

Does relative remoteness affect chronic disease outcomes? Geographic variation in chronic disease mortality in Australia, 2002–2006

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Recent studies have reported differences in mortality outcomes between remote and urban populations,¹⁻⁵ with a correlation between increasing remoteness and excess deaths observed in both Australia and overseas.⁶⁻⁹ Some researchers have described the scale of discrepancies while others have examined the cause of the differences.^{5,10-13} Studies in Australia have also highlighted the substantial mortality burden attributable to socioeconomic inequality and proposed that this may, in part, be the result of inequality in the individual benefits of healthcare.¹⁴ Poorer health care access, health risk factors and environmental health hazards have been associated with increasing remoteness.^{4,7,8} An additional factor that may also explain poorer mortality outcomes for remote areas is the higher concentration of Indigenous people who, as a population, have poorer health outcomes including mortality.¹⁵⁻¹⁷ Among the Indigenous population, the association of mortality and remoteness has varied, with two studies reporting lower mortality in very remote areas,^{18,19} while in Queensland, Indigenous death rates have recently been reported as higher in remote areas.²⁰ Past studies investigating geographic remoteness and mortality have examined either Australia as a whole or selected states.^{5,10-12} In Australia, chronic diseases contribute significantly to premature mortality,^{21,22} but we know of no previous studies that have examined the six leading causes of chronic disease mortality across all

Abstract

Objective: To examine the variation of chronic disease mortality by remoteness areas of Australia, including states and territories.

Methods: Australian Bureau of Statistics (ABS) death registration data, by Statistical Local Area (SLA), were used to identify chronic disease mortality by remoteness category for states and territories and Australia. The analysis used multiple cause of death for six common chronic diseases: diabetes, ischaemic heart disease, stroke, hypertension, chronic obstructive pulmonary disease and renal disease. ABS correspondence files were used to adjust the SLA level death records and population.

Results: The chronic disease mortality rate for Australian residents living in a very remote area (512 per 100,000 persons) was respectively 1.3, 1.4, 1.5, and 1.6 times higher than Remote, Outer Regional, Inner Regional and Major Cities categories. This pattern was consistent for the two age groups of 35–64 years and 65 years and over, all six chronic diseases and all states and territories except Victoria.

Conclusion and implications: This study shows that chronic disease mortality increases with increasing relative remoteness. The results highlight the importance and opportunity to redress poorer health outcomes for rural and remote area populations. The study is limited by absence of reliable Indigenous identification in national death data.

Key words: chronic disease, multiple cause of death, remoteness area, correspondence file, statistical local area

states and territories by relative remoteness. Further, in this study we examined national death registration data and dealt with data discrepancies associated with geographic boundary changes that occurred during the study period.

Historically, only underlying cause of death was available in death registration data although it is well documented that underlying cause of death alone underestimates the true burden of chronic disease mortality.^{9,23-25} More recent studies

have used multiple causes of death, to more accurately estimate the impact of any one particular disease on mortality.^{24,26,27} This study examined the variation in multiple cause mortality rates from chronic diseases by relative remoteness for Australia as a whole, and within each state and territory.

The study was approved by the Human Research Ethics Committee of the Northern Territory Department of Health and Menzies School of Health Research (HREC, 2011-1551).

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Methods

Death data

This study used Australian Bureau of Statistics (ABS) death registration data from 2002 to 2007 to identify deaths that occurred between 2002 and 2006 across all ages. The additional registration year (2007) allowed the inclusion of late registrations. Death registration data contains a deceased person's age; sex; usual residence coded to five-digit Statistical Local Area (SLA); and disease diagnosis codes for underlying cause of death and associated causes of death. The coding, completed by ABS, used the International Classification of Diseases, 10th Revision (ICD-10).²⁸ Six common chronic diseases were included: diabetes (E10-E14); ischaemic heart disease (I20-I25); stroke (I60-I69); hypertension (I10); chronic obstructive pulmonary disease (J40-45, J47); and renal disease (N18-N19). Cases were selected using multiple causes of death (both underlying and associated causes) for the six chronic diseases.

In ABS death registration data, usual residence addresses recorded in death certificates were assigned a five-digit SLA code. These codes were based on the Australian Geographic Classification System (ASGC) SLA codes from the previous year.²⁹ Historically, SLA geographic boundaries were modified annually to incorporate new local government council areas, expansion of suburban areas or realignment of town planning zones. Based on our analysis, it was estimated an average 6% of total SLAs in Australia were modified between 2002 and 2006. In this study, we mapped the 2002 to 2006 SLA level death data to 2006 SLAs using ABS population weighted correspondence files.³⁰ Of the total 663,121 death records between 2002 and 2006, the number of deaths excluded from analysis was 2,411 (0.36%), which included deaths that occurred in the Off-Shore Areas & Migratory SLAs and records with invalid or missing SLAs.

Measure of Remoteness Area

In 2001, ABS listed the Remoteness Area (RA) classification within the ASGC.²⁹ The RA classification was based on the Accessibility/Remoteness Index of Australia (ARIA), initially developed by the Commonwealth Department of Health and Ageing (DoHA)³¹ and the National Centre for Social Applications of GIS (GISCA).³² The

RA classification was derived using the road distance to the nearest urban centres in each of five categories based on population size.³³ The RA classification defines Australian areas into the five categories: Major Cities (MC), Inner Regional (IR), Outer Regional (OR), Remote (R) and Very Remote (VR) areas.

Population data

The ABS estimated resident population (ERP) for the years from 2002 to 2006, rebased to 2006 SLAs, was obtained from ABS. The population data contains five-year age group, sex, SLA code and states and territories identifier. The population data used in this study were consistent with death data after the previous adjustment, by ABS, from 2002 to 2005 SLA level ERPs to 2006 SLAs, using population weighted correspondence files.³⁰

The SLA level death and population data were aggregated to RA categories by states and territories and Australia, using ABS population weighted correspondence file of 2006 RA to 2006 SLA.³⁴ The study data, by RA categories, were further aggregated to three analysis groups: all persons; persons aged 35-64; and persons aged 65 years and above.

Statistical analysis

Age-standardised mortality rates for the combined six chronic diseases for all persons, persons in the age groups 35-64 and 65 years and above, and rates for each individual chronic disease for all persons were calculated using direct standardisation to the 2001 Australian standard population. Chronic disease mortality rates for each RA category of states and territories and Australia were examined for the two age groups and all persons. A standardised rate ratio (SRR) for chronic disease deaths was used to measure the differences in mortality rate between capital cities of states and territories and very remote areas. All statistical analyses were conducted using STATA software, version 11.³⁵

Results

Overall chronic disease mortality

During the period 2002-2006, there were 240,975 deaths with one of the six selected chronic diseases listed as the underlying cause and an additional 114,261 deaths with at least one of the chronic diseases listed as an associated cause of death. Of the total multiple causes of chronic disease deaths

(355,236), 10.3% of deaths were in the age group 35-64 years and 89.3% deaths were in the age group 65 years and above, with the small balance (0.4%) among those aged less than 35 years. In the age group 35-64 years, the proportion of total deaths in each of the remoteness categories increased with increase in remoteness in both males and females. As a result, there was a converse distribution in the older age group with the proportion of total deaths by remoteness areas decreasing with increase in remoteness (Table 1). Overall, at least one of the six chronic diseases was recorded as a cause of death for more than half (54%) of total deaths. Ischaemic heart disease was the leading cause of chronic disease death and was recorded as either the underlying or associated cause of death for half of total deaths (51%), followed by: stroke (28%); hypertension (18%); chronic obstructive pulmonary diseases (COPD, 17%); diabetes (16%); and chronic renal disease (13%).

Chronic disease mortality rates by Remoteness Area (RA) at national level

Table 2 shows age-standardised chronic disease mortality rates for age groups: 35-64 years; 65 years and above; and all persons. The rates were lowest among those living in MC and consistently increased toward VR (Table 2). This pattern was seen in both males and females and both age groups. A standardised rate ratio was used to compare mortality rates in different remoteness categories with the rate in the MC category. The SRR to MC in the age group 35-64 years is much higher than age group 65 and above. In the age group 35-64, the mortality rate in VR is 4.2 times higher than MC, female rates much higher (6.2 times) than males rates (3.2 times). In the age group 65 and above, the SRR is moderately increased with remoteness; in VR the mortality rate among males is 1.2 times higher than MC and 1.3 times higher among females.

A similar trend was also observed for individual chronic diseases for all persons, with MC having the lowest mortality rate increasing towards VR (Table 3). There was a minor reversal in the point estimates for stroke between IR and OR remoteness categories.

Chronic disease mortality rates by Remoteness Area (RA) for states and territories

Age-standardised mortality rates for chronic diseases also varied across RAs within state and territories; again there was a general increase in mortality rates with increasing remoteness, with the exception of Victoria (Table 4). In Victoria, the point estimate for the R mortality rate was lower than either the IR or OR categories, though there was no statistical difference between the three categories. The greatest increase in mortality rate with increased remoteness was in the NT, where the VR mortality rate was 1.9 times higher than the Darwin area – classified as OR in remoteness categories.

Discussion

Australia has among the lowest mortality rates in the world³⁶ with rates that have been consistently falling over the past century.³⁷ The improvements in the early part of the century have been largely attributed to changes in living conditions while, more recently, improvements in health care have played an important role.³⁸ However, the decline in mortality has not been shared equally by high and low socioeconomic groups.¹⁴ A mortality gap is also apparent based on the geographic variation of relative remoteness.¹⁷ The current study confirms that there is a marked gradient of increasing chronic disease mortality from major cities to remote and very remote areas of Australia. This pattern was observed in Australia as a whole, as well as within most states and territories, and for each of the six common chronic diseases. We estimate that, during the study period, there were a total of 11,900 deaths (3.3% of total) that may have been prevented if all remoteness categories had the same mortality rate as the MC category. The authors are not aware of previous studies that are directly comparable with this study. Similar studies have been limited to either individual states or territories or Australia as a whole^{7,26,39-41} and in most cases have excluded deaths for which locality was not available as a result of SLA boundary changes. We believe that this study provides nationally consistent results for chronic disease mortality differentials across remoteness categories and states and territories.

There are a number of possible reasons for the observed association between relative

Table 1: Number and proportion of chronic disease deaths for five remoteness categories^a by age group and gender, 2002-2006, Australia.

		Male		Female		Person	
		no	%	no	%	no	%
<35 years	Major Cities	581	0.5	367	0.3	948	0.4
	Inner Region	190	0.5	127	0.3	317	0.4
	Outer Region	102	0.5	73	0.4	175	0.5
	Remote	41	1.5	26	1.4	67	1.5
	Very Remote	66	4.8	19	2.0	85	3.7
	Australia	978	0.5	604	0.3	1,582	0.4
35-64 years	Major Cities	15,303	13.4	6,547	5.6	21,850	9.5
	Inner Region	5,629	13.5	2,507	6.4	8,136	10.1
	Outer Region	3,291	16.5	1,362	8.2	4,653	12.8
	Remote	704	26.5	328	17.4	1,032	22.7
	Very Remote	573	41.4	361	38.2	934	40.1
	Australia	25,500	14.2	11,105	6.3	36,605	10.3
65 years & above	Major Cities	98,410	86.1	109,960	94.1	208,370	90.1
	Inner Region	35,991	86.1	36,285	93.2	72,276	89.5
	Outer Region	16,541	83.0	15,103	91.3	31,644	86.8
	Remote	1,915	72.0	1,526	81.2	3,441	75.8
	Very Remote	744	53.8	564	59.7	1,308	56.2
	Australia	153,602	85.3	163,447	93.3	317,049	89.3
All persons	Major Cities	114,294	100.0	116,874	100.0	231,168	100.0
	Inner Region	41,810	100.0	38,919	100.0	80,729	100.0
	Outer Region	19,934	100.0	16,538	100.0	36,472	100.0
	Remote	2,660	100.0	1,880	100.0	4,540	100.0
	Very Remote	1,383	100.0	944	100.0	2,327	100.0
	Australia	180,080	100.0	175,156	100.0	355,236	100.0

a The Remoteness Area classification is based 2006 census year.

Selected chronic diseases are: diabetes (E10-E14); ischaemic heart disease (I20-I25); stroke (I60-I69); hypertension (I10); chronic obstructive pulmonary disease (J40-45, J47); and renal disease (N18-N19).

Table 2: Age standardised chronic disease mortality rates (and 95%CI) for five remoteness categories^a by age group and gender, 2002-2006, Australia.

		Male		Female		Person	
		Rate	95% CI	Rate	95% CI	Rate	95% CI
Deaths per 100,000 population ^b							
35-64 years	Major Cities	113.7	(111.9-115.5)	47.9	(46.7-49.1)	80.5	(79.4-81.6)
	Inner Region	129.6	(126.2-133.0)	57.9	(55.6-60.2)	93.9	(91.8-95.9)
	Outer Region	151.8	(146.6-157.0)	67.9	(64.3-71.5)	111.5	(108.3-114.7)
	Remote	210.0	(194.6-225.6)	117.5	(104.8-130.2)	168.1	(157.8-178.3)
	Very Remote	368.3	(338.2-398.5)	294.5	(264.1-324.9)	335.5	(314.0-357.1)
	Australia	124.7	(123.1-126.2)	54.4	(53.5-55.5)	89.6	(88.7-90.5)
65 years & above	Major Cities	2,721.0	(2,704.0-2738.0)	2,078.0	(2,065.7-2090.3)	2,353.4	(2,343.3-2363.5)
	Inner Region	2,892.0	(2,862.2-2922.0)	2,186.2	(2,163.7-2208.7)	2,502.4	(2,484.1-2520.6)
	Outer Region	3,011.0	(2,965.1-3056.9)	2,216.2	(2,180.8-2251.5)	2,585.4	(2,556.9-2613.8)
	Remote	3,090.8	(2,952.4-3229.2)	2,271.0	(2,157.1-2385.0)	2,672.2	(2,583.0-2761.5)
	Very Remote	3,258.6	(3,025.0-3492.7)	2,670.0	(2,449.5-2890.4)	2,984.4	(2,822.6-3146.1)
	Australia	2,796.8	(2,782.8-2810.8)	2,118.2	(2,107.9-2128.4)	2,415	(2,406.6-2423.4)
All persons	Major Cities	386.7	(384.5-388.9)	280.2	(278.6-281.8)	327.5	(326.2-328.9)
	Inner Region	414.9	(410.9-418.9)	297.9	(295.0-300.9)	351.8	(349.4-354.3)
	Outer Region	438.4	(432.3-444.5)	305.9	(301.2-310.6)	369.3	(365.5-373.0)
	Remote	473.4	(455.4-491.4)	333.5	(318.4-348.5)	404.0	(392.3-415.8)
	Very Remote	563.7	(534.0-593.4)	452.6	(423.7-481.5)	512.4	(491.6-533.2)
	Australia	400.8	(398.9-402.7)	287.9	(286.6-289.2)	339.0	(337.9-340.1)

a The Remoteness Area classification is based 2006 census year.

b Estimated Resident population for the year 2002-2006, rebased to 2006 Remoteness Areas.

Selected chronic diseases are: diabetes (E10-E14); ischaemic heart disease (I20-I25); stroke (I60-I69); hypertension (I10); chronic obstructive pulmonary disease (J40-45, J47); and renal disease (N18-N19).

remoteness and chronic disease mortality in Australia that may be related to either the context or the composition of the population. Firstly, shortages of healthcare professionals in rural and remote area present a serious challenge for access and continuity of healthcare delivery. In Australia, the distribution of health workforce remains geographically skewed, with concentrations of doctors and nurses in MC or IR areas much higher than R and VR areas.⁴² The shortage of general practitioners, medical specialists and dentists in remote and very remote areas will exacerbate the inequality

in resource allocation in the Medical Benefit Scheme, Pharmaceutical Benefit Scheme and dental services.⁴³ Second, many studies have identified social and economic factors as one explanation of inequality in health. Socioeconomic status (SES) is one of the most reliable descriptors of health disparities, with people from low SES experiencing poorer health and higher mortality.^{5,40,41,44} It is likely that lower SES people in more remote areas are less likely to benefit from universal health care than those at the higher end of SES.¹⁴ A third explanation is the higher proportion of Indigenous people in VR areas. Indigenous

Australians have a significant gap in health outcomes^{15,46} and make up 47.4% of the total population in VR areas, compared to 15.2% in R areas, 5.8% in OR, 2.7% in IR and 1.2% in MC.⁴⁵

There are a number of limitations to the study. The first is that the study depends on the reliability of death certificate data and subsequent cause of death coding.⁴⁷ This limitation is offset by the strict coding conventions applied to the national deaths dataset and our use of multiple causes of death.⁴⁸ Second, the study data is unlinked and numerator (mortality) and denominator (population) data came from different sources, for which there may be some inconsistency in SLA coding between different versions of ASGC available over the study period. This study minimised the misclassification, due to differences in SLA coding, by rebasing individual year datasets to 2006 SLAs. This approach may underestimate real differences at SLA, sex or age group level; however, this analysis was based on data aggregated to RA category, minimising the effect on the final results. A third limitation is that RA categories used in this study were based on the ABS 2006 Census, and calculated using road distance to the nearest service location, and extrapolated to Collection District (CD)²⁹ and SLA geographic areas. This approach provides a useful summary measure but may underestimate the true extent of remoteness, particularly in larger SLAs. A fourth limitation is that Indigenous status was not included in the analysis, as it is not available in death data for all states and territories. This precluded the examination of the separate effect of Indigenous status on the differences in mortality across remoteness categories. A final limitation is that the study was unable to report mortality from 2007 onwards because of changes in the administrative responsibility for release of the national cause of death unit record file. Changes in health service funding, workforce and policies may have affected chronic disease mortality rates in recent years.^{49,50}

Conclusion

This study shows that more remote areas have a much higher chronic disease mortality rate than less remote areas, and that there is a gradient of increasing chronic disease mortality with increasing remoteness. This gradient also exists for individual chronic

Table 3: Age standardised mortality rates (and 95% CI) for six chronic diseases by remoteness category,^a 2002-2006, Australia.

Chronic diseases	Major Cities (MC)	Inner Region (IR)	Outer Regional (OR)	Remote (R)	Very Remote (VR)	Australia (AUS)
Deaths per 100,000 population ^b						
Diabetes	51.6 (51.1-52.1)	55.4 (54.4-56.3)	64.8 (63.3-66.4)	84.1 (78.9-89.4)	139.7 (129.1-150.3)	54.5 (54.1-54.9)
Ischaemic heart disease	169.6 (168.6-170.6)	180.1 (178.4-181.8)	183.8 (181.1-186.4)	190.7 (182.6-198.7)	222.3 (208.8-235.7)	174 (173.2-174.8)
Stroke	93.3 (92.5-94.0)	95.2 (94.0-96.5)	93.9 (92.0-95.8)	96.5 (90.7-102.4)	106.1 (96.2-116.0)	94 (93.4-94.6)
Hypertension	59.7 (59.1-60.3)	60.8 (59.8-61.8)	67.0 (65.4-68.7)	78.2 (73.0-83.4)	96.7 (87.5-105.8)	61.1 (60.6-61.6)
Chronic obstructive pulmonary disease	53.6 (53.0-54.1)	62.8 (61.8-63.8)	71.0 (69.4-72.7)	81.3 (76.0-86.5)	113.5 (103.5-123.6)	57.9 (57.4-58.4)
Renal	44.3 (43.8-44.8)	45.0 (44.2-45.9)	48.0 (46.7-49.4)	60.3 (55.8-64.9)	92.5 (83.7-101.3)	46.6 (46.2-47.0)

a The Remoteness Area classification is based 2006 census year.

b Estimated Resident population for the year 2002-2006, rebased to 2006 Remoteness Areas.

Table 4: Age standardised chronic disease mortality rates (and 95% CI) for States and Territories by remoteness category,^a 2002-2006, Australia.

	Major Cities (MC)	Inner Regional (IR)	Outer Regional (OR)	Remote (R)	Very Remote (VR)
Deaths per 100,000 population ^b					
New South Wales & Australian Capital Territory	336.3 (334.1-338.6)	351.9 (347.9-356)	366.3 (359.2-373.5)	448.9 (415.9-481.9)	490.3 (390-590.5)
Victoria ^c	323.5 (321-326.1)	360.6 (355.7-365.4)	369.6 (360.3-378.8)	349.3 (286.8-411.7)	
Queensland	328.4 (325-331.7)	352.1 (346.6-357.6)	367.7 (360-375.3)	409.2 (385.6-432.8)	479.5 (446.6-512.5)
South Australia	323.9 (319.7-328.1)	311.4 (300.8-322)	379.8 (368.3-391.3)	360.6 (337.1-384.1)	451.5 (395-508.1)
Western Australia	308.4 (304.2-312.6)	304 (294.3-313.6)	331.5 (319.2-343.8)	357.6 (335-380.1)	436.5 (396.9-476.1)
Tasmania ^d		380.6 (371.7-389.5)	392.9 (379.7-406.1)	417.2 (351-483.4)	450.2 (343.2-557.2)
Northern Territory ^e			382 (356.7-407.4)	495.3 (453.1-537.5)	711 (656.1-766)
Australia	327.5 (326.2-328.9)	351.8 (349.4-354.3)	369.3 (365.5-373.0)	404.0 (392.3-415.8)	512.4 (491.6-533.2)

a The Remoteness Area classification is based 2006 census year.

b Estimated Resident population for the year 2002-2006, rebased to 2006 Remoteness Areas.

c There were no VR category areas in Victoria.

d There were no MC category areas in Tasmania. Hobart is classified as an IR remoteness area.

e There were no MC and IR category areas in the Northern Territory. Darwin is classified as an OR remoteness area.

Selected chronic diseases are: diabetes (E10-E14); ischaemic heart disease (I20-I25); stroke (I60-I69); hypertension (I10); chronic obstructive pulmonary disease (J40-45, J47); and renal disease (N18-N19).

diseases and across most states and territories. Unlike similar studies, this study was able to accommodate the effect of SLA boundary changes on analysis by remoteness category.

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References

- Altmayer CA, Hutchison BG, Torrance-Rynard VL, Hurley J, Birch S, Eyles JD. Geographic disparity in premature mortality in Ontario, 1992–1996. *Int J Health Geogr.* 2003;2:7.
- Benach J, Yasui Y, Borrell C, Rosa E, Pasarín MI, Benach N, et al. Examining geographic patterns of mortality. *Eur J Public Health.* 2003;13(2):115–23.
- Levin KA, Leyland AH. Urban-rural inequalities in ischemic heart disease in Scotland, 1981–1999. *Am J Public Health.* 2006;96(1):145–51.
- Pong RW, DesMeules M, Lagacé C. Rural–urban disparities in health: How does Canada fare and how does Canada compare with Australia? *Aust J Rural Health.* 2009;17(1):58–64.
- Dobson A, McLaughlin D, Vagenas D, Wong KY. Why are death rates higher in rural areas? Evidence from the Australian Longitudinal Study on Women's Health. *Aust N Z J Public Health.* 2010;34(6):624–8.
- Yu XQ, Robertson C, Brett I. Socioeconomic correlates of mortality differentials by Local Government Area in rural northern New South Wales, 1981–1995. *Aust N Z J Public Health.* 2000;24(4):365–9.
- Phillips A. Health status differentials across rural and remote Australia. *Aust J Rural Health.* 2009;17(1):2–9.
- Mackenbach JP, Cavelaars AEJM, Kunst AE, Groenhou F. Socioeconomic inequalities in cardiovascular disease mortality. An international study. *Eur Heart J.* 2000;21(14):1141–51.
- Banham D, Jury H, Woollacott T, McDermott R, Baum F. Aboriginal premature mortality within South Australia 1999–2006: a cross-sectional analysis of small area results. *BMC Public Health.* 2011;11:286.
- Wilkinson D, Ryan P, Hiller J. Variation in mortality rates in Australia: correlation with Indigenous status, remoteness and socio-economic deprivation. *J Public Health Med.* 2001;23(1):74–7.
- Turrell G, Mathers C. Socioeconomic inequalities in all-cause and specific-cause mortality in Australia: 1985–1987 and 1995–1997. *Int J Epidemiol.* 2001;30(2):231–9.
- Turrell G, Kavanagh A, Subramanian S. Area variation in mortality in Tasmania (Australia): the contributions of socioeconomic disadvantage, social capital and geographic remoteness. *Health Place.* 2006;12(3):291–305.
- Pearce J, Tisch C, Barnett R. Have geographical inequalities in cause-specific mortality in New Zealand increased during the period 1980–2001? *N Z Med J.* 2008;121(1281):15–27.
- Korda RJ, Butler JRG, Clements MS, Kunitz SJ. Differential impacts of health care in Australia: trend analysis of socioeconomic inequalities in avoidable mortality. *Int J Epidemiol.* 2007;36(1):157.
- Peach HG, Pearce DC, Farish SJ. Age-Standardised mortality and proportional mortality analysis of Aboriginal and non-Aboriginal deaths in metropolitan, Rural and Remote areas. *Aust J Rural Health.* 1998;6(1):36–41.
- Coory M. Can a mortality excess in remote areas of Australia be explained by Indigenous status? A case study using neonatal mortality in Queensland. *Aust N Z J Public Health.* 2003;27(4):425–7.
- Australian Institute of Health and Welfare. *Rural, Regional and Remote Health: A Study on Mortality.* Canberra (AUST): AIHW; 2007.
- Glover JD, Tennant SL, Page A. *The Impact of Socioeconomic Status and Geographic Location on Indigenous Mortality in Australia, 1997–99.* Adelaide (AUST): University of Adelaide Public Health Information Development Unit; 2004.
- Andreassan K, Hoy W. Patterns of mortality in Indigenous adults in the Northern Territory, 1998–2003: Are people living more remotely worse off? *Med J Aust.* 2009;190(6):307–11.
- Andreassan K, Hoy W, Kondalsamy-Chennakesavan S. Indigenous mortality in remote Queensland, Australia. *Aust N Z J Public Health.* 2007;31:422–7.
- Australian Institute of Health and Welfare. *Premature Mortality from Chronic Disease.* Bulletin No. 84. Canberra (AUST): AIHW; 2010.
- Australian Institute of Health and Welfare. *Contribution of Chronic Disease to the Gap in Adult Mortality between Aboriginal and Torres Strait Islander and Other Australians.* Catalogue No. IHW 48. Canberra (AUST): AIHW; 2010.
- Xue QY, Christine R, Ingrid B. Socioeconomic correlates of mortality differentials by Local Government Area in rural northern New South Wales, 1981–1995. *Aust N Z J Public Health.* 2000;24(4):365–9.
- Li SQ, Cunningham J, Cass A. Renal-related deaths in Australia 1997–1999. *Intern Med J.* 2004;34(5):259–65.
- Australian Institute of Health and Welfare. *Multiple Causes of Death.* Catalogue No. AUS 159. Canberra (AUST): AIHW; 2012.
- Fearnley E, Li SQ, Guthridge S. Trends in chronic disease mortality in the Northern Territory Aboriginal population, 1997–2004: using underlying and multiple causes of death. *Aust N Z J Public Health.* 2009;33(6):551–5.
- Australian Bureau of Statistics. *3319.0.55.001 – Multiple Cause of Death Analysis, 1997–2001.* Canberra (AUST): ABS; 2003.
- World Health Organisation. *International Classification of Diseases 2010.* Geneva (CHE): WHO; 2010.
- Australian Bureau of Statistics. *1216.0 – Statistical Geography Volume 1 – Australian Standard Geographical Classification (ASGC), July 2006.* Canberra (AUST): ABS; 2006.
- Australian Bureau of Statistics. *1216.0.15.002 – Australian Standard Geographical Classification (ASGC) Concordances.* Canberra (AUST): ABS; 2006.
- Department of Health and Ageing. *Occasional Papers: New Series 14 – Measuring Remoteness: Accessibility/Remoteness Index of Australia (ARIA) Revised Edition.* Canberra (AUST): Commonwealth of Australia; 2001.
- National Centre for Social Applications of Geographic Information Systems (GISCA). *ARIA+ (Accessibility/Remoteness Index of Australia)* [Internet]. Adelaide (AUST): University of Adelaide Australian Population and Migration Research Centre; 2012 [cited 2012 Apr 6]. Available from: http://gisca.adelaide.edu.au/projects/category/about_aria.html
- Australian Bureau of Statistics. *2901.0 – Census Dictionary, 2006 (Reissue).* Canberra (AUST): ABS; 2006.
- Australian Bureau of Statistics. *1216.0.15.003 – Australian Standard Geographical Classification (ASGC) Remoteness Area Correspondences, 2006.* Canberra (AUST): ABS; 2011.
- STATA: statistical software [computer program]. Version 12. College Station (TX): Stata Corporation; 2011.
- Day P, Pearce J, Dorling D. Twelve worlds: a geodemographic comparison of global inequalities in mortality. *J Epidemiol Community Health.* 2008;62(11):1002–10.
- Australian Bureau of Statistics. *3302.0 – 2010 Deaths, Australia.* Canberra (AUST): ABS; 2011. Table 7.1 Deaths, Summary, Remoteness Areas – 2005–10.
- Australian Institute of Health and Welfare. *Australia's Health 2012.* Canberra (AUST): AIHW; 2012. p. 120–2.
- Dempsey K, Condon J. *Mortality in the Northern Territory 1979–1997.* Darwin (AUST): Northern Territory Department of Health and Community Services; 2000.
- Cunningham J. Socio-economic gradients in self-reported diabetes for Indigenous and non-Indigenous Australians aged 18–64. *Aust N Z J Public Health.* 2010;34:518–24.
- Beard JR, Tomaska N, Earnest A, Summerhayes R, Morgan G. Influence of socioeconomic and cultural factors on rural health. *Aust J Rural Health.* 2009;17(1):10–5.
- Department of Health and Ageing. *Report on the Audit of Health Workforce in Rural and Regional Australia.* Canberra (AUST): Commonwealth of Australia; 2008.
- Australian Institute of Health and Welfare. *Australian Health Expenditure by Remoteness: a Comparison of Remote, Regional and City Health Expenditure.* Canberra (AUST): AIHW; 2010.
- Smith KB, Humphreys JS, Wilson MGA. Addressing the health disadvantage of rural populations: How does epidemiological evidence inform rural health policies and research? *Aust J Rural Health.* 2008;16(2):56–66.
- Australian Bureau of Statistics. *3238.0.55.001 – Experimental Estimates of Aboriginal and Torres Strait Islander Australians by Remoteness, June 2006.* Canberra (AUST): ABS; 2006.
- Hill K, Barker B, Vos T. Excess Indigenous mortality: are Indigenous Australians more severely disadvantaged than other Indigenous populations? *Int J Epidemiol.* 2007;36(3):580–9.
- Australian Bureau of Statistics. *3303.0.55.001 – Cause of Death, Australia: Doctor Certified Deaths, Summary Tables, 2008.* Canberra (AUST): ABS; 2010.
- Australian Bureau of Statistics. *Deaths, Australia.* Canberra (AUST): ABS; 2006.
- Department of Health and Ageing. *The National Strategic Framework for Rural and Remote Health.* Canberra (AUST): Commonwealth of Australia; 2012.
- Department of Health and Ageing. *National Partnership Agreement on Preventative Health.* Canberra (AUST): Commonwealth of Australia; 2012.