Epidemiology at the extremes: an examination of the factors that affect health outcomes in very remote areas of Australia

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Introduction

Australia is a country of extremes. It is the hottest and driest of the permanently inhabited continents, with a relatively small, low-density population, the majority of which is dispersed around the coastline. In terms of distance alone, residents of Australia's most remote communities are among the most isolated on Earth. Much effort over the past few decades has been invested in attempts to define and measure rurality in the context of health. This process has been driven by the recognition that residents of rural and remote communities have health needs and outcomes that differ from those of their urban counterparts. In Australia, several different classification systems have been used, with the current system, the Australian Standard Geographical Classification system for Remoteness Areas (ASGC-RA) considered by some experts in the field to be imperfect for the purposes of health policy planning and resource allocation.[1-3] This has led to the more recent development of other indices specifically for use in the health context, as well as the growing recognition that use of remoteness areas alone is insufficient to distinguish the unique health needs of remote communities.[4,5]

While geography and distance remains key characteristics of remote communities in Australia, there are other critical differences between rural and urban communities that contribute to the disparities in health outcomes observed between them. These differences relate to demographic, industrial, economic, environmental and social factors which distinguish urban from rural communities and contribute to the unique concept of what "rural" means in the Australian context. With respect to health, there is a broad trend towards increasing morbidity and mortality with increasing remoteness, with the majority of the excess health burden due to circulatory disease and injuries.[6] While the association between rurality and poor health, as measured in crude terms by life expectancy and/or death rates, is one that has been observed in other developed countries such as the USA and Canada[7,8], it has proven difficult to generalise a trend across countries. A recent review of the 'rural-urban' health differential in developed countries found that rurality was not necessarily an independent risk factor for poor health but rather a reflection of the increased health risk in rural areas due to the effects of socioeconomic disadvantage, exposure to environmental and occupational hazards, lack of access to health services and risk-taking behaviours.[9]

Demographic characteristics also contribute to the differences in health outcomes observed between rural and urban communities in Australia. While in the non-Indigenous population there is a trend towards increasing age with remoteness, the most marked demographic difference between urban and remote communities in Australia is the proportion of the population who are Indigenous.[10,11] The Indigenous to non-Indigenous ratio rises sharply with remoteness, and there is little doubt that the overwhelming excess health burden borne by Aboriginal and Torres Strait Islander people is one of the major drivers of the increased morbidity and mortality in remote Australia communities.[6,12] While the trend is not linear, that is, Indigenous mortality does not necessarily increase with remoteness, and studies that have attempted to "control" for Indigenous ethnicity have reached different conclusions regarding the relative contribution of ethnicity to poor health in rural communities, it nevertheless seems clear that a large part of the excess health burden in remote communities is attributable to the higher proportion of those populations who are Indigenous.[5,13,14] In the most remote communities, which are the focus of this study, the effects of remoteness and Indigenous ethnicity may in fact be compounded, with the combined effects resulting in greater health disadvantage than either characteristic alone.[15]

The purpose of this study was to examine the epidemiological factors which contribute to the excess health burden in the most remote communities in Australia, in an attempt to ascertain which factors contribute most strongly to this phenomenon, as well as identify which communities seem to be performing relatively better or worse when compared with others within this diverse and inhomogeneous group, in order to better facilitate planning and resource allocation from a health policy perspective.

Methods

Statistical local area measures (SLAs) were used as proxies for "communities", as these units are the smallest geographical area defined by the ASGC-RA and form the basis for collection and dissemination of data by the Australian Bureau of Statistics (ABS) in non-census years. SLAs also more closely approximate social and geographic boundaries in remote areas than in regional or urban settings. Only the most remote SLAs (those classified as "very remote" in the five-tier ASGC-RA system) were included in the analysis. Data on health outcomes and epidemiological determinants was sourced from the Social Health Atlas of Australia (2010), produced by the Public Health Information Data Unit (PHIDU) at the University of Adelaide. Age-standardised, avoidable mortality rates (AMR) were used as a proxy measure for health outcomes; these were produced by the PHIDU from data supplied by the ABS from 2003 to 2007, including the 2006 Census year, from which population denominators were derived. Demographic, social and economic factors were selected for analysis based on the completeness of the datasets (some data was missing for very remote SLAs, and not all states collected the same sets of information) and the relevance to the study question based on the literature review. Of those very remote SLAs with complete datasets, a list was generated with SLAs ranked according to AMR. Statistical analysis, including analysis of variance (Bartlett's and chi-squared tests) and factor analysis, was then undertaken to determine which of the epidemiological determinants correlated most strongly with the observed differences in AMR between SLAs. An additional step selected the top, middle and bottom twenty SLAs based on AMR and grouped them into three ranks – high, middle and low – based on the mean values for each variable in the groups of twenty, in order to highlight trends in differences in the variables between these groups. Based on the above findings, a measure of "predicted" AMR was derived, and a second list generated ranking SLAs by their "observed to predicted" AMR. The conceptual rationale for this method was to attempt to identify those SLAs that were not behaving as expected – those with the highest observed: predicted ratios could be said to be "underperforming" (with AMR greater than that which could be expected based on their epidemiological determinants); those SLAs with the lowest observed: predicted ratios were defying expectation with low mortality rates despite significant epidemiological risk.

Results

Of the 137 SLAs classified as "very remote" by the ASGC-RA, 83 had complete datasets and were thus included in the analysis. Figure 1 demonstrates the location of these SLAs. Table 1 lists the 83 very remote SLAs ranked from highest to lowest AMR, with total population and per cent Indigenous included. Figure 2 shows the location of the twenty SLAs with the highest AMR and the twenty with the lowest AMR. Table 2 lists the epidemiological variables included in the study, gives the results of the tests for statistical significance for each variable's association with the differences in AMR, and demonstrates broad trends in these variables between those SLAs with the highest and lowest AMR using the three-rank categorisation system described above. From this table several broad trends can be discerned, namely that, compared with the SLAs with the lowest rates of avoidable mortality, the SLAs with the highest rates of avoidable mortality also have a younger population, a higher proportion of whom are Indigenous; lower levels of employment, education and literacy; higher rates of poverty, overcrowding and single parent families; and a health workforce comprised mainly of Indigenous health workers, with fewer doctors and nurses. Table 3 lists the SLAs ranked by observed to predicted AMR, demonstrating that several SLAs, after key epidemiological risk factors are taken into consideration, shift significantly in position compared with Table 1. Figure 3 locates the "top" and "bottom" twenty SLAs based on observed to predicted AMR, as an indication of those very remote communities that have avoidable mortality rates significantly lower or higher (respectively) than could be expected based on the variables examined.

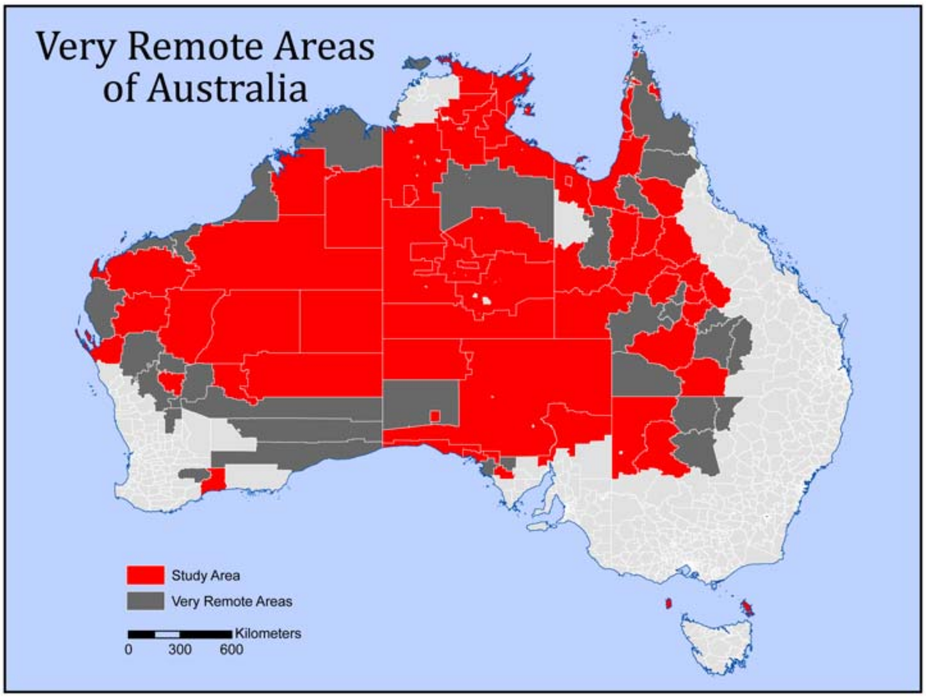

Figure 1 Map of all 137 SLAs with the 83 included in analysis highlighted

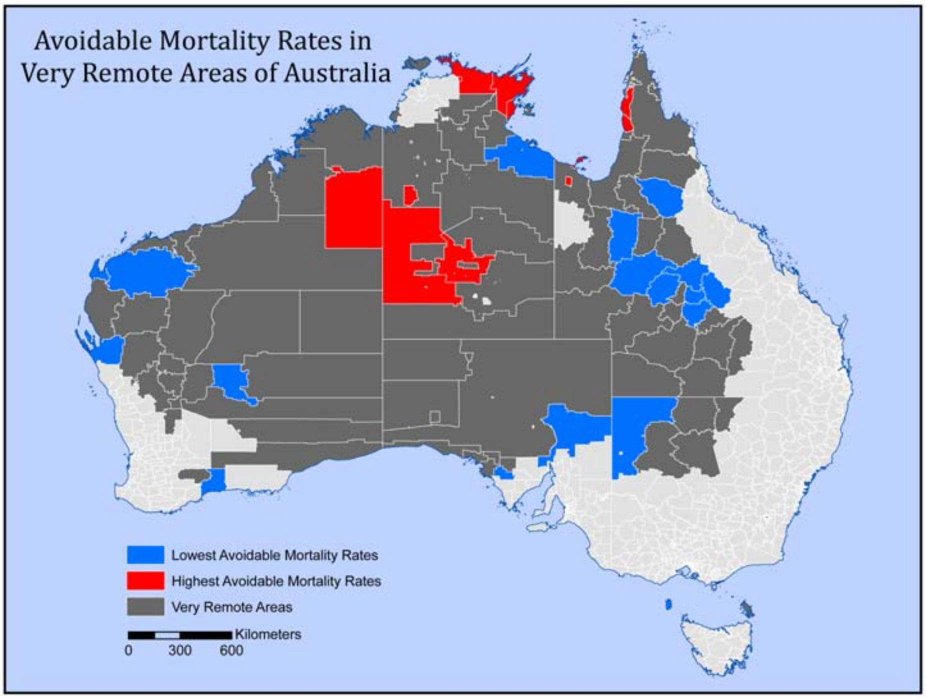

Figure 2 Map of top and bottom twenty SLAs in terms of AMR

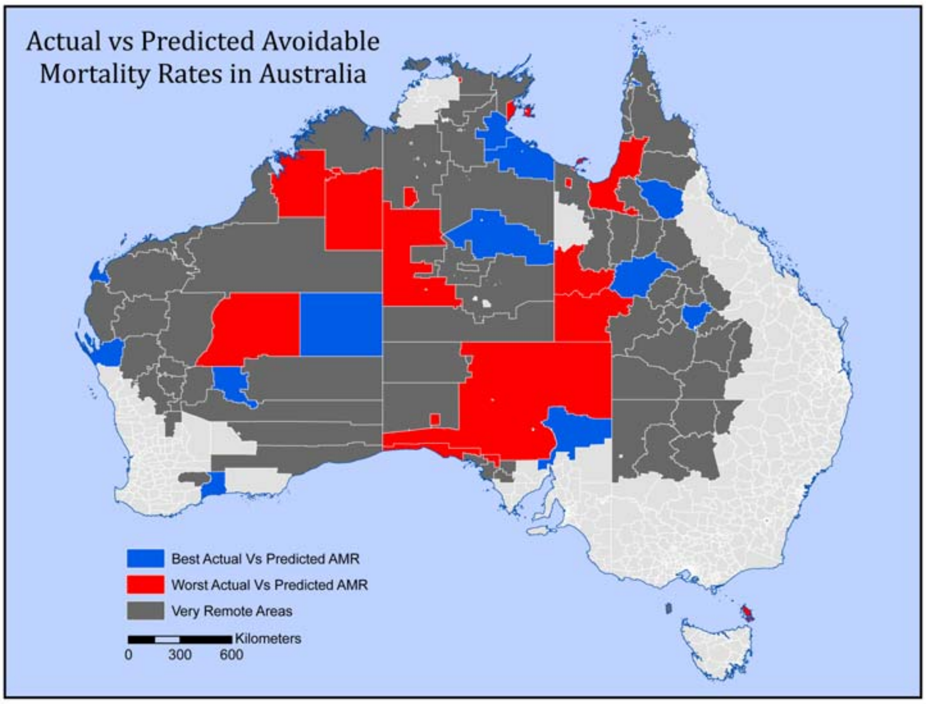

Figure 3 Map of top and bottom twenty SLAs in terms of observed:predicted AMR

Table 1 SLAs ranked by avoidable mortality rate (AMR)

SLA name	AMR* (/100 000)	Population**	% Indigenous**
Tapatjatjaka	1507.3	219	90.35533
Kunbarllanjnja	1367.6	882	91.35514
Doomadgee	1202.4	1,082	94.30502
Lajamanu	1165.8	669	89.77636
Watiyawanu	1159.5	270	95.34884
Mornington	1129.9	1,032	89.41747
Numbulwar Numburindi	1069.7	678	90.75758
Tanami	1028.9	2,441	75.81602
Hanson	995.6	801	83.10893
Kubin	962.7	202	94.62366
West Arnhem	943.8	3,333	89.70544
Arltarlpilta	920.8	239	92.82511
Tennant Creek	829.3	2,919	51.83863
Halls Creek	826.2	3,136	70.37037
Anmatjere	794.4	966	86.27244
East Arnhem - Bal	791.3	6,522	91.36758
Sandover	778.5	2,771	82.43105
Angurugu	775.6	813	97.31458
Aurukun	773.9	1,044	92.59259
Nyirranggulung Mardrulk Ngadberre	723.6	936	78.65685
Yuendumu	703.2	692	86.63793
Kowanyama	699.9	1,021	93.12749
Lockhart River	690	551	90.36609
Derby-West Kimberley	671.7	6,507	52.46977
Yorke	670.1	299	87.07483
Victoria	658.4	887	41.9295
Borroloola	637.5	773	68.06084
Elliott District	630.3	417	83.80952
Groote Eylandt	607.2	1,541	44.64164
Pormpuraaw	600.2	600	91.00346
Unincorp. Far North	561.5	1,568	6.10362
Ngaanyatjarraku	557.7	1,335	84.85294
Anangu Pitjantjatjara	542.1	2,230	83.01887
Carpentaria	526.1	1,939	25.21208
Boulia	525.6	419	21.06339
Yugul Mangi	523.7	1,641	88.86827
Tennant Creek - Bal	522.5	1,211	75.46099
Timber Creek	520.2	229	43.38235
Wiluna	500.8	681	18.71693
Diamantina	490.6	281	19.94819
Burke	486.5	497	15.00504
Petermann-Simpson	477.9	2,390	23.49857
Napranum	473.5	841	94.02439
Injinoo	445.6	416	97.72152

SLA name	AMR* (/100 000)	Population**	% Indigenous**
Upper Gascoyne	434.7	286	43.94299
Daguragu	429.3	544	91.15913
Coober Pedy	426.7	1,913	14.06883
Unincorp. West Coast	422.1	457	30.07813
Badu	402.9	819	84.81167
Flinders	393.4	864	18.01242
Laverton	392.2	730	20.29262
Bamaga	389.8	783	89.14518
Ceduna	387.2	3,574	24.91309
Meekatharra	355.3	1,136	35.10029
Central Darling	350.9	1,936	34.99268
Paroo	331.7	1,929	26.30777
Elsey	325.9	777	26.77596
Torres	308	3,233	71.08141
Quilpie	299.4	986	9.144793
Mount Magnet	295.4	458	17.72908
East Pilbara	283.6	6,543	17.83998
Gulf	278.5	639	46.61572
Le Hunte	261.1	1,314	2.02855
Flinders	258	1,792	7.932311
Ashburton	251.6	6,078	8.640585
Longreach	241.9	3,523	4.354508
Aramac	240.2	726	3.3241
Jericho	223	919	3.010033
Richmond	218.5	902	5.658199
Nhulunbuy	210.9	4,111	6.302521
Unincorp. Flinders Ranges	209.4	1,099	14.42185
Unincorp. Far West	209.2	732	3.850782
King Island	208	1,639	2.851711
McKinlay	201.3	898	4.223107
Barcaldine	197.2	1,616	8.873322
Blackall	189.8	1,456	2.474916
Weipa	178.4	2,830	16.82825
Exmouth	168.6	2,063	0.7722008
Winton	164.5	1,379	8.547009
Leonora	127.3	1,413	6.790946
Etheridge	116	851	1.083032
Ravensthorpe	100.2	1,950	2.026783
Shark Bay	92.5	862	4.62766

* AMR = avoidable mortality rate (per 100 000 population) based on 2003-2007 data from PHIDU
** Total population and per cent Indigenous based on 2006 Census data from ABS

Table 2 Variables grouped by SLA rank

Variable	Top 20 SLAs by AMR	Middle 20 SLAs	Bottom 20 SLAs by AMR	Bartlett's test for equal variances value
AMR / 100 000	118.8	277.5	541.2	0.0
% Indigenous	7.6	52.5	85.9	0.0
% over 65 years old	10.9	7.8	4.6	0.0
% under 4 years old	8.1	8.2	11	0.249
% with poor English language skills	0.5	8	17.6	0.0
% foreign born	17.3	13.2	3.1	0.147
% in professional occupation	29.2	20.4	19.6	0.0
% in low-skilled occupation	28.1	35.1	35.7	0.644
% adults employed	77	65.5	48.7	0.103
% jobless families	7.3	25.7	42.7	0.0
% total unemployed	2.5	4.8	9.7	0.0
% receiving long-term unemployment payment	4	10.2	11.4	0.295
% of 16 year olds in school	49.5	28.2	15.4	0.0
% 15-19 year olds either in school or working	68.3	40.6	23.7	0.397
% rate of high school dropout	20.2	36.9	55.7	0.126
% children in poor families	21.4	38	45.3	0.717
% families in poverty	13.1	29.5	46.5	0.524
% population in poverty	20.5	47.9	68.1	0.518
% elderly on aged pension	58.6	80.1	88.4	0.335
% families caring for other children	5.7	9.9	13.6	0.0
% single parent families	6.3	17.6	23.1	0.0
% living in overcrowded houses	4.2	21.3	41.7	0.0
% households with no car	8.2	32.3	48.8	0.0
Total health workers / 100 000	205.4	300.7	228.8	0.191
Doctors / 100 000	6.4	4.4	2.4	0.053
Nurses / 100 000	111.6	78.6	48.5	0.134
Indigenous health workers / 100 000	0.4	20.8	38.2	0.0
SEIFA*	971.6	696.4	559.6	0.033
% adults engaged in volunteerism**	28.8	18.5	13.1	0.377

* SEIFA = Socioeconomic Indexes for Areas; this product of the ABS indicates the social "disadvantage" of an area, with 1000 the "average" score (ie. a lower score reflects greater disadvantage)

** The proportion of the adult population engaged in volunteerism was selected as a proxy (and in fact the only available) measure of social capital or social cohesion, postulated to be a protective or "resilience" factor in remote communities

Table 3 SLAs ranked by observed:predicted AMR

SLA name	Observed AMR (/100 000)	Predicted AMR (/100 000)	Observed:predicted AMR
Unincorp. Far North	347	165.6805	2.094392
Boulia	415	203.2161	2.042161
Doomadgee	712	424.9639	1.675436
Diamantina	314	191.3351	1.6411
Kunbarllanjnja	753	464.4624	1.621229
Tennant Creek	454	283.4831	1.601507
Groote Eylandt	401	270.2998	1.483538
Mornington	636	434.3951	1.464105
Kubin	621	431.6278	1.43874
Flinders	257	182.552	1.407818
Carpentaria	301	214.2089	1.405171
Lajamanu	652	464.9234	1.402382
Unincorp. West Coast	330	240.8715	1.370025
Numbulwar Numburindi	652	485.0081	1.344307
Derby-West Kimberley	404	309.442	1.305576
Borroloola	480	380.5587	1.261303
Wiluna	318	255.2641	1.245768
Coober Pedy	243	195.8488	1.240753
Tanami	555	449.0962	1.235816
Halls Creek	473	387.7171	1.219962
Elliott District	498	419.6634	1.186665
Burke	211	180.1699	1.171117
Petermann-Simpson	309	266.8072	1.15814
Upper Gascoyne	315	272.3294	1.156687
Yorke	475	412.2919	1.152096
Watiyawanu	616	535.6443	1.150017
Pormpuraaw	442	400.4632	1.103722
Ceduna	227	208.2015	1.09029
Tapatjatjaka	495	459.7635	1.07664
West Arnhem	510	475.1396	1.073369
Quilpie	178	170.5144	1.0439
Mount Magnet	180	172.5042	1.043453
Hanson	440	426.6589	1.031269
Ashburton	154	154.8703	0.9943805
Paroo	220	221.3936	0.9937054
Victoria	308	310.5265	0.9918637
Aurukun	484	493.2078	0.9813308
Richmond	161	165.0798	0.9752861
Laverton	221	226.8391	0.9742587
Le Hunte	160	165.0753	0.9692547
Aramac	153	159.0631	0.9618824
Timber Creek	281	292.3947	0.9610298
Lockhart River	408	425.7244	0.9583666

SLA name	Observed AMR (/100 000)	Predicted AMR (/100 000)	Observed:predicted AMR
East Pilbara	187	195.544	0.9563065
Elsey	220	235.1245	0.9356746
Flinders	163	175.3548	0.929544
Anmatjere	405	437.7223	0.9252442
Unincorp. Far West	158	171.8717	0.9192904
Kowanyama	401	438.9844	0.9134721
Arltarlpilta	426	466.4701	0.9132417
Angurugu	431	473.9046	0.9094657
Nhulunbuy	131	146.137	0.896419
East Arnhem - Bal	445	496.6095	0.8960763
Sandover	399	449.1344	0.8883756
Yuendumu	386	443.5345	0.8702818
Jericho	144	166.5439	0.8646371
Longreach	135	159.761	0.8450123
Meekatharra	195	232.4738	0.8388042
Anangu Pitjantjatjara	353	423.2205	0.8340806
King Island	131	158.0003	0.8291125
McKinlay	125	155.4961	0.8038785
Nyirranggulung Mardrulk Ngadberre	371	464.1775	0.7992632
Central Darling	193	247.3457	0.7802845
Barcaldine	134	174.6333	0.7673221
Leonora	122	159.3665	0.765531
Badu	285	410.1758	0.694824
Bamaga	265	391.7236	0.6764974
Ngaanyatjarraku	283	423.0091	0.6690164
Yugul Mangi	312	469.4941	0.6645451
Exmouth	96	149.4267	0.6424554
Weipa	105	164.4176	0.6386178
Torres	196	318.0765	0.616204
Unincorp. Flinders Ranges	109	179.087	0.6086428
Napranum	259	438.369	0.5908265
Blackall	96	162.6646	0.5901715
Injinoo	258	448.3795	0.5754054
Etheridge	86	163.1207	0.527217
Daguragu	232	452.0915	0.5131705
Alpurrurulam	232	455.7776	0.5090202
Winton	81	164.4629	0.4925124
Tennant Creek - Bal	186	404.636	0.4596723
Ravensthorpe	66	150.8639	0.4374804
Gulf	132	337.3136	0.3913272
Shark Bay	57	151.2193	0.3769359

Discussion

The results demonstrate clearly that, despite the shared characteristic of being classified as "very remote", and the relatively small total population involved, within-group comparison of these communities highlights important differences in terms of epidemiological risk factors and health outcomes as measured by avoidable mortality. The contribution of chronic disease prevalence, and health risk behaviours (which include, *inter alia*, smoking, inactivity and poor nutrition) to overall morbidity and mortality is well recognised in rural and remote communities in Australia and has been extensively discussed elsewhere.[16,17] Similarly, the epidemiological factors that contribute to the so-called rural-urban health differential have been previously documented and include, but are not limited to, risk-taking behaviours, rates of injuries, environmental exposures, socioeconomic disadvantage, demographics and lack of access to health services (which encompasses the issues of availability, accessibility, equitability and sustainability of the health workforce).[5,9,14] The purpose of this study is to demonstrate that the diverse and inhomogeneous communities that constitute the most remote, and frequently the most vulnerable populations in the country, have epidemiological risk factors and health outcomes that differ widely. Several of the trends observed in this within-group comparison, namely that higher rates of avoidable mortality are correlated with poverty, overcrowding, unemployment and lack of education, align with the trends seen in comparisons between rural and urban communities.

The fact that the poorest-performing communities, as measured by both avoidable mortality rates and observed to predicted mortality rates, are almost exclusively Indigenous communities, reflects in part the ongoing challenge of the immensely increased health burden in the Aboriginal and Torres Strait Islander population in Australia in general. What may prove useful at both a national and regional level is to examine in more detail those Indigenous communities in close proximity to each other which have significantly different rates of avoidable mortality, in order that the most clear imbalances in terms of socioeconomic and health workforce determinants may be addressed. Examples of communities in the same geographical region that differ dramatically in terms of their AMR include Kubin and Badu in the Torres Strait Islands; Nhulunbuy and Kunbarllarnjnja in Arnhem Land.

Of acute interest from a health policy perspective is the observation that those SLAs which have the highest rates of avoidable mortality tended to have a health workforce comprised mainly of Indigenous health workers, with relatively fewer doctors and nurses. It is important to note that this observation does not imply causality; Indigenous health workers are widely acknowledged to be the most sustainable element of the health workforce in remote communities. Rather, identifying those communities that are falling behind other communities, despite sharing similar disadvantages in terms of distance and isolation, may help to target workforce planning more appropriately. Given the general lack of success of purely financial incentives to attract and retain medical and nursing workforces in remote communities, a deeper examination of the factors which contribute to the transient phenomenon commonly observed, such as the intrinsic "likeability" or "liveability" of an area, as well as social and environmental factors, may yield useful information for health workforce planning.

It is also important to recognise that rurality does not confer risk alone; a growing area of research interest lies in the examination of social capital in remote communities.[18] The cohesion that exists within small rural communities is one of their most attractive features, and the resilience that such communities can demonstrate, for example in response to natural disasters, is impressive; the phenomenon, however, is difficult to quantify and measure. An attempt has been made in this study to capture something of this quality in including adult volunteerism as a variable for analysis, given that volunteerism may indicate something of the level of engagement in community affairs and thus be a proxy for social cohesion. In the analysis, SLAs with higher rates of volunteerism had lower rates of AMR. It is, nevertheless, a weak indicator at best, and obviously in reality opportunities for volunteerism in remote communities are often limited.

Finally, acknowledgement must be made that any statistical analysis of the data from these very remote communities is vulnerable to error from multiple sources. The population denominators are small and may not accurately reflect the resident populations in remote communities with historically high levels of migration. Mortality rates calculated from crude death rates may not take into account residents of remote communities who die outside their communities, such as in hospitals or in larger regional centres. The data on variables relies on information from the 2006 Census, rather than having been directly collected for the specific purposes of this study. Only two-thirds of the total "very remote" SLAs were included in the analysis due to incomplete datasets; hence the lists in this paper do not represent complete coverage of very remote communities in Australia, and are representative of broad trends only. Also the authors recognise that SLAs are not interchangeable with "communities" in the literal or practical sense of the word, and that SLA boundaries do not necessarily reflect true geographical or social divisions in remote Australia.

Conclusion

Very remote communities in Australia share some important characteristics, but are nevertheless in many ways different from each other in terms of geography, environment, industry, wealth, demographics, opportunities for employment and education and access to health care. This is reflected in the differences in the rates of avoidable mortality when these communities are compared. From such a comparison several key factors can be identified which correlate with higher rates of avoidable mortality: poverty, overcrowding, lack of education and employment, and a high proportion of the population who are Indigenous. Many of these risk factors are interrelated and interdependent; while the challenge of addressing these factors both individually and together is ongoing, a more efficient targeting of health resources may be achieved by identifying those communities which are lagging behind and achieving health outcomes below that which might be expected based on their epidemiological risk.

It is hoped that this analysis may highlight some important issues related to the epidemiology of the excess health burden in very remote Australian communities, and help guide future policy planning to support and improve the health of some of Australia's most vulnerable populations. For specific policy recommendations refer to Appendix B.

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