Australia and overseas. They generally include some measure of access (distance or personal mobility), service availability (provider-to-population ratio) and need (mixture of health status indicating unmet need for primary care and socioeconomic status).

Table 2.1: Examples of geographically-based health-care indexes

Index	Country	Components	Geographic level
Multi-attribute Primary Care Targeting Strategy (Dulin et al. 2010)	United States of America (North Carolina)	Median household income Population density Percentage of uninsured emergency department patients Emergency department use for illness preventable or treatable through primary care Use of safety-net clinics	Census tract
Index of Rural Access (McGrail & Humphreys 2009)	Australia (Victoria)	Spatial accessibility to GPs (travel times and provider-to-population ratios) Need (based on socioeconomic and demographic variables) Mobility (based on percentage of households without cars, low personal mobility and public transport availability)	Census Collection Districts in regional and remote Victoria; Statistical Local Areas in Melbourne
Spatial accessibility and need indexes (Bagheri et al. 2008)	New Zealand (Otago)	Spatial accessibility to a primary health-care team (travel times and provider-to-population ratios) Need (based on socioeconomic variables used to calculate New Zealand deprivation index score)	Census mesh blocks
Resource Allocation index (Houston 2003)	Australia (Western Australia) (WA)	Capacity to benefit from health resources (weighted by the proportion of deaths and disease arising separately from environmental, social and lifestyle factors) Relative disadvantage (based on ABS SEIFA indicators) Community infrastructure (including management, economic, social and human resources) Costs associated with remoteness and travel Costs associated with providing culturally-secure services	WA Aboriginal and Torres Strait Islander Commission regions
Index of Relative Disadvantage (Field 2000)	United Kingdom (Northampton District Health Authority)	Percentage of population with high health-care needs (children aged 0–4, women of child-bearing age, and people aged 65 and over) Socioeconomic status Housing tenure, amenities and overcrowding Transport availability Personal mobility Service awareness	Census Enumeration Districts
Medically Underserved Areas/ Populations (US Department of Health and Human Services 2012)	United States of America	Health-care provider-to-population ratio Infant mortality rate Percentage of population with an income below the federal poverty level Percentage of population aged 65 and over	Rational Service Areas
Primary Care index (Arizona Department of Health Services 2009)	United States of America (Arizona)	Provider-to-population ratio Percentage of population below poverty level Geographic accessibility (travel times and transportation) Percentage of uninsured births Percentage of low birthweight babies Percentage of births with late or no prenatal care Infant mortality rate Percentage of deaths before life expectancy Proportion of hospitalisations for ambulatory sensitive conditions Percentage of minorities, elderly and unemployed	Rational Service Areas

Two of the geographically-based indexes combined measures of access and need—the ones developed by McGrail and Humphreys (2009) and Bagheri and others (2008). However, neither of these indexes can be applied to a specific population group such as Indigenous Australians because they were designed only for the purpose of analysing the access of the total population.

To overcome this, the AIHW identified that the components used in McGrail and Humphreys' (2009) Index of Rural Access could be manipulated to develop a population-specific index. The Index of Rural Access combined measures of physical accessibility and mobility with a measure of predicted need that was used in combination with population sizes to estimate total demand on service providers. The AIHW recognised that the mobility and need measures could be calculated separately for the Indigenous and non-Indigenous populations, and that these measures could then be used to develop a population-specific index that also included the physical access to health services in each area.

To test if this would work in practice, the AIHW conducted a pilot study in 2012 using WA data. That study confirmed that a population group-specific index of access relative to need could be based on a modified version of McGrail and Humphreys' (2009) methodology.

Following the pilot study, the AIHW conducted a review of the methodology underpinning that study and identified several areas that required modification, correction or refinement (see Section 2.2 and Appendix A). Following those changes, the revised index—referred to as the Access Relative to Need (ARN) index—was applied to 2011 national data.

This paper presents the results of the ARN index at the national level for both Indigenous and non–Indigenous people.

An explanation of the key concepts used in the study is provided in Box 2.1 (see also Section 2.2 and Appendix A).

Box 2.1: Key concepts

Access to general practitioners

'Access to GPs' describes the physical availability of GP services to the population of an area (SA1). It takes into account the road travel time to all GPs within reach of the population and the capacity of these GPs to meet the total service demands of all the populations they serve, based on the population sizes and predicted need for primary health care of these populations.

Statistical Area Level 1

'Statistical Area Level 1' (SA1) is the second smallest geographical unit in the Australian Statistical Geography Standard (ASGS), which was developed by the ABS to collect and report geographical statistics (ABS 2011). It is the smallest unit for which ABS 2011 Census of Population and Housing data were released for both Indigenous and non-Indigenous Australians. For this reason, it is the geographical unit used in this paper. Using the smallest geographical unit with available data was important to pick up variation between geographical areas.

(continued)

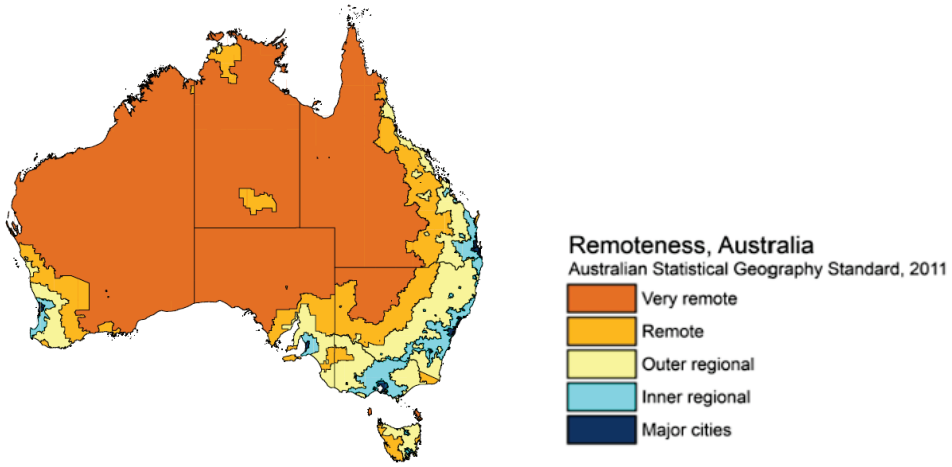
Box 2.1 (continued): Key concepts

Area centroid

An 'area centroid' is the geographical mid-point of an SA1 that is used to calculate the population's average travel time to the nearest GP. Centroids were determined manually for geographically vast SA1s (as found in *Very remote* areas) based on the location of townships rather than the geographical mid-point of the SA1.

Remoteness areas

Australia is divided into several regions based on relative accessibility to goods and services as measured by road distance. These regions are based on the Accessibility/Remoteness Index of Australia and are classified in each Census year as *Major cities*, *Inner regional*, *Outer regional*, *Remote* and *Very remote* (see map below).



Primary health care

'Primary health care' refers to the first health service visited by patients with a health concern. It includes most services not provided by hospitals and involves a wide range of professions, such as GPs, pharmacists, paramedics, community health workers, Aboriginal health workers, practice nurses and dentists. This study focused on access to GPs, including both GPs in mainstream and Indigenous-specific services.

Need for primary health care

'Need for primary health care' is the per capita need for primary health care of a certain population. Demographic and socioeconomic variables from the 2011 Census that correlate with need for health care were used to estimate this need in this study. The variables used were 'proportion of people in high needs age groups', 'proportion of people who need assistance with core activities', 'proportion of unemployed people', 'proportion of households without access to a motor vehicle' and 'proportion of people who have not attained Year 12 or equivalent school or non-school qualification'.

Mobility

'Mobility' reflects how easily the people of a certain population can travel to access GPs. In this study, 'mobility' is determined by the proportion of households with access to a motor vehicle and the proportion of people aged under 18 or 75 and over, as people in these age ranges are more likely to need assistance to attend a GP (either because they are not licensed to drive or are less likely to drive than the rest of the population).

2.2 Methods

The ARN index is based on the following information:

- the locations of health services and the populations they serve
- the number of GPs (FTE) working at each service location
- the demographic and socioeconomic characteristics of the Indigenous, the non-Indigenous and the total populations of all SA1s.

This information was used to calculate the 3 components of the ARN index: 'predicted need for primary health care', 'access to GPs' and 'mobility'. These components are described below (for additional details see Appendix A).

Predicted need for primary health care

In this study, the need for primary health care was estimated using demographic and socioeconomic variables. This method was also used by Bagheri and others (2008) and McGrail and Humphreys (2009) to model access to primary health care in New Zealand and Australia, respectively.

'Predicted need for primary health care' is not a measure of the current health of a population, but an estimate of the need for primary health care based on the characteristics of the population. The need for health care varies strongly with age. Small children, women of child-bearing age and the elderly are more likely to need to access the health-care system than other age groups. As a consequence, age structure is an important predictor of a population's need for primary health care. In the Australian context, socioeconomic factors have also been shown to be strong predictors of hospital use (Zhao et al. 2011) and hospitalisation for ambulatory care sensitive conditions (ACSC) (Ansari et al. 2012) (Box 2.2). Socioeconomic factors, like educational attainment and employment, have been found to be associated with important behavioural health risks such as smoking, excessive alcohol consumption and sedentary lifestyles (AIHW 2014a). They also seem to influence health outcomes beyond the associations with identified risky behaviours (AIHW 2014a). In all, it should therefore be possible to use a measure made up of a combination of demographic and socioeconomic variables to capture a large part of the variation in per capita need for primary health care that exists between areas and populations.

An alternative approach to using demographic and socioeconomic variables would be to use direct measures of health outcomes—such as hospitalisations due to ACSC, premature mortality, or avoidable deaths amenable to treatment (ADAT)—as indicators of predicted need for primary health care. However, the numbers of these outcomes at the SA1 level are too small (particularly for the Indigenous population) to provide reliable estimates of the need of an SA1 population in any given year. Furthermore, ACSC, premature mortality and ADAT are not ideal measures of overall need as they are likely to reflect not only need but also the extent to which this need is unmet (Box 2.2). Rates of these outcomes would be expected to differ between populations with identical needs when the extent to which the needs are met varies between populations.

Associations between demographic and socioeconomic variables and ADAT at the Statistical Area Level 2 (SA2) level were used to inform the selection of variables included in the index calculations. In the ABS's ASGS, SA2s are made up of a number of whole SA1s and have an average population of about 10,000 persons, compared with about 400 for SA1s (ABS 2011).

The greater average population size means that rates of ADAT are less sensitive to year-to-year random fluctuations at this geographic level.

Box 2.2: Ambulatory care sensitive conditions and avoidable deaths amenable to treatment

Ambulatory care sensitive conditions

ACSC are conditions for which hospitalisations are potentially preventable if adequate ambulatory care is provided in time. Ambulatory care is health care provided in community settings, emergency departments and outpatient clinics. For example, influenza hospitalisations could be prevented through vaccination, and asthma hospitalisations could be prevented through adequate treatment.

Avoidable deaths amenable to treatment

ADAT are deaths that are potentially preventable through adequate and timely provision of prevention measures or treatment. For example: deaths due to HIV/AIDS, injuries and lung cancer could be avoided through prevention; those due to asthma, appendicitis and a range of other types of cancer could be avoided through treatment; and those through coronary heart disease, stroke and diabetes could be avoided through a combination of prevention and treatment.

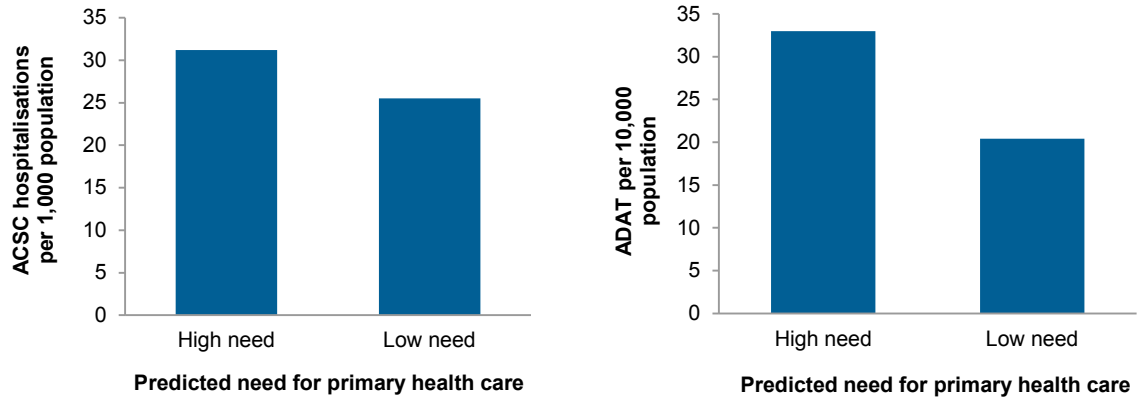
A selection of 5 variables from the 2011 Census was used to create the predicted need for primary health-care component of the ARN index. The 5 variables all have a conceptual or previously demonstrated empirical link with health outcomes. Furthermore, when calculated for populations at the SA2 level, all variables showed significant associations with rates of ADAT (in 2010 and 2011 combined), based on data from the AIHW's National Mortality Database (Appendix A). The same selection of variables was used for the Indigenous, non-Indigenous and total populations. The variables were:

- proportion of people in **high needs age groups** (all children aged 0–4, all women of the child-bearing age 18–44, Indigenous people aged 55 and over and all people aged 65 and over)
- proportion of people who **need assistance** with core activities (that is, activities related to self-care, mobility and communication)
- proportion of **unemployed** people
- proportion of households without **access to a motor vehicle**
- proportion of people who **have not attained Year 12 or equivalent school or non-school qualification**.

Two of the variables—high needs age groups and need for assistance—showed the strongest association with health outcomes at the SA2 level and were allowed to each make up one-third of the index. The remaining 3 variables, together, made up the remaining third.

The predicted need component is used both as an estimate of a population's need for primary health care and, in combination with population size, as an estimate of the demand that a population is putting on the primary health-care system. Even though it is not a measure of population health, it is expected to be correlated with health outcomes. Populations with a high predicted need would normally be expected to have worse health outcomes than populations with lower predicted need. Figure 2.1 shows that when all SA1s were divided into areas with above average (that is, high need) and below average (low

need) predicted need, high need areas had higher rates of both ACSC hospitalisations and ADAT than low need areas (see also Box 2.2, 'Validation of index' section below and Appendix A).



Note: Data for this figure are shown in Appendix Table B2.1.

Source: AIHW analysis of ARN index; AIHW National Hospital Morbidity Database; AIHW National Mortality Database.

Figure 2.1: Rates of hospitalisations due to ACSC and rates of ADAT in areas with high and low predicted need for primary health care

Access to GPs

The access to GPs component is a measure of the extent to which the population of an SA1 has access to GPs that have the capacity to meet the demand from all population groups in all SA1s they serve. In other words, it is a measure of access to GPs that takes into account travel time, population size and competition from populations in other SA1s with access to the same GPs. The demand a population of an SA1 places on a GP depends on the travel time to the GP, the size of the population of the SA1 and its predicted need for primary care (see 'Predicted need for primary health care' above). The access to GPs component can be calculated only for the whole population of each area as both Indigenous and non-Indigenous people are assumed to use all available service providers and live at the same location within each SA1 (that is, the area centroid, see Box 2.1 and Appendix A).

Access to GPs was estimated using the 2-step floating catchment area (2SFCA) approach introduced by Luo and Wang (2003) and developed further by McGrail and Humphreys (2009). The 2 steps of the 2SFCA are:

1. the calculation of a service provider-to-population ratio for each service location based on the sizes of all populations within a certain travel time or distance
2. the calculation of the level of access by taking the sum of the service provider-to-population ratios of all service locations within reach of each population.

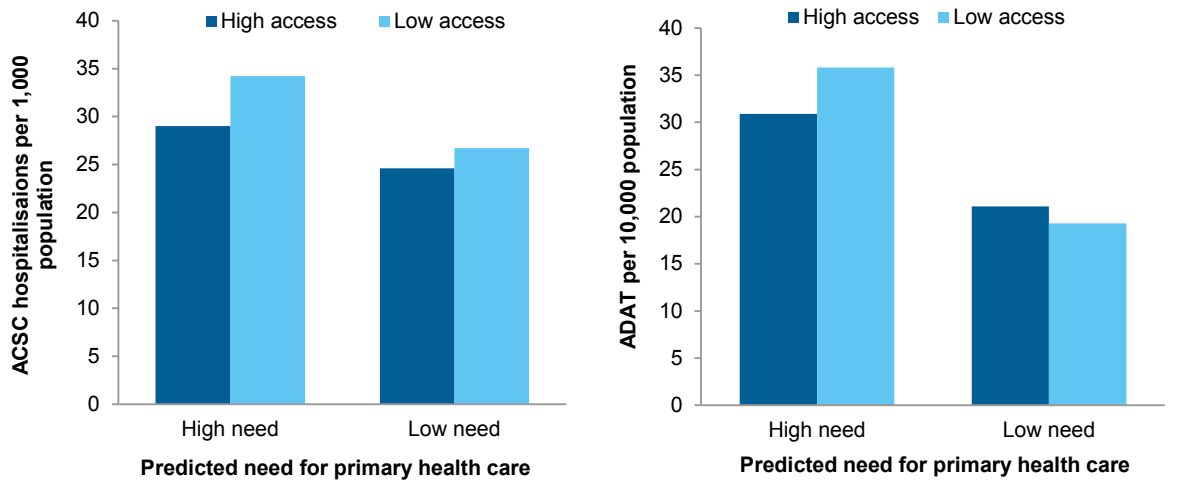
Improvements McGrail and Humphreys made to the 2SFCA included adding 3 main components.

- First, they allowed access to decline gradually with distance by including a travel impedance function to steps 1 and 2. Access (that is, demand on the service provider in step 1) was deemed to be unimpaired when service locations were within 10 minutes travel time; it then gradually declined to 0 for travel times longer than 60 minutes.

- Second, they included a needs component (see 'Predicted need for primary health care' above) to reflect per capita demand on the service providers in step 1. High need in an area effectively increases the size of the population (and therefore reduces the provider-to-population ratio for all areas that have access to the same service providers) to reflect the greater number of GP visits required by this community.
- Third, they included the mobility component (see 'Mobility' below) in step 2 to reflect a population's ability to travel to the available services.

The current study used McGrail and Humphreys' version of the 2SFCA to estimate the capacity of the service providers who are within reach of the population of each SA1 to provide primary health care to all the populations they serve—this is used as a component of the ARN index (see 'Access relative to need' below). However, some important changes were made to McGrail and Humphreys' methodology. Most importantly, these included a different way of standardising the variables used to calculate the need component and not capping the number of service providers each population can access in step 2 of the 2SFCA (see Appendix A for further details and rationale).

Improved access to GPs would be expected to lead to improved health outcomes, especially in areas with high needs for primary health care. As expected, in this study, high needs areas with above average access (high access) had rates of ACSC hospitalisations and ADAT that were lower than in high needs areas with below average access (low access). In areas with low needs, the differences between areas with high and low access were much smaller; low needs areas with low access even had slightly lower rates of ADAT than low needs areas with high access (Figure 2.2). This suggests that variation in access to GPs does indeed have the biggest impact on health outcomes when the predicted need for primary care is high (see also 'Validation of index' section below).



Note: Data for this figure are shown in Appendix Table B2.2.

Source: AIHW analysis of ARN index; AIHW National Hospital Morbidity Database; AIHW National Mortality Database.

Figure 2.2: Rates of hospitalisations due to ACSC and rates of ADAT in areas with high and low predicted need for primary health care, by level of access to GPs

Mobility

How easily people can travel to a service provider depends on a number of factors including the distance to the provider and the mobility of the population. The mobility, or ease of

access, of a population was estimated using data from the 2011 Census on the proportion of households without a motor vehicle and the proportion of people with low mobility. The latter is defined as people aged under 18 or 75 and over, since people in these age ranges are more likely to need assistance to attend a GP (either because they are not licensed to drive or because they are less likely to drive than the rest of the population).

When estimating mobility for their index of access to primary health care for rural Victoria, McGrail and Humphreys (2009) assumed that car travel contributed 80% to personal mobility, public transport 10% and personal mobility (walking or riding a bicycle) 10%. As data on public transport for all of Australia were not available, the proportion of households without a motor vehicle was assumed to contribute 90% to personal mobility and the proportion of people with low mobility 10%.

McGrail and Humphreys (2009) estimated that populations with the lowest mobility are 70% as mobile as the populations with the highest mobility. Here, mobility scores were transformed to fit within a similar range. The same formula was used for all 3 population groups. Using this formula, areas where all households had access to a car and there were no people with low mobility would get a score of 1, and areas where no households had access to a car and everyone had low mobility would get a score of 0.67. This resulted in average mobility scores of 0.91 for Indigenous people, 0.97 for non-Indigenous people and 0.96 for the total population.

Access relative to need

To calculate the final ARN index for each population group, the access to GPs component was related to the specific predicted need for primary health-care and mobility components of the Indigenous, non-Indigenous and total populations described above as follows:

$$ARN_{pi} = \left(\frac{Access\ to\ GPs_i}{Need_{pi}}\right) * Mobility_{pi}$$

where

ARN_{pi} is the ARN index score for population group p (Indigenous, non-Indigenous or total) in $SA1_i$

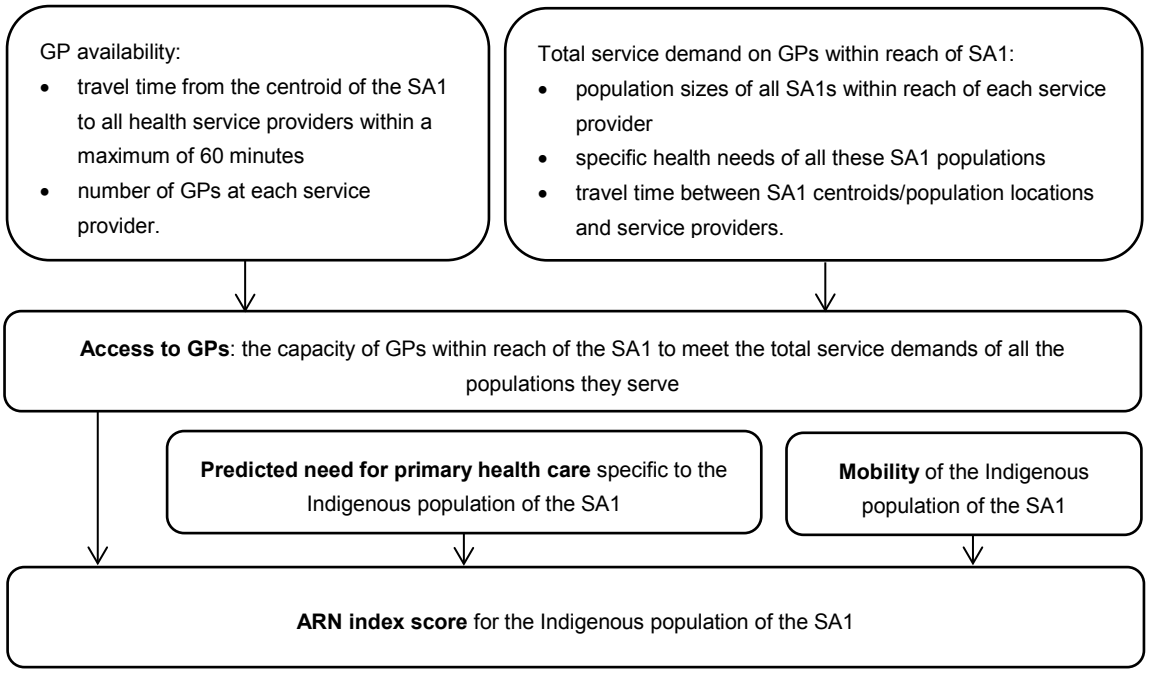
Access to GPs_i is the access to GPs component for $SA1_i$

$Need_{pi}$ is the predicted need for primary health-care component for population group p in $SA1_i$

$Mobility_{pi}$ is the mobility component for population group p in $SA1_i$.

When this index is used, if populations in 2 areas have equal access to service providers with the same capacity to meet the total service demand they are under, the population with the highest predicted need for primary health care will have the lowest access relative to need. This contrasts with McGrail and Humphreys' access index where the 2 areas would have the same score.

Figure 2.3 shows the components that make up the ARN index and the information that is required to calculate each of the components.



(a) Similarly, an ARN index score can be calculated for the non-Indigenous or total population by using the specific predicted need and mobility of the non-Indigenous or total population of an SA1, rather than for the Indigenous population.

Figure 2.3: Overview of how the ARN index for Indigenous people[(a)] in an SA1 was calculated

Interpretation

The ARN index and its access to GPs component can, theoretically, take on any value that is greater than or equal to 0. For example, giving a population access to more GPs will always increase the score of both the ARN index and the access to GPs component. In contrast, the predicted need and mobility components are based on proportions and can vary only within certain ranges of values. For example, it is not possible for more than 100% of the people of an area to be in a high needs age category or to have access to a car.

Because of the way its components are calculated, the ARN index is not a measure of something easily interpreted like, for example, GPs per 10,000 people. However, it is possible to use some hypothetical examples to illustrate what the ARN index scores represent. A population of 10,000 people with access to 1 GP that is unimpeded by travel time would have an ARN index score of 1 if the population had an average need for primary health care (1) and maximum mobility (1), as long as no other populations had access to the same GP. For every additional GP added within 10 minutes of travel time of this population, the ARN index score would increase by 1.

A hypothetical population made up of the entire Australian population at the time of the 2011 Census (21,507,717), living in 1 area with an average predicted need for primary health care (1), average mobility (0.96) and with unimpeded access to all of Australia's employed GPs—25,964 in 2012 (AIHW 2014b)—would, assuming every GP worked full time, have an

ARN index score of 11.6. In contrast, in this study, the average Australian lived in a population experiencing an ARN index score (for the total population) of 8.8. The lowest ARN index score (for the total population) for any area was 0 and the highest 98.9.

Validation of index and access relative to need approach

The ARN index aims to capture physical access to primary health care (as measured by access to GPs) relative to need for primary health care. A low index score should indicate an area where the risk of bad health outcomes is relatively high because the need for primary health care is likely to be unmet to a relatively large degree. Health outcomes that are classified as ACSC hospitalisations or ADAT have, by definition, a large component of unmet needs related to primary health care (Box 2.2). An appropriately designed index of access relative to need should therefore be statistically associated with rates of ACSC hospitalisations and ADAT. In general, areas with low access relative to need would be expected to have high rates of ACSC hospitalisations and ADAT (see also the 'Predicted need for primary health care' and 'Access to GPs' sections above).

To validate the ARN index, the association between these rates and the index were examined using data from both the AIHW's National Hospital Morbidity Database and its National Mortality Database (Section 1.1 and Appendix C). The ARN index showed a statistically significant association with both rates of ADAT and hospitalisations due to ACSC. As expected, areas with lower access relative to need tended to have higher rates of ACSC hospitalisations and ADAT. Importantly, the ARN index could explain much more of the between-area variation in ACSC hospitalisations and ADAT (14% and 11%, respectively) than the access to GPs component on its own (5% and 0.7%, respectively).

A focus on access to health care relative to need is motivated by the seemingly plausible assumption that the importance of access to health care increases with increasing need. If true, a useful index of access relative to need should assign low scores to areas where improved access would improve health outcomes more than it would in areas with high scores. For this to work, the access component of the index has to capture variation in actual access to health care and the predicted need component has to capture variation in actual need for health care. Health outcomes would therefore be expected to improve more in areas with high need when access to health care is increased, compared with areas with low need.

Overall, results from the current study indicated that health outcomes (as measured by ACSC hospitalisations and ADAT) improved more dramatically with improved access (as measured by the access to GPs component of the ARN index) in areas with relatively high predicted need (as measured by the need for primary health-care component of the ARN index) than in areas with relatively low predicted need. When the areas were divided into 2 groups based on their predicted needs, there was a bigger difference in health outcomes between areas with relatively good access to GPs and areas with relatively bad access to GPs in the group of areas with high predicted need, than in the group with low predicted need. This suggests that the components of the ARN index do capture a substantial part of the variation in actual access to health care and in actual need for primary health care. It also suggests that access to primary health care relative to need is a meaningful concept to apply to the levels of access and need seen in Australia and to their impact on health outcomes.

More details on the validation of the ARN index are available from the AIHW on request.

Comparing the Indigenous and non-Indigenous populations

The ARN index and all its components are calculated in the same way for the Indigenous, non-Indigenous and total population. However, care should be taken when comparing index scores of different population groups in an area, or the average scores of, for example, a remoteness area. It is possible that distance influences access differently for Indigenous and non-Indigenous people and that the variables used to calculate predicted need for primary health care and mobility have different associations with their respective index components in the 2 population groups. For example, the need for primary health care may change more dramatically with socioeconomic or demographic status in 1 group than in the other. This is certainly the case for age, which is taken into account in the way the high needs variable is defined for the Indigenous and non-Indigenous populations (Appendix A).

It is difficult to assess whether the associations between the predicted need for primary health-care component of the ARN index and health outcomes are similar in the Indigenous and non-Indigenous populations because of the small Indigenous population sizes of many areas. However, it is clear that there are statistically significant associations between the predicted need component and health outcomes in both population groups: higher predicted needs are associated with higher rates of ADAT and hospitalisations due to ACSC. Furthermore, the relationships between rates of hospitalisations due to ACSC and the predicted need component appear to be similar in the Indigenous and non-Indigenous populations (rates of ADAT are too low to be reliable when looking at the Indigenous population in isolation). Based on these relationships, it is expected there would be 31.8 more hospitalisations due to ACSC when the score of the predicted need component increased by 1 in the Indigenous population and 27.2 more hospitalisations in the non-Indigenous population.

It is also important to note that the predicted need for primary health-care component of the ARN index is not a measure of the overall health or health outcomes of a population group. For example, a population group that for some reason has relatively high rates of deaths in relatively young people may, as a result, have a relatively small proportion of its people in the older age groups that have a high need for primary health care. Its relatively poor health outcomes may therefore not be completely reflected by how its overall need for primary health care compares with the needs of other population groups. In this study, the Indigenous population had much higher average predicted need for primary health-care scores than the non-Indigenous population in all remoteness areas (Figure 3.4). This is consistent with the difference in health outcomes that exists between the 2 population groups. However, for reasons outlined above, the size of the difference in predicted need for primary health care should not be seen as a measure of the size of the difference in any health outcomes or of general health.

3 Results

Results of the 'access to GPs' and 'predicted need for primary health care' components of the ARN index are provided below, followed by the index results. Colour-coded maps show the scores for both the Indigenous and non-Indigenous populations of all SA2s across Australia. While the analysis was performed at the SA1 level, the maps show results that have been aggregated to the SA2 level (population-weighted mean scores of all SA1s within each SA2). The close to 55,000 SA1s cover all of Australia and vary in size with population density. The average SA1 has a population of about 400, which means that SA1s in densely populated urban areas generally are too small to be visible on a national map. The 2,196 SA2s are made up of whole SA1s and have an average population of about 10,000 (see ABS 2011 for more information on SA1s and SA2s).

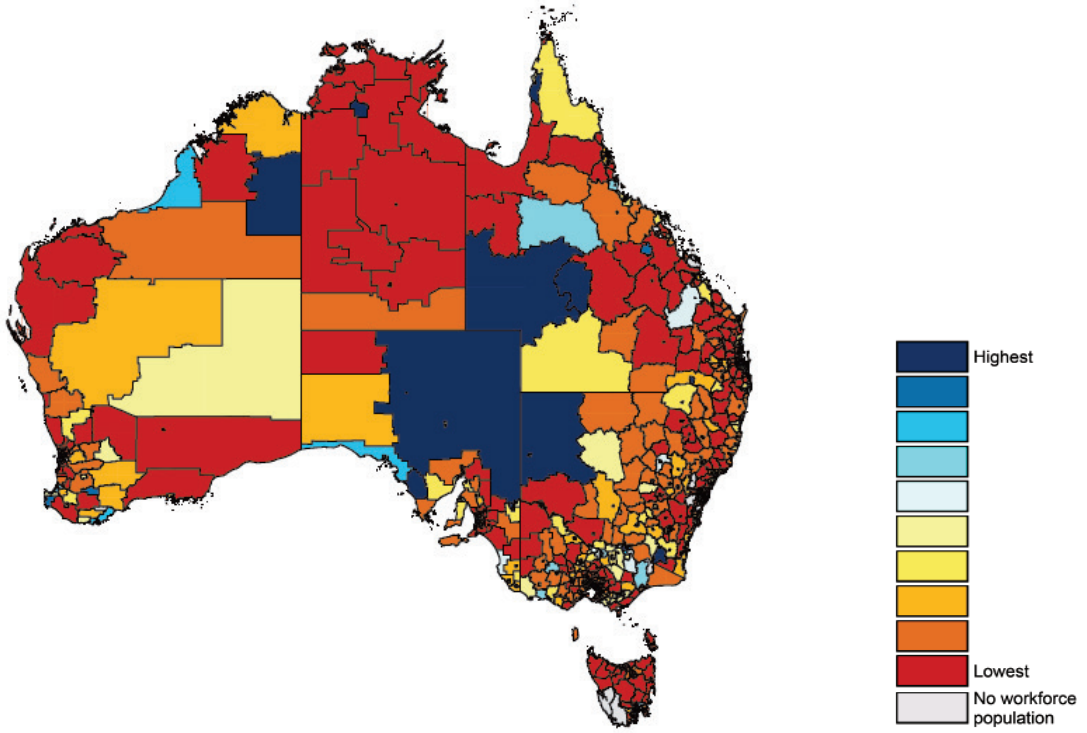
Deciles were created based on the whole population and then applied as cut-offs to the scores of the Indigenous and non-Indigenous populations. Areas that fared best (highest access, lowest predicted need and highest access relative to need, respectively) are shown in dark blue in the maps; areas that fared worst are shown in red. Areas in between are represented along the colour gradient. Areas that had no workforce population according to the 2011 Census are shown in grey. These areas were not included in the index because the unemployment rate is necessary to estimate predicted need for primary health care. In the 2011 Census, 1,814 of the 54,805 SA1s (or 3%) did not have a workforce population.

In addition to the maps, the average scores for the components and the index are shown in graphs by population group and remoteness area. It is important to note that the total population is not simply the combined Indigenous and non-Indigenous populations. It includes people whose Indigenous status is unknown and can therefore sometimes have the highest or lowest average score. Care should be taken when comparing scores of the 3 population groups (see 'Comparing the Indigenous and non-Indigenous populations' in Section 2.2).

3.1 Access to GPs

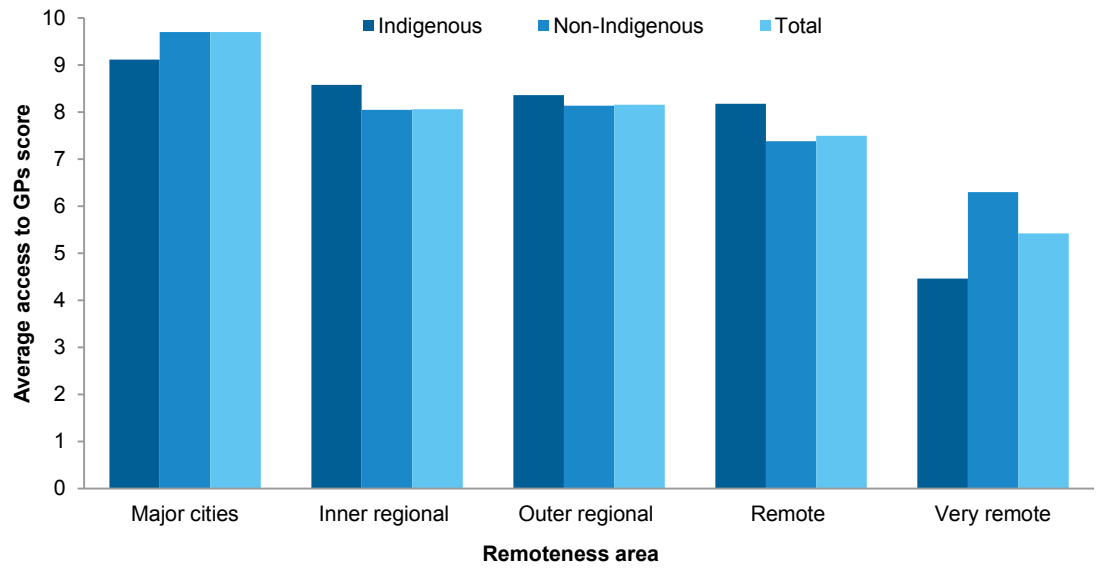
As noted in Section 2.2, all people of all population groups living in an SA1 are assumed to have access to the same GPs and will compete over access to these GPs with the same neighbouring populations. This means that the 'access to GPs' component of the ARN index can be calculated only for the whole population in each area. Every area therefore has the same access to GPs for all 3 population groups (Appendix A). However, different averages for the 3 population groups can still be calculated by remoteness area, based on how the populations are distributed across areas (Figure 3.2). For example, the access to GPs score of an SA1 with 100 Indigenous people will influence the average Indigenous access to GPs twice as much as the score of an SA1 with 50 Indigenous people. Figures 3.1 and 3.2 show the variation in access to GPs between SA2s and across remoteness areas.

These figures show that, even though *Inner regional* and *Outer regional* areas have very similar access on average, there is a general decrease in access to GPs with increasing remoteness.



Source: AIHW analysis of ARN index.

Figure 3.1: Access to GPs, total population, 2011



Notes

1. Total population includes people with an Indigenous status of 'not stated'. Averages are population, not area, based.
2. Data for this figure are shown in Appendix Table B3.1.

Source: AIHW analysis of ARN index.

Figure 3.2: Average access to GPs score, by remoteness and Indigenous status, 2011

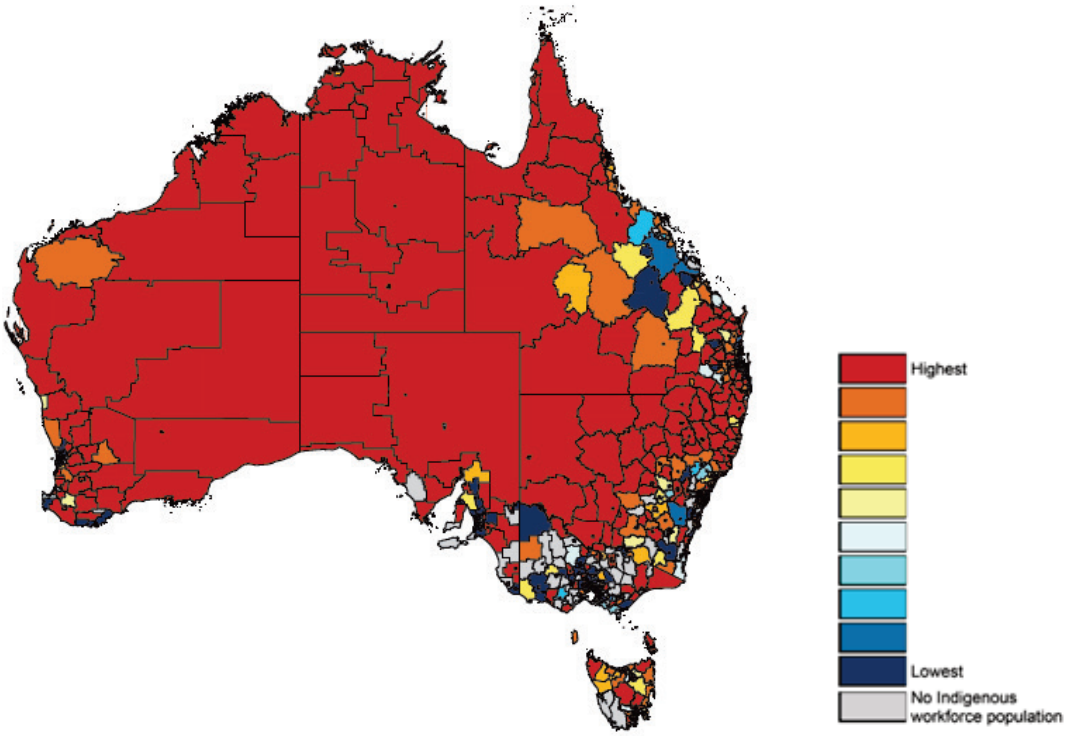
3.2 Predicted need for primary health care

Figures 3.3 and 3.4 show the predicted need for primary health care for the Indigenous and non-Indigenous populations. As is evident, the Indigenous and non-Indigenous populations display markedly different distributions of predicted needs by remoteness. As for access to GPs, the averages presented in Figure 3.4 refer to the average person (population based) and not the average area.

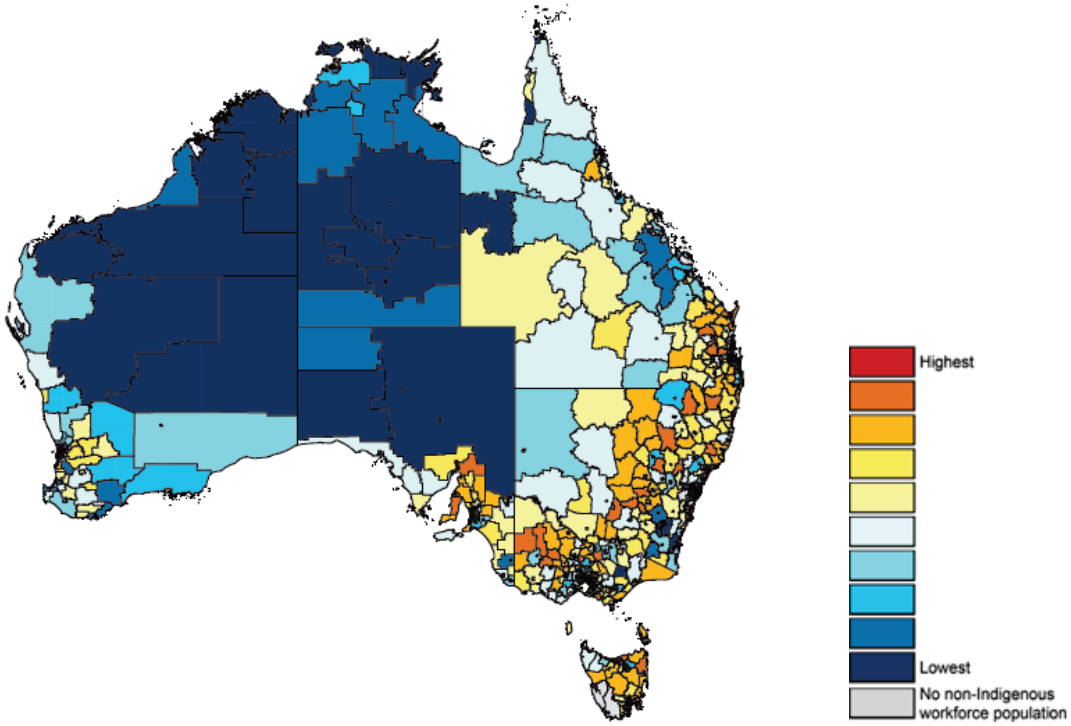
On average, whereas the predicted needs of the Indigenous population increase with remoteness, the predicted needs of the non-Indigenous population are similar in *Major cities*, *Inner regional* and *Outer regional* areas but are lower in *Remote* and *Very remote* areas (Figure 3.4).

While care should be taken when the scores of the Indigenous and non-Indigenous populations are compared (see the 'Comparing the Indigenous and non-Indigenous populations' section), it seems clear that the average need for primary health care of the Indigenous population is much greater than that of the non-Indigenous population in all remoteness areas. This difference appears to be especially pronounced in *Remote* and *Very remote* areas. Few *Remote* and *Very remote* areas are high need areas for the non-Indigenous population. This is not the case for the Indigenous population.

Indigenous population

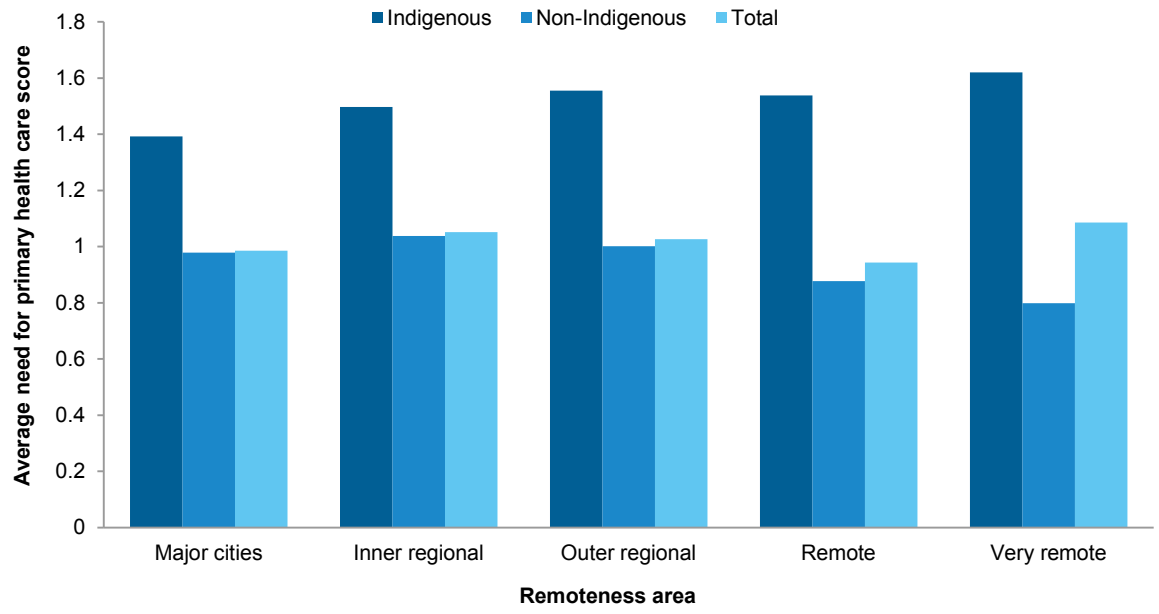


Non-Indigenous population



Source: AIHW analysis of ARN index.

Figure 3.3: Predicted need for primary health care, by Indigenous status, 2011



Notes

1. Total population includes people with an Indigenous status of 'not stated'. Averages are population, not area, based.
2. Data for this figure are shown in Appendix Table B3.2.

Source: AIHW analysis of ARN index.

Figure 3.4: Average predicted need for primary health care score, by remoteness and Indigenous status, 2011

3.3 ARN index

Figures 3.5 and 3.6 illustrate the findings from the ARN index for Indigenous and non-Indigenous Australians, and for the total population.

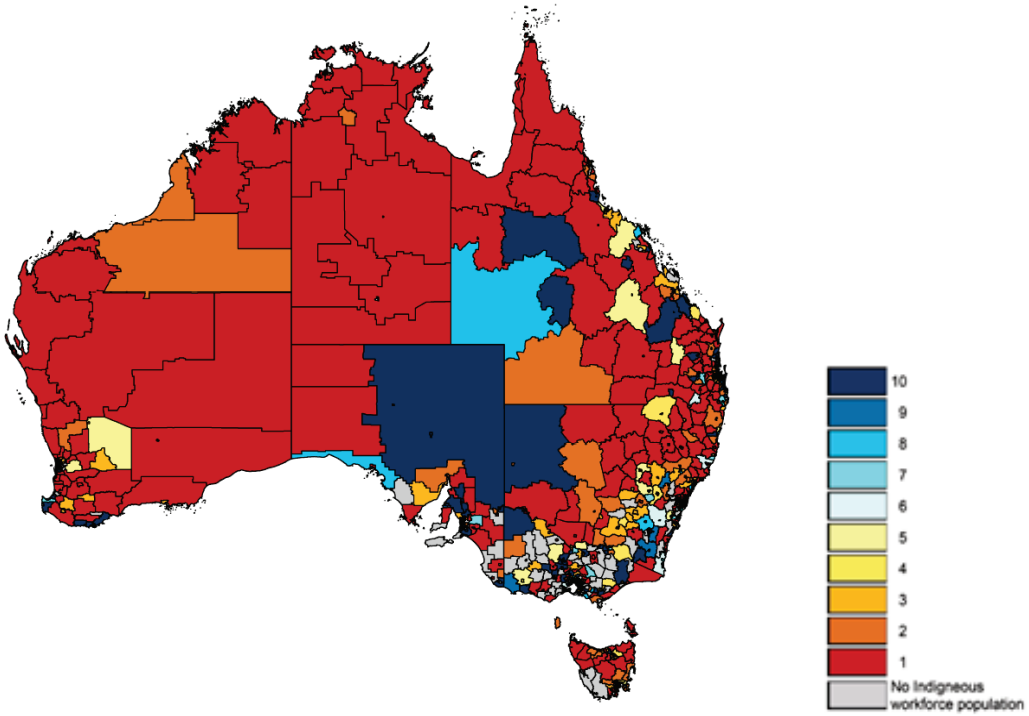
Average access to health care relative to need decreases with remoteness for Indigenous people. This is due to the combined effects of worsening access to GPs and increasing predicted need for primary health care (sections 3.1 and 3.2). *Major cities* also had the highest average scores in the non-Indigenous population but the differences between the other remoteness areas were much smaller than for the Indigenous population. This difference between the 2 population groups was caused by a less dramatic decrease in access to GPs with remoteness in the non-Indigenous population and, most importantly, the relatively low average predicted needs of non-Indigenous people in *Remote* and *Very remote* areas (sections 3.1 and 3.2).

A few SA1s in *Very remote* areas had very high ARN scores that had a relatively large impact on the average scores of all 3 population groups. This was also the case for Indigenous people across all remoteness areas. To give a more accurate view of the access to GPs relative to need experienced by the majority of people, Figure 3.7 shows the population-based median ARN index scores. For example, the median score for Indigenous people in *Major cities* is 6.83. This means that 50% of Indigenous people in *Major cities* live in SA1s with an ARN index score of 6.83 or less for the Indigenous population.

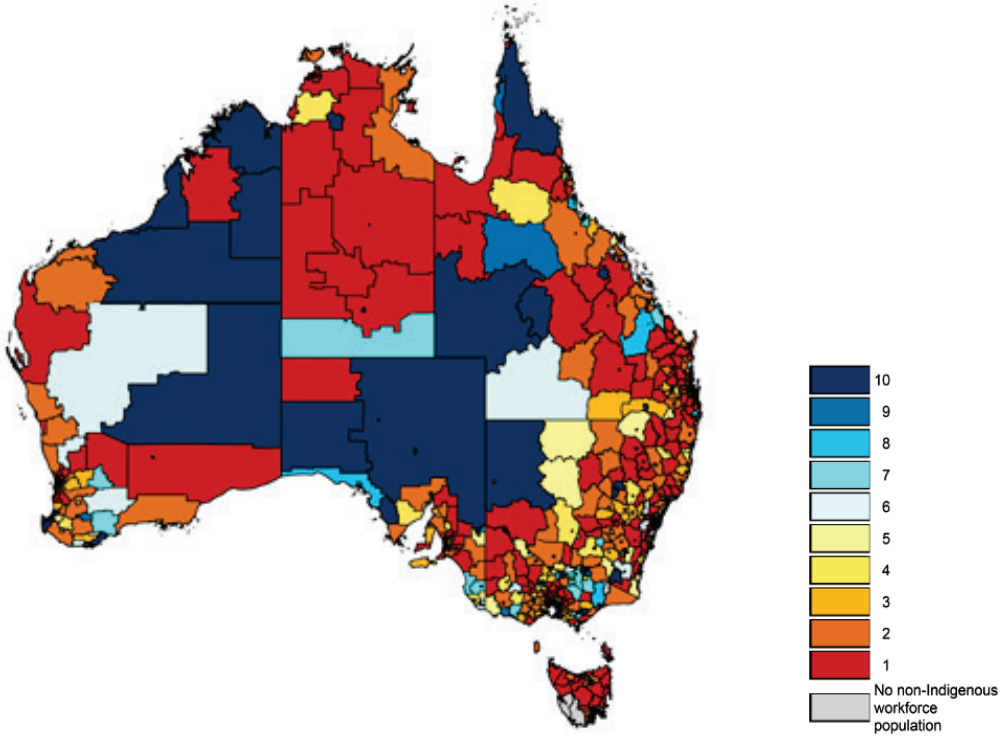
The median ARN index score for Indigenous people in *Very remote* areas was 0.47. This suggests that a high proportion of Indigenous people living in *Very remote* areas experience a very low access to GPs relative to their need for primary health care.

SA1s with relatively low access relative to needs for the Indigenous population also tended to have relatively low access relative to needs for the non-Indigenous population (Pearson correlation: $r = 0.37$, $P < 0.0001$). However, the moderate strength of the correlation indicates that this is far from always the case. Further analysis of the ARN index scores could identify areas with a large discrepancy between access relative to need for the Indigenous and non-Indigenous populations.

Indigenous population

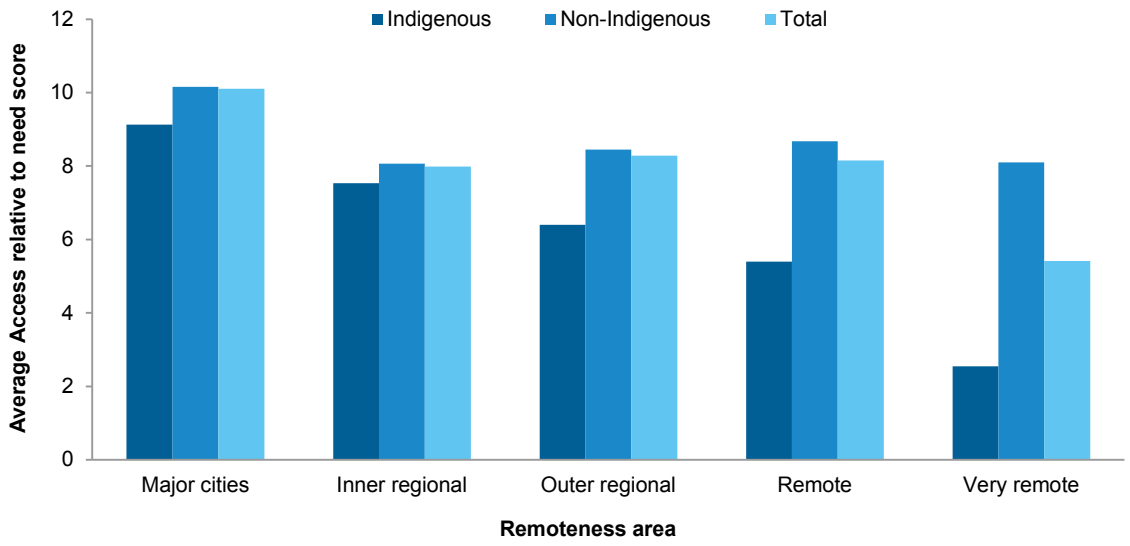


Non-Indigenous population



Source: AIHW analysis of ARN index.

Figure 3.5: ARN index, by Indigenous status, 2011

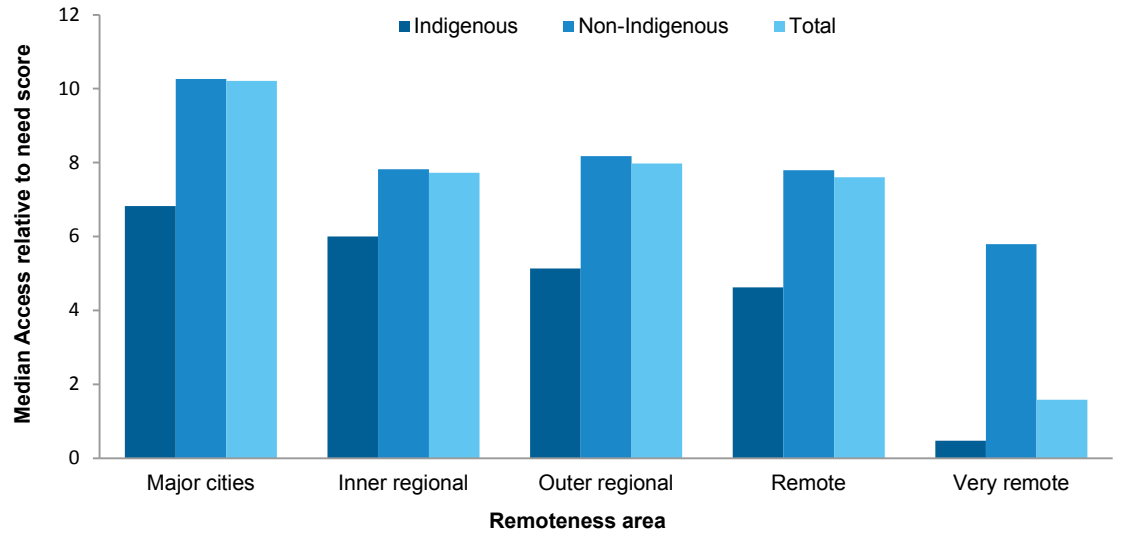


Notes

1. Total population includes people with an Indigenous status of 'not stated'. Averages are population, not area, based.
2. Data for this figure are shown in Appendix Table B3.3.

Source: AIHW analysis of ARN index.

Figure 3.6: Average ARN index score, by remoteness and Indigenous status, 2011



Notes

1. Total population includes people with an Indigenous status of 'not stated'. Medians are population, not area, based.
2. Data for this figure are shown in Appendix Table B3.4.

Source: AIHW analysis of ARN index.

Figure 3.7: Median ARN index score, by remoteness and Indigenous status, 2011

4 Discussion

The main aim of this study was to create an index of access to primary health care relative to need that could be applied to the Indigenous and non-Indigenous populations in isolation. McGrail and Humphreys' (2009) index of access to primary health care for rural Victoria provided useful methodology for incorporating factors such as access to GPs, per capita health-care needs and mobility into a primary health-care access index. However, it was not designed to compare access between population groups, within metropolitan areas or relative to the need of the population of a particular area. In order to measure Indigenous Australians' access to primary health-care services relative to need, McGrail and Humphreys' index had to be modified, as discussed in Section 2.2 and Appendix A. The resulting ARN index is the first index to describe how access to GPs relative to need varies geographically across Australia. It is also the first index to allow a comparison of the geographic variation in access relative to need for Indigenous Australians, non-Indigenous Australians and the entire Australian population.

4.1 Findings

At the national level, the ARN index indicated that average access to GPs relative to need decreased with remoteness for the Indigenous population (Figure 3.6). This was the result of both worsening access to GPs and increasing predicted need for primary health care with increasing remoteness (figures 3.2 and 3.4). The change in average access to GPs relative to need with remoteness was less pronounced for the non-Indigenous population. Non-Indigenous people in *Major cities* had the highest average scores on the ARN index. However, unlike for Indigenous people, there was not a clear trend of decreasing average access relative to need with increasing remoteness across the other remoteness areas (Figure 3.6). Average access to GPs did decrease with remoteness (except between *Inner regional* and *Outer regional* areas) for non-Indigenous people, but the remoteness areas with the lowest average predicted need for primary health care were *Remote* and *Very remote* areas.

The average ARN index score for *Very remote* areas was affected by a small number of areas with very high scores. The median ARN index scores revealed that *Very remote* areas had 50% of their populations of both Indigenous and non-Indigenous people in SA1s with much lower ARN index scores than other remoteness areas (Figure 3.7). This was especially true for the Indigenous population of *Very remote* areas, which had 50% of its people living in SA1s with an ARN index score of 0.47 or less.

A demographic factor that contributes to the different patterns seen across remoteness areas in Indigenous and non-Indigenous people is population age structure. Remote areas tend to have lower proportions of non-Indigenous people in age groups with high needs for primary care than Indigenous people (33.6% non-Indigenous versus 46.5% Indigenous in *Very remote* areas compared with 41.7% versus 43.7% in *Major cities* in this study). For example, whereas the non-Indigenous populations of some areas with remote mining towns may have a high concentration of men aged 18–64 (low needs group) working in the mining industry, the Indigenous populations of the same areas are more likely to also include a high proportion of women of child-bearing age (18–44), and children aged 0–4 (high needs groups).

The differences between Indigenous and non-Indigenous people in the average access to GPs component of the index were small in all remoteness areas except in *Very remote* areas where average access to GPs was much lower for Indigenous people. This means that Indigenous people in *Very remote* areas tend to live in SA1s with worse access to GPs than non-Indigenous people in *Very remote* areas. This is consistent with what is known about the distribution of Indigenous and non-Indigenous people in remote parts of the Northern Territory. The Northern Territory has the highest proportion of Indigenous Australians in its population (30%) of all jurisdictions, and most of its Indigenous population (80%) live in *Remote* or *Very remote* areas. In contrast, only 30% of its non-Indigenous population live in these areas (ABS 2013). Indigenous people living in *Remote* or *Very remote* areas of the Northern Territory are widely dispersed in small communities that have few services, whereas non-Indigenous people in these areas are more likely to live in towns (Taylor 2012).

As is clear from the maps in Section 3, there was much variation in access relative to need for Indigenous and non-Indigenous people within remoteness areas (Figure 3.1) reflecting the varying predicted need for primary health care of populations in each SA1 (Figure 3.5) as well as local variation in access to GPs (Figure 3.3). In some cases, unexpectedly low ARN index scores were the result of unusual circumstances. Box 4.1 presents an example of an anomaly that can be explained by the presence of a residential aged-care facility and a retirement village. In addition to such facilities, other SA1s with 'unusual' populations and service use whose true access relative to need may not be reflected by the ARN index include those for which a substantial proportion of the total population live on university campuses or in detention centres.

Box 4.1: Explaining unexpectedly poor ARN index results

Case study: Inner west Sydney

As would be expected, based on its relatively high socioeconomic status and proximity to services, most of inner west Sydney has relatively excellent access to health care relative to need. However, there are a few pockets with relatively poor access. One such area, which falls in the lowest decile, is situated in Ashfield. Access to GPs in this area is relatively high, but the predicted need for primary health care of this population is also relatively high.

Analysis of the demographics of this SA1 shows that 71% of the population is classified to be in a high needs age group (that is, children aged 4 years and under, women of child-bearing age, non-Indigenous people aged 65 and over and Indigenous people aged 55 and over), 60% had low mobility and 26% needed assistance with core activities. Further investigation found that a residential aged-care facility offering low care and high care services is located in this SA1, as well as a retirement village offering low care services. The number of residents in these facilities equated to 88% of the SA1's population in 2011. Due to the relatively high need for primary health care of people in this SA1, the area fared relatively poorly on the ARN index.

However, this may not be a true reflection of this population's access to health care because it is highly likely that GPs would travel to the residential aged care facility to offer their services, or residents could choose to visit a service provider outside of the facility. The model underlying the ARN index is unable to take this into account because data on GP visits to facilities such as residential aged care facilities are unavailable.

The creation of an index of access relative to need that can be applied to Indigenous and non-Indigenous populations separately will be useful for policy makers wanting to identify

underserved areas and plan accordingly. The analyses done to validate the ARN index, using health outcomes that have a large component of unmet health needs related to primary health care, suggest that it can be a useful tool when identifying the areas where the Indigenous and/or the non-Indigenous populations would benefit most from improved access to primary health care. Further analysis may also reveal whether access relative to need, as measured by the ARN index, influences health outcomes in different ways in the Indigenous and non-Indigenous populations. For example, there may be factors that are more important to the health outcomes of one population group than to the other. If so, this will result in different relationships between the ARN index and health outcomes in the 2 groups.

The ARN index can also be applied to contexts other than access to all types of GPs. For example, it could be used to describe access to other primary care providers, such as dentists and pharmacists, as well as access to bulk-billing GPs. It could be applied to access relative to need for other types of services such as maternal health and mental health services, early childhood education and community housing. It could also be used to describe access relative to need for other populations such as overseas-born residents. In addition, the results can be aggregated into larger areas (for example, Medicare Locals, larger Statistical Areas, states and territories) as required for policy analysis and planning purposes.

The results of this study show that geographic variation in access to GPs relative to predicted need for primary health care differs between Indigenous and non-Indigenous Australians. They also show that health outcomes improve more dramatically with improved access to GPs in areas with relatively high need than in areas with low need. This suggests that access to primary care relative to need is still an important factor underlying geographic variation in health outcomes in Australia. Updating the ARN index when data from future Censuses become available would make it possible to keep track of how access to GPs relative to need changes over time for Indigenous and non-Indigenous Australians and other population groups.

4.2 Limitations

Physical access to GPs

As discussed in Section 2, the ARN index measures access to GPs only in terms of availability (or supply relative to demand) and physical accessibility. Other factors that contribute to Indigenous (and other) people's access to primary care services are affordability and cultural acceptability. Earlier work has found that Indigenous people tend to underuse available primary care services and that this is partly due to cost issues (Urbis Keys Young 2006). Furthermore, this index cannot provide a complete overview of Indigenous people's access to health care relative to their need because it is limited to one type of primary care provider—GPs. Access to other health services, such as specialist and allied health care, and health care products (such as pharmaceuticals and medical aids) are also important for the continuum of care and therefore need to be considered in strategies to improve Indigenous people's access to health care.

Access by road

The accuracy of the ARN index is limited somewhat by the way the access to GPs component is determined. This is because the measurement of travel times from population centroids to

service providers is unable to capture all the possible ways that people access GPs. For example, the use of public transport to access services is not incorporated into the index because of the unavailability of adequate data on public transport scheduling in many areas. The ARN index also does not capture variation in access to GPs through video consultations which are, for example, a part of Medicare's Telehealth program.

Some areas, such as islands, are problematic because the software used to estimate travel times—that is, the Drivetime software—does not take water transport into account. SA1s on islands may therefore appear to have poorer access than surrounding areas because they appear to have access only to service providers located on the same island. Another limitation of the Drivetime software is that it does not take into account changes to road access in tropical areas during the wet season, which can dramatically limit access to service providers in some remote communities.

Geographical scale

Calculating the ARN index at the SA1 level also imposes some limitations. SA1s were used in this project as they are the smallest geographical unit for which Census data are released. However, there is still a possibility that these areas—in which the population can range from 200 to 800 people—could mask pockets of disadvantage if the SA1 is relatively advantaged overall. Some SA1s produced unusual results where they appeared to have relatively poor access relative to need while surrounding SA1s had relatively good access relative to need. These SA1s were investigated further and, as noted earlier, an example of such an anomaly is presented in Box 4.1.

SA1s in remote areas also pose some problems because they can cover vast geographical areas and have populations that may be dispersed across more than one locality. Since the travel times are calculated based on the locations of providers relative to the SA1's centroid, a dispersed population could cause the centroid to be located in an area of the SA1 that is far removed from most of the population and service providers. In this case, the travel times will be falsely inflated and not reflect true access. This effect is not seen in non-remote areas because the SA1s are small enough geographically for the centroid to reflect an accurate location of the population. To avoid this problem, using population-weighted centroids rather than geographic centroids would be preferable. However, at the moment, the data necessary to calculate population-weighted centroids for SA1s are not available. Instead, the AIHW manually assigned a population centroid for geographically vast SA1s using Google Maps to more precisely pinpoint where most of the population lives. Applying the manual area centroids improved access in some SA1s but not in others.

When considering very large SA2s in *Remote* and *Very remote* areas, or the large SA1s that make up the SA2s, it is important to note that while the ARN index represents the population of an area, access to primary health care relative to need is not going to be the same for every individual in that area. For example, some areas in north-east South Australia have relatively excellent access relative to need. However, due to the vastness of these areas, people who live far from the area centroid may experience an access relative to need that is very different to that indicated by the ARN index.

GP locations

The available data on the locations of GPs were for 2013. All other data used in this study (demographic, socioeconomic and health outcomes) were for 2011. This means that changes

in the location of GPs that occurred between 2011 and 2013 may influence the results of some areas.

Determining the need for primary care

The predicted need for primary health-care component of the ARN index is an indirect measure of need using demographic and socioeconomic variables known to be correlated with health outcomes. The alternative approach of using rates of ACSC and ADAT—health outcomes thought to reflect need for primary health care (but also unmet need; see Section 2.2)—was not possible in this study as the numbers of these outcomes at the SA1 level are too small to be reliable for individual areas (particularly for the Indigenous population).

Future availability of new data may enable further refinements of this component. For example, the ABS's 2016 Census of Population and Housing may introduce long-term health conditions as a new topic. This would provide data that could improve the precision of the predicted need for primary health-care component.

Appendix A: Additional methodological information

Software

Each component and the final ARN index were calculated using SAS Enterprise Guide 5.1. Travel times were estimated using Mapinfo Professional 11.5 and its Drivetime 7.1 application.

Spatial distribution of GPs

Information about health-care service providers was sourced from AMPCo, which provides current information on registered GPs including GP service addresses, the number of GPs working at each service, and an FTE for each GP. Additional GP service location and FTE data were sourced from the RFDS. Services deemed not to provide 'traditional' GP medical care—such as homeopaths, naturopaths, cosmetic services, tanning clinics and plastic surgeons—were not included. All GP data were for 2013.

Latitude and longitude coordinates were obtained for all GP addresses using the online geocoder application GPS Visualizer (Schneider 2013). The coordinates were loaded into the geospatial information system software Mapinfo Professional, which was used to plot the locations of each of the GP service locations on an SA1 digital boundary map of Australia that was obtained from the ABS website.

Population data

Population data for Indigenous and non-Indigenous populations were sourced from the 2011 Census at SA1 level using the ABS's TableBuilder. The SA1 is the smallest level at which Census data are available for both Indigenous and non-Indigenous people.

Area centroids were assigned to all SA1 populations to represent the average locations of their populations. It was not possible to use population-weighted centroids as population data from the 2011 Census are not released at a level lower than SA1. Therefore, the centroids are geographic midpoints in most areas. The use of geographic centres to represent population centres works well in smaller SA1s, such as those found in metropolitan and inner and outer regional areas, but loses validity as SA1 areas increase with remoteness due to reduced population densities. Very large SA1s in *Remote* and *Very remote* areas had their centroids adjusted manually based on the locations of settlements. Fewer than 1% (0.19%) of area centroids were manually derived and the decision to manually select their positions was based on the size of the SA1 (some of which cover as much as 300,000 square kilometres in very remote locations) and the locations of communities. More details on the assignment of area centroids are available from the AIHW on request.

Travel times

The Drivetime application of the Mapinfo Professional software was used to estimate drive times between each SA1 centroid and all the service providers considered to be within reach. Following McGrail and Humphreys (2009), providers considered to be within reach were those that were within a maximum drive time of 60 minutes. Drivetime determines travel

times based on the quickest route between the origin (area centroid) and destination (GP). Travel times are generated according to the ambient travel speed available on a given road network. Travel time represents the minimum off-peak travel time for the road type (highway, suburban street, and so on), assuming the highest driving speeds available to a driver of a car on a given road network between the hours of 8.30 am and 3.30 pm and after 7 pm on weekdays.

A potential limitation of using geographic-based centroids when calculating population travel times to health providers is that the location of the centroid representing the population may not be on a road. Mapinfo Professional's Drivetime attempts to control for this by allowing for the adjustment of off-network travel speed at the point of origin and point of destination. Origin and destination off-network travel speeds were both set at 200 km/h. When an area centroid (origin point) is located some distance away from a road network, Drivetime travels the distance between the origin/destination point and the nearest road at 200 km/h. This ambient travel speed of 200 km/h was selected arbitrarily and is based on the assumption that the majority of Australian cities, towns and communities, including Indigenous communities, are accessible by road. Therefore, travel times between area centroids and the nearest road network should be set at a high speed in order to model travel times as realistically as possible. Off-network travel time is a concern only in very large SA1s where the area centroid is more likely to be located far from a road network. In this study, in addition to setting the off-network travel times to 200 km/h, the locations of area centroids were adjusted manually in these larger SA1s to make travel time estimates more realistic.

Predicted need for primary health care

Following the methodology of McGrail and Humphreys (2009), demographic and socioeconomic variables were used to estimate the per capita predicted need for primary health care of SA1 populations. However, unlike McGrail and Humphreys, in this study, the specific needs of the Indigenous and non-Indigenous populations were also estimated separately.

The following demographic and socioeconomic variables that were available from the 2011 Census data at the SA1 level and by Indigenous status were evaluated for potential inclusion in the 'predicted need for primary health care' component. The Pearson correlation coefficients (r) are from their correlations with rates of avoidable deaths amenable to treatment at the SA2 level (mortality in 2010 and 2011 combined).

- proportion of people who are in **high needs** age groups (all children aged 0–4; all women aged 18–44; and people aged 65 and over for the non-Indigenous population and 55 and over for the Indigenous population) ($r = 0.32$, $P < 0.0001$)
- proportion of people who speak an **Indigenous language** at home ($r = 0.016$, $P = 0.45$)
- proportion of people who have not completed **Year 12** ($r = 0.26$, $P < 0.0001$)
- proportion of people who **need assistance** with core activities ($r = 0.51$, $P < 0.0001$)
- proportion of people who **speak English** 'not well' or 'not at all' ($r = -0.090$, $P < 0.0001$)
- proportion of households that are **renters** ($r = 0.0030$, $P = 0.89$)
- proportion of people who are **unemployed** ($r = 0.16$, $P < 0.0001$)
- proportion of households that do not have access to a **motor vehicle** ($r = 0.16$, $P < 0.0001$).

One group of socioeconomic variables that have been used to predict need for health care in the past, including by McGrail and Humphreys (2009), is the income by family composition variables that underpin the ABS' Socio-Economic Indexes for Areas (ABS 2011). Due to the small size of the Indigenous population in many SA1s, a large number of areas with an Indigenous population did not have data for many family composition categories. Therefore, these variables were not used in this study.

McGrail and Humphreys (2009) standardised their need predictors using the chi-square distribution. This was not appropriate as it causes areas with small populations to appear to have lower per capita needs than areas with larger populations when they have identical proportions of people in the categories of the variables used to estimate need. In this study, the predictor variables used for the total population were instead standardised to have a mean of 0 and a standard deviation of 1. The formulas necessary for this transformation were then applied to the Indigenous and non-Indigenous populations as well, resulting in means and standard deviations that deviated from 0 and 1 depending on the proportions of people in the predictor variable categories in the 2 population groups.

Five of the variables listed above were selected for inclusion in the need for primary health-care component of the ARN index. The '**Indigenous language**' and '**renters**' variables were not significantly correlated with ADAT and were excluded. The '**speak English**' variable was also excluded as it showed only a weak negative association with ADAT. The same selection of variables was used for the Indigenous, non-Indigenous and total populations.

Principal components analysis (PCA) was used by McGrail and Humphreys (2009) to define the relative weights for the predictor variables that were used to calculate their composite need measure. The weights were based on the 2 principal components that captured most of the total variation in the predictor variables. However, PCA does not reveal anything about how need (or the health outcomes measure that is used as a proxy for need) varies within the multidimensional space that is created when the predictor variables are combined. Most of the variation in this multidimensional space does not necessarily occur along an axis that has the strongest association with variation in need. Therefore, the principal components that capture most of the variation in the predictor variables are not necessarily the ones that are the best predictors of need. That is why PCA was not used to determine weights for the calculation of the composite need for primary health care component in this study.

As the '**high needs**' and '**need assistance**' variables showed the strongest association with health outcomes at the SA2 level, they were allowed to each make up one-third of the need for primary health-care component of the index. The 3 socioeconomic variables, '**unemployed**', '**motor vehicle**' and '**Year 12**', together made up the remaining third. This means that the untransformed need component was calculated in the following way for all population groups:

$$Untrans\ Need = High\ needs + Need\ assistance + \frac{Unemployed + Motor\ vehicle + Year\ 12}{3}$$

Other ways of calculating the need for primary health-care component, including using all the variables listed above and using different weights, were also explored. However, no other tested formula resulted in a final ARN index that was better able to predict health outcomes.

McGrail and Humphreys (2009) estimated that the actual health-care needs of small area populations in Victoria range from approximately half to twice that of an average population. In this study, the predicted need for primary health-care component of the index was transformed to have an average score of 1 and a range of 0.24 to 8.30, with 98% of areas between 0.62 and 2.46 for the whole population.

$$Need = \left(\frac{(Untransformed\ need + 20)}{21}\right)^3 / 1.0287582$$

The same transformation was then applied to the predicted need components of the Indigenous and non-Indigenous populations, resulting in different averages and ranges for the 2 groups. The Indigenous population had an average score of 1.33, a range of 0.23 to 9.98, and 98% of areas between 0.24 and 4.34. The average score for the non-Indigenous population was 0.99 and it had a range of 0.24 to 8.32, with 98% of areas between 0.61 and 2.40.

The final predicted need for primary health-care component showed strong positive associations with both rates of ADAT (population-weighted Pearson correlation for total population: $r = 0.65$, $P < 0.0001$) and hospitalisations due to ACSC (population-weighted Pearson correlation for total population: $r = 0.39$, $P < 0.0001$); SA2 areas with high predicted need scores also tended to have high rates of these health outcomes.

Mobility

Mobility was calculated using the proportion of households without a motor vehicle and the proportion of people with low mobility (defined as persons under 18 or over 75):

$$Untransformed\ mobility = (1 - motor\ vehicle) * 0.9 + (1 - low\ mobility) * 0.1$$

The following transformation was applied to the mobility estimates of all 3 population groups:

$$Mobility = \frac{Untransformed\ mobility + 2}{3}$$

Access to GPs

For travel times between 10 and 60 minutes, impedance was calculated using the following equation:

$$f(d_{ij}) = \left(\frac{d_{max} - d_{ij}}{d_{max} - d_{init}}\right)^{\beta}$$

where, d_{max} is the maximum allowed travel time (60 minutes), d_{ij} is the travel time from population i to service provider j and d_{init} is the travel time to the edge of the initial catchment where there is no impedance (10 minutes).

McGrail and Humphreys (2009) set β to 1.5, which makes access decay somewhat faster initially once the 10 minute limit of the inner catchment is reached than if there were a steady decline over travel times between 10 and 60 minutes. McGrail (2008) argued that this was reasonable given the inclusion of the initial catchment and reported that varying β within the range of 1 to 2 made little difference to variation in access scores. The same impedance function has been used in this study. However, future empirical evidence regarding how access decays with distance and fine-tuning of the ARN index based on its ability to predict health outcomes may lead to revisions of the travel impedance function.

McGrail and Humphreys included their population-specific mobility component in step 2 of the 2SFCA. In this study, mobility components have been calculated for each population group in each area (see 'Mobility' above). These mobility estimates were instead included as one of the three of components that make up the ARN index (see 'Access relative to needs' in section 2.2).

Following the modifications to the methodology of McGrail and Humphreys (2009) outlined above, the equations used for the 2 steps of the 2SFCA were:

Step 1:

$$R_j = \frac{S_j}{\sum_i f(d_{ji}) * P_i * N_i}$$

where R_j is the population-to-GPs ratio for service provider j (or capacity given demand), S_j is the number of GP FTEs at service location j, $f(d_{ij})$ is the travel impedance between population i and service provider j, P_i is the population size at location i and N_i is the need for primary health care component for the total population at location i (in this study, need components for the different population groups are used when the ARN index is calculated – see below).

Step 2:

$$A_i = \sum_j f(d_{ij}) * R_j * 10{,}000$$

where A_i is the Access to GPs for the population at location i, $f(d_{ij})$ is the travel impedance between population i and service provider j, R_j is the population-to-GPs ratio for service provider j. The multiplication by 10,000 is done in order for the access to GPs component and the final ARN index to be on a more convenient scale.

McGrail and Humphreys (2009) capped the number of service providers the population of an area can access at 100 (or 10 minutes travel time in densely populated areas) in step 2 of the 2SFCA. This was done in order to prevent the large population of Melbourne from swamping the service providers of nearby regional areas. However, because the cap applies only to step 2, populations within reach of more than 100 service providers can influence the service provider-to-population ratios of service providers in step 1 that they are now not allowed to access in step 2. This leads to unrealistically low levels of access in regions where many areas are within reach of more service providers than the cap level allows. No caps were applied to step 2 of the 2SFCA in this study.

Appendix B: Additional tables

Table B2.1: Rates of hospitalisations due to ACSC and rates of ADAT in areas with high and low predicted need for primary health care.

Predicted need	ACSC[(a)]	ADAT[(b)]
High	31.2	33.0
Low	25.5	20.4

(a) Number of hospitalisations due to ACSC per 1,000 population in 2011.

(b) Number of avoidable deaths amenable to treatment per 10,000 population in 2010 and 2011 (average annual rate).

Source: AIHW analysis of ARN index; AIHW National Hospital Morbidity Database; AIHW National Mortality Database.

Table B2.2: Rates of hospitalisations due to ACSC and rates of ADAT in areas with high and low predicted need for primary health care, by level of access to GPs

	ACSC[(a)]		ADAT[(b)]	
Predicted need	High access	Low access	High access	Low access
High	29.0	34.2	30.9	35.8
Low	24.6	26.7	21.1	19.3

(a) Number of hospitalisations due to ACSC per 1,000 population in 2011.

(b) Number of avoidable deaths amenable to treatment per 10,000 population in 2010 and 2011 (average annual rate).

Source: AIHW analysis of ARN index; AIHW National Hospital Morbidity Database; AIHW National Mortality Database.

Table B3.1: Average access to GPs score, by remoteness and Indigenous status, 2011

	Average access to GPs score		
Remoteness area	Indigenous	Non-Indigenous	Total
Major cities	9.12	9.70	9.70
Inner regional	8.58	8.05	8.06
Outer regional	8.36	8.14	8.16
Remote	8.18	7.38	7.50
Very remote	4.47	6.30	5.42

Note: Total population includes people with an Indigenous status of 'not stated'. Averages are population, not area, based.

Source: AIHW analysis of ARN index.

Table B3.2: Average predicted need for primary health care score, by remoteness and Indigenous status, 2011

	Average need for primary health care score		
Remoteness area	**Indigenous**	**Non-Indigenous**	**Total**
Major cities	1.39	0.98	0.99
Inner regional	1.50	1.04	1.05
Outer regional	1.56	1.00	1.03
Remote	1.54	0.88	0.94
Very remote	1.62	0.80	1.09

Note: Total population includes people with an Indigenous status of 'not stated'. Averages are population, not area, based.

Source: AIHW analysis of ARN index.

Table B3.3: Average ARN index score, by remoteness and Indigenous status, 2011

	Average ARN index score		
Remoteness area	**Indigenous**	**Non-Indigenous**	**Total**
Major cities	9.13	10.16	10.11
Inner regional	7.53	8.06	7.99
Outer regional	6.40	8.45	8.28
Remote	5.40	8.67	8.15
Very remote	2.55	8.10	5.41

Note: Total population includes people with an Indigenous status of 'not stated'. Averages are population, not area, based.

Source: AIHW analysis of ARN index.

Table B3.4: Median ARN index score, by remoteness and Indigenous status, 2011

	Median ARN index score		
Remoteness area	**Indigenous**	**Non-Indigenous**	**Total**
Major cities	6.83	10.26	10.21
Inner regional	6.00	7.82	7.73
Outer regional	5.13	8.17	7.97
Remote	4.62	7.79	7.60
Very remote	0.47	5.80	1.58

Note: Total population includes people with an Indigenous status of 'not stated'. Medians are population, not area, based.

Source: AIHW analysis of ARN index.

Appendix C: AIHW data sources

National Mortality Database

Mortality data have been extracted from the AIHW's National Mortality Database. Data are sourced from the Registrars of Births, Deaths and Marriages in each state and territory and from the National Coronial Information System, and compiled and coded by the ABS. The ABS codes the cause of death using the International Statistical Classification of Diseases and Related Health Problems and passes the data to the AIHW for inclusion in the National Mortality Database.

For more information about deaths in Australia and data quality, refer to ABS *Deaths, Australia* (ABS cat. no. 3302.0) and ABS *Causes of death, Australia* (ABS cat. no. 3303.0), which are available from <http://www.abs.gov.au>.

National Hospital Morbidity Database

Hospitalisation data have been extracted from the AIHW's National Hospital Morbidity Database, which is a compilation of episode-level records from admitted patient morbidity data collection systems in Australian hospitals in each state and territory. Information on the characteristics, diagnoses and care of admitted patients in public and private hospitals is provided annually to the AIHW by state and territory health departments.

Statistics on admitted patients are compiled when an admitted patient (that is, a patient who undergoes a hospital's formal admission process) completes an episode of admitted patient care and 'separates' from the hospital. This is because most of the data on the use of hospitals by admitted patients are based on information provided at the end of the patient's episode of care, rather than at the beginning. The length of stay and the procedures carried out are then known and the diagnostic information is more accurate. The principal diagnosis is the diagnosis established, after study, to be chiefly responsible for occasioning the patient's episode of admitted patient care.

Hospital records are for 'separations' and not individuals; since there can be multiple separations for the same individual, hospital separation rates do not usually reflect the number of people who were hospitalised. For example, it is not possible to identify whether 1 patient was admitted 5 times or 5 patients were admitted once.

Diagnoses were recorded using the 7th edition of the *International statistical classification of diseases and related health problems, 10th revision, Australian modification* (ICD-10-AM) (NCCH 2010). It comprises classifications of diseases and external causes of injuries and poisoning based on the World Health Organization's version of ICD-10. The ICD-10-AM classification is hierarchical, with 20 summary disease chapters that are divided into a large number of more specific disease groupings.

Separations with a care type of 'newborn' (without qualified days) and records for 'hospital boarders' and 'posthumous organ procurement' have been excluded from the analyses presented in this paper.

From 2010–11 onwards, Indigenous status information within hospital separations data from all jurisdictions were of sufficient quality for statistical reporting purposes (AIHW 2013). An AIHW study found an estimated 88% of Indigenous patients were correctly identified in

Australian public hospital admission records in 2011–12. Analyses in this paper therefore include data for all jurisdictions.

The complete data quality statement for the NHMD is available online at <www.aihw.gov.au/hospitals/>.

References

ABS (Australian Bureau of Statistics) 2000. Report on experimental Indigenous socioeconomic disadvantage indexes. Consultant's report for the Commonwealth Grants Commission. Canberra: ABS.

ABS 2011. Australian Statistical Geography Standard (ASGS): Volume 1—main structure and greater capital city statistical areas, July 2011. ABS cat. no. 1270.0.55.001. Canberra: ABS.

ABS 2013. Estimates of Aboriginal and Torres Strait Islander Australians, June 2011. ABS cat. no. 3238.0.55.001. Canberra: ABS.

AIHW (Australian Institute of Health and Welfare) 2013. Indigenous identification in hospital separations data—quality report. Cat. no. IHW 90. Canberra: AIHW.

AIHW 2014a. Australia's health 2014. Cat. no. AUS 178. Canberra: AIHW.

AIHW 2014b. Medical workforce 2012. National health workforce series no. 8. Cat. no. HWL 54. Canberra: AIHW.

Ansari Z, Imran Haider S, Ansari H, de Gooyer T & Sindall C 2012. Patient characteristics associated with hospitalisations for ambulatory care sensitive conditions in Victoria, Australia. BMC Health Services Research 12:475. doi: 10.1186/1472-6963-12-475.

Arizona Department of Health Services 2009. Arizona Medically Underserved Areas: fact sheet. Phoenix: Arizona Department of Health Services. Viewed 23 January 2014, <http://www.azdhs.gov/hsd/shortage/documents/arizona-medically-underserved-areas.pdf>.

Bagheri N, Benwell G & Holt A 2008. Modelling accessibility to primary healthcare using a spatial accessibility index. Hawai'i Journal of Public Health 1:14–27.

Biddle N 2009. Ranking regions—revisiting an index of relative Indigenous socio-economic outcomes. Australasian Journal of Regional Studies 15:329–53.

Dulin MF, Ludden TM, Tapp H, Blackwell J, de Hernandez BU, Smith HA & Furuseth OJ 2010. Using Geographic Information Systems (GIS) to understand a community's primary care needs. Journal of the American Board of Family Medicine 23(1):13–21.

Field K 2000. Measuring the need for primary health care: an index of relative disadvantage. Applied Geography 20(4):305–32.

Houston S 2003. The past, the present, the future of Aboriginal health policy. Unpublished PhD thesis. Perth: Curtin University of Technology.

Lee RC 1979. Designation of health manpower shortage areas for use by public health service programs. Public Health Reports 94(1):48–59.

Lee RC 1991. Current approaches to shortage area designation. The Journal of Rural Health 7(4):437–50.

Luo W and Wang F 2003. Measures of spatial accessibility to health care in a GIS environment: synthesis and a case study in the Chicago region. Environment and Planning B: Planning & Design 30(6):865–84.

McGrail M 2008. The McGrail Index of Access to primary care for rural Australians. PhD thesis. Melbourne: Monash University.

McGrail MR & Humphreys JS 2009. The index of rural access: an innovative integrated approach for measuring primary care access. BMC Health Services Research 9:124. doi:10.1186/1472-6963-9-124.

McNamara J, Harding A, Daly A & Tanton R 2008. Child social exclusion: an updated index from the 2006 Census. Australian Journal of Labour Economics 12(1):41–64.

NCCH (National Centre for Classification in Health) 2010. The international statistical classification of diseases and related health problems, 10th revision, Australian modification (ICD-10-AM), Australian Classification of Health Interventions (ACHI) and Australian Coding Standards (ACS), 7th ed. Sydney: University of Sydney.

NIRA (National Indigenous Reform Agreement) Review Working Group 2011. Review of the National Indigenous Reform Agreement performance framework: final report. Canberra: NIRA Review Working Group.

O'Campo P, Burke JG, Culhane JF, Elo IT, Eyster J, Holzman C et al. 2008. Neighborhood deprivation and preterm birth among non-Hispanic black and white women in eight geographic areas in the United States. American Journal of Epidemiology 167(2):155–63.

Penchansky R & Thomas J 1981. The concept of access: definition and relationship to consumer satisfaction. Medical Care 19: 127–40.

Schneider A 2013. GPS Visualizer. Portland: Adam Schneider. Viewed 22 July 2013, <http://www.gpsvisualizer.com/geocoder>.

Taylor A 2012. Information communication technologies and new Indigenous mobilities? Insights from remote Northern Territory communities. Journal of Rural and Community Development 7(1):59–73.

Urbis Keys Young 2006. Aboriginal and Torres Strait Islander access to major health programs: final report. Prepared for Medicare Australia and the Department of Health and Ageing. Sydney: Urbis Keys Young.

US (United States) Department of Health and Human Services 2012. Medically Underserved Areas & Populations (MUA/Ps). Washington DC: US Department of Health and Human Services. Viewed 23 January 2014, <http://www.hrsa.gov/shortage/mua/index.html>.

Vinson T 2007. Dropping off the edge: the distribution of disadvantage in Australia. Sydney: Jesuit Social Services and Catholic Social Services Australia.

Zhao Y, You J, Guthridge SL & Lee AH 2011. A multilevel analysis on the relationship between neighbourhood poverty and public hospital utilization: is the high Indigenous morbidity avoidable? BMC Public Health 11:737. doi: 10.1186/1471-2458-11-737.

This paper describes the development, and presents the results, of an area-based index that measures access to General Practitioners relative to the need for primary health care for both the Indigenous and non-Indigenous populations of Australia. The Access Relative to Need index is able to explain more of the variation in health outcomes than measures of access to GPs alone. Indigenous people experience a general pattern of worsening access to GPs relative to need with increasing remoteness. A less dramatic decrease by remoteness is noted in the non-Indigenous population.