Regional variation in cardiovascular mortality in Australia 2009–2012: the impact of remoteness and socioeconomic status

Jane Jacobs,[1] Karen Louise Peterson,[2] Steven Allender,[1] Laura Veronica Alston,[1] Melanie Nichols[1]

Cardiovascular disease (CVD) has been the leading cause of death in Australia for most of the past century.[1] Cardiovascular mortality and morbidity represent a high economic and health burden and disproportionately affect certain subgroups within the population.

In 2010, 69% of the total Australian population resided in major cities, 29% lived in inner or outer regional areas, and 2% in areas classified as remote and very remote.[2] There are regional differences in cause-specific mortality,[3-6] with populations resident outside of major cities experiencing higher mortality and morbidity from all major chronic diseases,[2] a finding replicated in other high-income countries.[7,8]

Higher mortality rates in regional and remote areas have been attributed to barriers in accessing optimal health services, higher costs and difficulties in sourcing fresh food, harsher environmental conditions, higher proportions of Aboriginal and Torres Strait Islanders and relative social isolation.[9] Those living outside of major cities have disproportionately higher levels of socioeconomic disadvantage compared to their metropolitan counterparts,[10] a factor also associated with increased avoidable mortality[11-14] and higher rates of chronic disease.[2] Like remoteness, this disparity is likely to be multifactorial and influenced by lower education levels and poorer health literacy,[15] higher rates of health-damaging behaviours[10] and fewer preventative measures being undertaken.[16] The impact

of the combination of different levels of remoteness and socioeconomic status (SES) on health and mortality are complex and to date have not been well understood.

Nationally representative Australian studies have assessed associations between cardiovascular mortality and disadvantage[14] or remoteness[17] alone. Data from individual states have consistently found that, once adjusted for SES, the impact of remoteness on mortality diminishes or becomes negligible.[18-20] What is less well understood is the combined impact of both remoteness and SES on cardiovascular mortality at the national level, and within different age groups.

Aims

The aims of this study were to: i) analyse and report the variation in cardiovascular disease mortality across regions of Australia and within age groups; and ii) analyse the extent to which the impact of remoteness on mortality is mediated by socioeconomic disadvantage.

Abstract

Objective: To assess the extent to which socioeconomic status (SES) contributes to geographic disparity in cardiovascular disease (CVD) mortality.

Methods: An ecological study assessed the association between remoteness and CVD mortality rates, and the mediating effect of SES on this relationship, using Australia-wide data from 2009 to 2012.

Results: Socioeconomic status explained approximately one-quarter of the increased CVD mortality rates for females in inner and outer regional areas, and more than half of the increased CVD mortality rates in inner regional and remote/very remote areas for males, compared to major cities. After allowing for the mediating effect of SES, females living in inner regional areas and males living in remote/very remote areas had the greatest CVD mortality rates (Mortality Rate Ratio: 1.12, 95%CI 1.07–1.17; MRR: 1.15, 95%CI 1.05–1.25, respectively) compared to those in major cities.

Conclusion: Socioeconomic status explained a substantial proportion of the association between where a person resides and CVD mortality rates; however, remoteness has an effect above and beyond SES for a number of subpopulations.

Implications for public health: This study highlights the need to focus on both socioeconomic disadvantage and accessibility to reduce CVD mortality in regional and remote Australia.

Key words: cardiovascular disease, epidemiology, socioeconomic status, health inequalities, rural health

Methods

Population and mortality data

This study analysed mortality, remoteness and area-level socioeconomic data across Statistical Areas Level 2 (SA2), according to the Australian Statistical Geography Standard.[21] There are 2,196 spatial SA2s in Australia, covering the whole of Australia without gaps or overlap, with populations ranging from approximately 3,000 to 25,000.[21]

Age-, sex- and cause-specific mortality data were provided by the Australian Institute of Health and Welfare (AIHW) for each SA2 between 2009 and 2012 for CVD deaths (all of ICD-10 chapter IX, codes I00-I99) in five-year age groups for each sex. Age groups were combined into six categories. Age- and sex-specific Estimated Resident Population (ERP) data for the corresponding years for each SA2 were retrieved from the Australian Bureau of Statistics (ABS).[22]

Socioeconomic data

The 2011 Index of Relative Socio-Economic Advantage-Disadvantage (IRSAD, a Socio-Economic Index for Areas) scores for each SA2 were obtained from the ABS. These provide a summary of the relative disadvantage and advantage of an area based on census data, taking into consideration both economic and social components. This is a continuous index, which is divided into quintiles, with a lower score indicating relative disadvantage and lack of advantage, and a higher score indicating relative advantage and lack of disadvantage.[23]

Remoteness data

The Accessibility/Remoteness Index of Australia (ARIA+)[21] was used to classify areas according to remoteness. This system categorises areas as: major cities, inner regional, outer regional, remote and very remote; due to small numbers, remote and very remote have been combined for analysis. This index is based on a continuous variable derived from the area's access to services, measured as distance by road, and the population of the closest centre.[24] Remoteness and SA2 boundaries do not exactly align, therefore the ABS provides population-weighted 'correspondences' quantifying the proportion of each SA2 falling within each remoteness classification. Of all SA2s, 95.3% fall completely within one remoteness area, while the remainder have some percentage in each of two or more

remoteness classifications.[25] Those SA2s with less than 75% correspondence to a single remoteness classification were excluded.

Statistical Area data

Statistical Areas with an average ERP of less than 500 for males or females, and age–sex subgroups with a population of fewer than 25 were excluded from analysis, due the instability of rate estimates with low populations. As all analyses were stratified by sex, SA2s were excluded only from the female or male analysis as necessary due to population sizes below the thresholds.

Analysis

Analysis was conducted using Stata Version 14 (StataCorp, College Station, TX, 2015). Sex-specific proportions of SA2s were tabulated by remoteness and IRSAD category. Death rates per 100,000 population per year were calculated by dividing the age- and sex-specific number of total deaths from 2009 to 2012 by the age- and sex- specific total population in that SA2 over the four years. Death rates were age standardised to the Australian 2001 'Standard Population for Use in Age-Standardisation', published by the ABS.[26] The sex-specific crude and adjusted mortality rate within each combination of SES and remoteness was tabulated.

Maps were created using ArcMap 10.1 (Esri, Redlands, CA) to visualise variation in the age-standardised death rate across Australia for males and females. To improve clarity of maps, data were aggregated to a Statistical Area 3 (SA3) level, (an SA3 is composed of multiple SA2s, with populations ranging from 30,000 to 130,000), and death rates were then calculated and age-standardised in the same manner as at the SA2 level.

Associations between remoteness and CVD deaths were analysed using negative binomial regression, with SES treated as a potential mediator. Negative binomial regression was selected in preference to Poisson regression due to the over-dispersion of the outcome variable whereby the variance was greater than the mean.[27] The presence of an interaction between remoteness and SES on CVD mortality rates was tested with a likelihood ratio test between regressions with and without the interaction term.

The results of the negative binomial regressions were antilogged to calculate mortality rate ratios (MRR) and 95% confidence intervals. Major cities were used

as the reference category for remoteness analysis and IRSAD quintile 5 (most advantaged and least disadvantaged) was the reference for SES analyses. A p-value of <0.05 was considered statistically significant.

For the overall national analysis, expected death count was the dependent variable, with the population included as the offset variable. For age-specific analysis, age-specific death count was the dependent variable, with age-specific population included as the offset variable. Remoteness was the primary independent variable. All analyses were stratified by sex.

Analysis of the possible mediating effects of SES (in quintiles) was based on the causal steps approach.[28] This approach requires that, firstly, the independent and dependent variable are correlated; secondly, the independent variable and proposed mediator are correlated; thirdly, the proposed mediator is correlated with the dependent variable, when controlled for the independent variable; and finally, the coefficient (MRR) from step 3 is smaller than that from step 1 (partially mediated), or reduced to zero (completely mediated).

Results

From 2009 to 2012, there were 180,530 total deaths from CVD in Australia (~45,000 per year).

Prior to analysis, the female population of 170 SA2s (8% of total) and male population of 168 SA2s (8% of total) were excluded due to small total ERPs, having populations fewer than 25 in one or more age–sex subgroups, or due to the SA2 not being allocated to a single remoteness area classification. This represented the exclusion of 2,559 female (2.7%) and 3,057 (3.6%) male deaths.

Among SA2s classified as major cities, the largest proportion were in the most advantaged quintile for males and females, while the inverse was true for those classified as remote/very remote areas, with the largest proportion in the most disadvantaged quintile (Table 1). The chi-squared p-value (<0.001) indicates a strong relationship between remoteness and SES quintile.

Looking at combinations of SES and remoteness, and excluding those combinations with two or less SA2s, the age-standardised death rate was highest for females living in SA2s classified as outer regional and in quintile 5 of SES, and for

males living in SA2s classified as remote and very remote and in quintile 1 (227.4 and 269.2 deaths per 100,000 population respectively), see Table 2.

Figures 1a and 1b show the age-standardised CVD death rates for males and females, respectively, across Australia at a SA3 level, with darker areas representing higher mortality rates.

There was no interaction found between remoteness and SES on CVD mortality rates for males or females (*p*-value for likelihood ratio test *p*=0.38; *p*=0.43, respectively), therefore the interaction term was not included in the model.

Overall results

With major cities as the referent category, the univariate negative binomial regressions show a significantly higher rate of death from CVD for females living in inner regional (MRR: 1.15, 95%CI: 1.11–1.20) and outer regional (1.14, 1.08–1.21) areas, with remote/very remote areas approaching significance (1.11, 0.99–1.24; *p*=0.07). For males, inner regional (1.13, 1.09–1.17), outer regional (1.12, 1.07–1.17) and remote/very remote areas (1.25, 1.14–1.37) all had significantly increased mortality rates (Table 3).

Mediating effect of socioeconomic status on remoteness

Addition of SES into the regression model attenuated the results (Table 3) indicating that the relationship between remoteness and age-standardised death rate is partially mediated by the effect of SES. There remained a significantly higher age-standardised death rate for females living in inner regional (1.12, 1.07–1.17) and outer regional (1.10, 1.04–1.16) areas after accounting for the role of area-level SES. For males, living in inner regional areas (1.06, 1.02–1.10) and remote/very remote areas (1.15, 1.05–1.25) also remained significantly associated with increased CVD mortality rate.

This indicates that increased CVD mortality rates for females in remote/very remote areas and males in outer regional areas were attributable to socioeconomic disadvantage. Socioeconomic status accounted for approximately one-quarter of the increased CVD mortality rates for females residing in inner and outer regional areas. Almost two-thirds of the increase in CVD mortality for males living in inner regional areas was attributable to lower SES, as was

Table 1: Distribution of SA2 socioeconomic status within remoteness categories, by sex.

Females	IRSAD quintiles N (% within remoteness category)				
Remoteness category n (% of SA2s)	Q1	Q2	Q3	Q4	Q5
Major City n=1167 (61)	140 (11.9)	144 (12.3)	222 (19)	307 (26.3)	354 (30.3)
Inner Regional n=437 (22.8)	116 (26.5)	129 (29.5)	111 (25.4)	64 (14.6)	17 (3.9)
Outer Regional n=257 (13.4)	94 (36.6)	95 (37)	34 (13.2)	23 (8.9)	11 (4.3)
Remote and Very Remote n=52 (2.7)	22 (42.3)	13 (25)	15 (28.8)	2 (3.8)	0
Total SA2s in quintile N (%)	372 (19.4)	381 (19.9)	382 (20)	396 (20.7)	382 (20)

Pearson chi squared p <0.001

Males	IRSAD quintiles N (% within remoteness category)				
Remoteness category n (% of SA2s)	Q1	Q2	Q3	Q4	Q5
Major City n=1166 (60.9)	140 (12)	144 (12.3)	223 (19.1)	307 (26.3)	352 (30.2)
Inner Regional n=438 (22.9)	116 (26.5)	129 (29.5)	111 (25.3)	64 (14.6)	18 (4.1)
Outer Regional n=261 (13.6)	94 (36)	95 (36.4)	37 (14.2)	24 (9.2)	11 (4.2)
Remote and Very Remote n=50 (2.6)	19 (38)	14 (28)	15 (30)	1 (2)	1 (2)
Total SA2s in quintile N (%)	369 (19.3)	382 (19.9)	386 (20.2)	396 (20.7)	382 (19.9)

Pearson chi squared p <0.001

IRSAD: Index of Relative Socio-Economic Advantage and Disadvantage (Q1 = most disadvantaged and least advantaged, Q5 = least disadvantaged and most advantaged)

Table 2: Crude and age-standardised death rates for remoteness and SES quintile combinations, stratified by sex.

Remoteness	IRSAD	Female		Male	
		Crude Death Rate	Age-standardised Death Rate	Crude Death Rate	Age-standardised Death Rate
Major City	Q1	212.5	171.1	211.4	220.8
Major City	Q2	234.3	174.1	212.8	214.7
Major City	Q3	201.1	165.1	181.2	197.7
Major City	Q4	182.5	161.3	162.1	189.2
Major City	Q5	190.7	160.0	153.8	176.2
Inner Regional	Q1	327.6	193.0	312.8	243.9
Inner Regional	Q2	272.2	183.3	256.8	217.4
Inner Regional	Q3	231.2	186.7	219.2	215.9
Inner Regional	Q4	200.1	180.0	179.9	198.2
Inner Regional	Q5	179.7	201.9	167.4	207.8
Outer Regional	Q1	289.0	188.6	284.5	234.1
Outer Regional	Q2	250.6	189.0	244.9	219.1
Outer Regional	Q3	175.5	180.3	171.7	197.4
Outer Regional	Q4	109.9	170.5	113.9	192.4
Outer Regional	Q5	130.8	227.4	106.6	222.7
Remote/Very Remote	Q1	142.3	205.4	222.6	269.2
Remote/Very Remote	Q2	210.9	165.7	240.0	247.6
Remote/Very Remote	Q3	109.1	158.0	137.8	212.5
Remote/Very Remote	Q4	n/a	n/a	n/a	n/a
Remote/Very Remote	Q5	n/a	n/a	n/a	n/a

n/a – overall rates not calculated for category combinations with 2 or fewer SA2s.

IRSAD: Index of Relative Socio-Economic Advantage and Disadvantage (Q1 = most disadvantaged and least advantaged, Q5 = least disadvantaged and most advantaged)
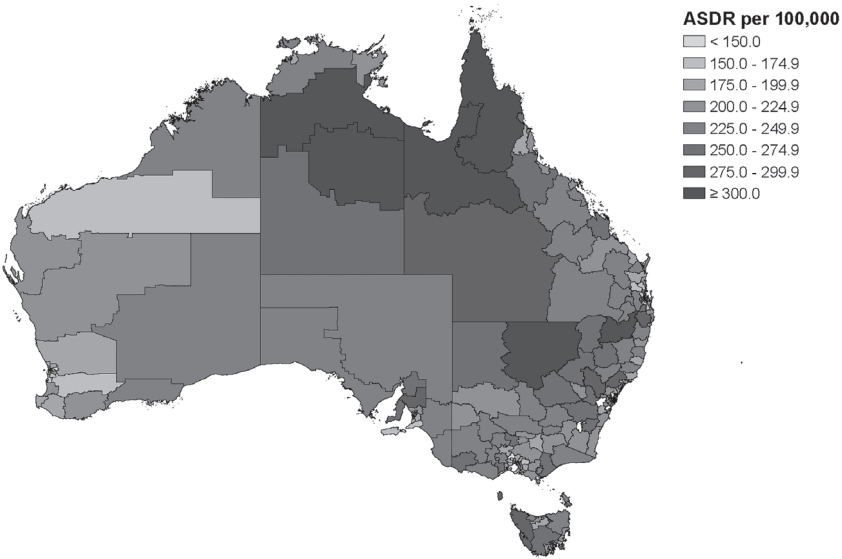
Figure 1a: Male age standardised death rates.

ASDR per 100,000
- < 150.0
- 150.0 - 174.9
- 175.0 - 199.9
- 200.0 - 224.9
- 225.0 - 249.9
- 250.0 - 274.9
- 275.0 - 299.9
- ≥ 300.0

Figure 1b: Female age standardised death rates.

ASDR per 100,000
- < 75.0
- 75.0 - 99.9
- 100.0 - 124.9
- 125.0 - 149.9
- 150.0 - 174.9
- 175.0 - 199.9
- 200.0 - 224.9
- ≥ 225.0
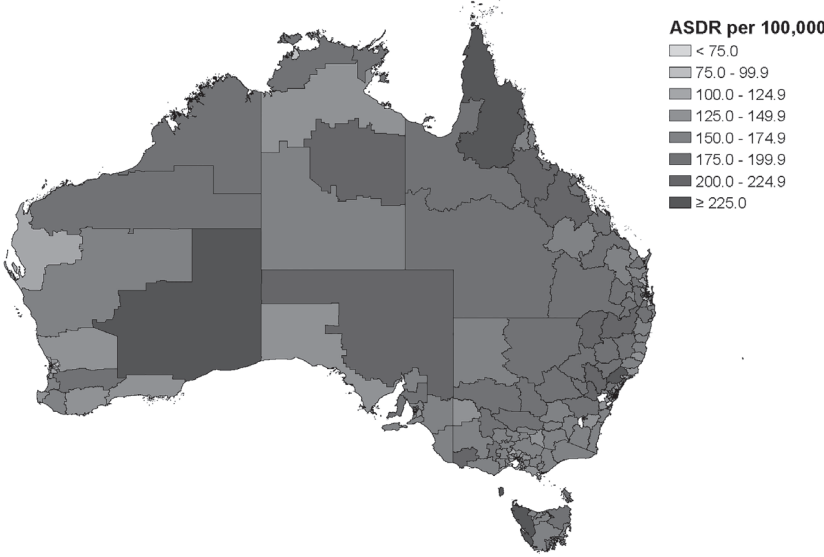
Table 3: Non-mediated and mediated mortality rate ratios: by sex.

| | Non-mediated model | | | | Mediated model | | | |
| | Female | | Male | | Female | | Male | |
Variables	MRR	95% CI	MRR	95% CI	MRR	95% CI	MRR	95% CI
Remoteness								
Major city	1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Inner Regional	1.15**	1.11–1.20	1.13**	1.09–1.17	1.12**	1.07–1.17	1.06**	1.02–1.10
Outer Regional	1.14**	1.08–1.20	1.12**	1.07–1.17	1.10**	1.04–1.16	1.03	0.99–1.08
Remote and Very Remote	1.11	0.99–1.24	1.25**	1.14–1.37	1.07	0.95–1.20	1.15**	1.05–1.25
Index of Relative Advantage and Disadvantage (quintile)								
Q5			n/a		1 (ref)		1 (ref)	
Q4					1.01	0.96–1.07	1.08**	1.03–1.12
Q3					1.04	0.99–1.10	1.13**	1.08–1.18
Q2					1.07*	1.01–1.13	1.20**	1.15–1.26
Q1					1.09**	1.04–1.16	1.29**	1.24–1.35

** $p < 0.01$, * $p < 0.05$.
MRR: Mortality Rate Ratio; IRSAD: Index of Relative Socio-Economic Advantage and Disadvantage (Q1 = most disadvantaged and least advantaged, Q5 = least disadvantaged and most advantaged)

approximately half of the increase for males in remote/very remote areas.

When adjusted for remoteness, greater disadvantage and a lack of advantage were consistently associated with increased age-standardised death rates across both sexes.

Figures 2a and 2b give a graphical representation of the mortality rate ratios associated with place of residence, while Figures 2c and 2d show the impact of SES on this relationship.

Age-specific results

When stratified into six age groups, using major cities as the referent, the univariate regression results show an increased risk of CVD mortality associated with residing in remote/very remote areas for all age groups and both sexes, except for the oldest age group (75 years and over). The highest MRR for females was for those aged 35 to 44 years (7.23, 4.92–10.63), and for males the greatest MRR was for those aged under 35 (3.31, 2.24–4.90), see Supplementary Table 1. The corresponding absolute mortality rates in these groups were 52 and 9.6 deaths per 100,000 population, respectively (results not shown).

Mediating effect of socioeconomic status on remoteness

Mediation due to SES was also apparent in the age-specific analysis, with the univariate results being attenuated after the addition of SES (Supplementary Table 1). However, there remained significantly elevated MRRs in remote/very remote areas for both sexes in the 35–44, 45–54, 55–64 and 65–74-year age groups, after accounting for SES. The highest MRR was again found for those in the 35–44-year age group for females (5.22, 3.59–7.58), and under 35s for males (2.65, 1.80–3.91). Females aged 75 and over had lower CVD death rates in remote/very remote areas compared to major cities (0.80, 0.70–0.91).

Apart from female deaths in the 75 years and over age group, all other age groups for both sexes showed greater disadvantage and lack of advantage to be significantly associated with higher age-specific death rate, when adjusted for remoteness.

Discussion

This is the first Australian study to analyse remoteness and the mediating effect of SES on CVD death rates at this fine level of geographic abstraction using representative

data at a national level and across a range of age groups. Socioeconomic status explained a substantial proportion of the association between place of residence and CVD mortality rates; however, results showed remoteness to have an effect above and beyond SES for a number of subpopulations.

The ecological study design used for this analysis, with data coming from different sources, has the potential of resulting in ecological fallacy bias.[29] Therefore, results in the data should not be taken as being reflective of all of the individuals within that group or region. Furthermore, such ecological data does not allow for adjustment for other potential confounding factors, such as education level, although many of these possible confounders are accounted for, at the area level, in the IRSAD equation. The design of this study only allows for analysis of the place of residence at the time of death, therefore it cannot be determined how long the resident had lived in, and been exposed to, that environment and consequently its impact on health. A longitudinal study design would be required to obtain such information.

The measure used to assess SES (IRSAD) is an area level marker. While it cannot be used to make inferences about individuals, it does provide information regarding the environment that residents live in, which can be useful when assessing what aspects of the built environment, both physical and social, may affect the health of residents.

The data precluded identification of Indigenous status. Indigenous Australians have a significantly higher rate of CVD death compared to non-Indigenous Australians,[9] and 28% of the Indigenous population live in remote and very remote areas, compared to 2% of the non-Indigenous population.[30] As well as the issues facing all people living in regional and remote Australia, Indigenous people living in these areas may face additional barriers to optimum heath, such as discrimination and racism,[31] a lack of access to culturally appropriate health services,[32] and low numbers of Indigenous health workers.[33,34] These factors could act to exacerbate existing disparities for Indigenous people living outside of metropolitan areas, with Indigenous status acting as a mediator in mortality rates across different remoteness categories. However, not all studies show poorer outcomes for Indigenous people living in rural areas when compared to their metropolitan counterparts. A Northern

Figure 2a: Non-mediated female mortality rate ratio.

Figure 2b: Non-mediated male mortality rate ratio.
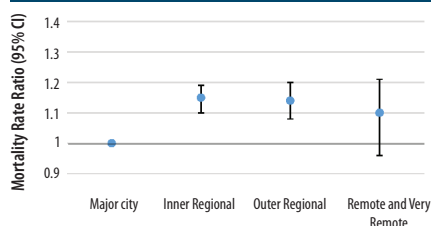
Figure 2c: Mediated female mortality rate ratio.

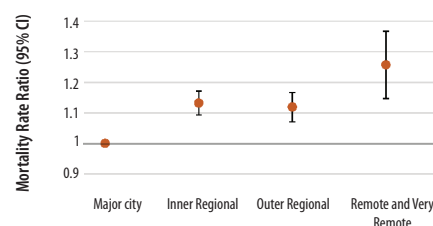Figure 2d: Mediated male mortality rate ratio.
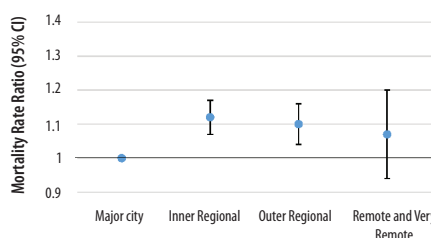
Territory study found no difference in acute myocardial infarction (AMI) incidence rates or pre-hospital death between Indigenous people living in remote and urban areas, although the AMI rates for Indigenous people were overall higher than for non-Indigenous people.[35] Inclusion of Indigenous status in the Australasian Cardiac Outcomes registry[34] will allow for further investigation into the impact of remoteness and SES on this population in the future.

Although the AIHW data used in this study is of high quality, there is the possibility that results may be influenced by misclassification of cause of death. However, a Western Australian study[36] found that while up to 16% of deaths in the state were classified incorrectly, misclassification rates were consistent between metropolitan and rural areas.

Australian studies assessing the association between remoteness and mortality or other health outcomes have consistently found worse outcomes for those living outside of major cities.[17,37,38] However, several studies have found this association became negligible or non-existent after controlling for SES, indicating that living outside of major cities may not be the driving force behind this disparity, although it may amplify other factors.[39] This is in contrast to our findings, where the association remained significant for most remoteness levels after controlling for SES. A New South Wales study[18] found no increased risk for ischaemic heart disease (IHD) incidence in rural and remote areas after SES adjustment. Similarly, a study comparing a regional area in Victoria to a metropolitan area of Adelaide[6] found poorer CVD risk factor profiles were associated with living in
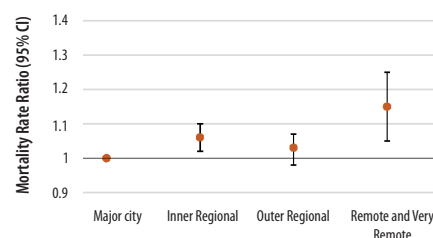
lower SES locations but found no difference between living in rural or metropolitan areas. A Tasmanian study[19] also found that SES accounted for one-third of mortality variation between Statistical Local Areas, but remoteness did not significantly contribute to this disparity. A significant factor in these findings may be a lack of variation in the levels of remoteness within just one state, or when comparing two small regions. Our study, however, benefited from nationwide data, allowing for greater contrast between areas.

Studies looking at cancer have also found poorer outcomes in regional and remote Australia[37,40] and in lower socioeconomic areas. However, a Queensland study found that breast cancer survival was associated with area-level SES but not remoteness, when the two factors were considered together.[41]

There are a number of potential factors contributing to higher CVD death rates outside of major cities. Regional and remote populations suffer from reduced access to, and use of, healthcare, with lower GP attendance rates outside of metropolitan areas[42] and reduced rates of cardiovascular medication prescription in rural and remote locations.[43] Contributing factors include lower number of services outside of major cities, potential long distances to existing services,[44,45] and difficulty attracting and retaining medical professionals.[46] Non-metropolitan hospitals have also been found to have lower use of evidence-based treatments.[47] An Australian study[48] found that the most socioeconomically disadvantaged groups had a 25% lower GP utilisation rate compared to the most advantaged groups in remote areas; whereas, in metropolitan areas

this rate was 10% higher for disadvantaged groups.

Those living outside of major cities also have higher proportions of CVD risk factors, such as obesity, smoking, high-risk alcohol use and inadequate physical activity,[2,37] with a national study finding that 38.2% of the gap in IHD death rates between urban and rural populations could be attributed to differences in modifiable risk factors.[49] However, it is difficult to attribute these differential risk factor profiles to remoteness alone, as many of the same factors are associated with socioeconomic disadvantage.[10]

The consistently higher mortality rates in inner regional areas, particularly for females, need further consideration and exploration. The majority of existing research has focused on rural and remote areas, or binary comparisons between metropolitan and non-metropolitan areas. While little evidence exists, inner regional areas of Australia may be subject to a unique risk factor profile, including greater access to unhealthy food outlets compared to outer regional and remote areas, combined with lower access to public transport and lower SES than metropolitan areas.

The apparent protective effect of remoteness for females aged 75 years and over may be due to 'internal migration', whereby older people who are unwell are more likely to move to populated centres to be closer to healthcare services.[4,50] If this is the case, the observed results may underestimate the effect of remoteness on cardiovascular health. Again, longitudinal data would be required to assess this.

The age-specific results are concerning, particularly for younger populations living in remote and very remote areas, as they indicate a greatly increased mortality rate compared to their major city counterparts. A study analysing Australian IHD mortality trends from 1976 to 2006 found that, while overall mortality had declined, the decline had plateaued for younger males and females from the early 1990s.[51] This was attributed to a slowing or reversal in previous trends of declining heart disease risk factors in these younger groups. A Western Australian study had similar findings, demonstrating a plateau of AMI incidence in those aged under 50, despite an overall decline.[52] Our data indicates that this trend may be of particular concern in remote and very remote populations, which is supported by Australian data showing overall reduction in mortality from IHD between

time periods 1997–2001 and 2010–2014, but increasing rate ratio between major cities and remote and very remote regions.[53]

The included maps of age-standardised deaths rates across Australia show generally higher rates outside of major cities, although there are some anomalies. For example, the Pilbara region in Western Australia has a much lower age-standardised death rate than other remote and very remote locations. This may be due a high proportion of young males living in the area due to the mining industry,[54] who may have overall better health than the permanent population.

A recent systematic review highlights the lack of research into the reasons behind geographic disparities in CVD outcomes.[55] Future research should focus on the reasons for this disparity between major cities and regional and remote areas, and between advantaged and disadvantaged populations, to identify strategies to address this inequality. Increased collection and analysis of empirical data is needed for regional and remote populations, particularly on risk factor levels, Indigenous status, health service access and health literacy, to ascertain how such factors interact with SES to contribute to differences in the CVD burden between non-metropolitan and metropolitan areas. This will assist in identifying priorities for health policy to reduce inequalities observed for regional and remote populations of Australia.

Conclusion

This study aimed to assess the extent to which socioeconomic disadvantage mediated the relationship between CVD mortality rates and residing outside of major cities in Australia. A substantial proportion of the increased CVD mortality rates outside of major cities was found to be attributable to socioeconomic disadvantage. However, a significant association between CVD mortality and place of residence remained for females living in inner and outer regional areas, and males living in inner regional and remote/very remote areas, after allowing for the mediating effect of SES. Further investigation is warranted into the underlying reasons for such disparity in health outcomes for those living outside of Australian major cities.

Funding source

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Supporting Information

Additional supporting information may be found in the online version of this article:

Supplementary Table 1: Non-mediated and mediated mortality rate ratios: by age.