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Abstract

Objectives:

To determine disparities in potentially preventable hospitalisations (PPH) for chronic conditions such as angina and diabetes among South Australia's Aboriginal and non-Aboriginal populations across area level socio-economic disadvantage and remoteness.

Setting:

All South Australian public hospitals.

Participants:

South Australian residents hospitalised from 2005-06 to 2010-11 and experiencing chronic PPH as defined by the Australian Institute of Health and Welfare.

Primary outcome measures:

Number and crude, unadjusted rates of chronic PPH and associated total length of stay (LOS) and direct hospital costs. Sex and age adjusted population rate ratios for Aboriginal and non-Aboriginal people were subsequently regressed against area level measures of socio-economic disadvantage and geographic remoteness.

Results:

Aboriginal South Australians experienced 1.8 (95%CI 1.6-2.1) higher risk of an index chronic PPH compared to non-Aboriginal (11.5 and 6.2 per 1,000 persons per year respectively) and at younger ages (median age 48 versus 70). Once hospitalised, Aboriginal people experienced more chronic PPH events, longer total LOS with higher costs (2.6 PPH, 11.7 days LOS at AUD$17,928 versus 1.9 PPH, 9.0 days at AUD$11,515). Total Aboriginal LOS rate increased by 0.03 (95% CI 0.00-0.07) for each increase in disadvantage rank and 1.04 (95%CI 0.63-1.44) as remoteness increased. Non-Aboriginal rates increased by 0.01 (95%CI 0.01-0.01) per increase in disadvantage. Similarly, costs associated with Aboriginal chronic PPH rate increased by 0.00.02 (95% CI 0.00-0.06) for each increase in disadvantage rank and 1.18 (95%CI 0.80-1.55) as remoteness increased. Non-Aboriginal rates increased by 0.01 (95%CI 0.01-0.01) per increase in disadvantage.

Conclusion:

Aboriginal people's heightened risk of chronic PPH at much younger ages meant more time in hospital at greater cost. Systematic increases in chronic PPH by Aboriginality, area disadvantage and remoteness suggest addressing disparities through commensurately improved uptake of effective primary care in those areas. Routine, regional reporting will help monitor progress in meeting population needs.

Article summary:

- Previous studies have not examined variations of total length of stay and direct hospital costs associated with chronic PPH.
- The dataset comprises a complete collection of public hospital records over a six year period from 2005-06 to 2010-2011.
- The study provides a necessary baseline for a performance measure of importance to the health system and patients receiving care.
- Hospital records of residents living in very remote areas who were hospitalised in other jurisdictions were not included in this study.

Background

Chronic health conditions are increasingly important contributors to poor population health throughout the world[1]. The increased prevalence and duration of these conditions adds to the mounting pressure on health systems to respond to those needs. Hospital expenditures are a key component of these systems[2]. Australia is an example of a developed and advantaged setting where annual hospital expenditure represents the largest recurrent and growing contribution[3 4] to the average health expenditure of $6,639 per person[5].

In constrained budgetary environments, hospitals are constantly scrutinised for potential efficiency gains and several performance measures have been adopted. For example, inpatient length of stay (LOS) is closely associated with hospital cost[6] and reimbursement levels within the health system[7] and Australia employs LOS within a suite of health system performance measures[3 8]. LOS is routinely analysed at hospital level with one hospital's performance contrasted against others. Such comparisons often make statistical adjustment for factors outside of a hospital's control, for instance, patient age, medical complexity and residential and geographic location. Each of these factors also influence the costs of hospital stays[9] and are factored into activity based funding models[7]. From a hospital's perspective, LOS indicates efficient production of care at a level adequate to meet clinical need while maximising bed availability and minimising treatment costs. From a patient perspective, hospital LOS means maximising quality outcomes from care while minimising risk of exposure to adverse events in hospital and time away from usual, societal roles.

Potentially Preventable Hospitalisations (PPH) are another performance indicator making use of administrative data[10-12]. Under different names, potentially avoidable hospitalisations or ambulatory care sensitive conditions, and with some variations in conditions and coding[13-15],

PPH are widely considered an indicator of a community's capacity to benefit from available and effective[16-19] primary health care by "preventing the onset of an illness or condition, controlling an acute episodic illness or condition, or managing a chronic disease or condition" p163[20]. Primary health care is the second most expensive component of Australia's health system at almost $55 billion annually[4]. Recent expert commentary argued Australia's primary health system provides around half the level of care recommended for chronic conditions which contributes to chronic PPH $2 billion annual cost to the health system[21]. Therefore, PPH provide an important junction between two critical system components in which policymakers and health planners can consider both the technical efficiency of one sector, its effect on another sector and opportunities to adjust allocations across sectors. Efficient use of healthcare resources can maximise health outcomes in the community served[22].

Equitable distribution of health is another high priority[22] and a challenging issue for contemporary health systems[22-25]. PPH result from a complex interplay of person-related[26 27], health system, geographical[28] and socio-economic factors[29-31] which highlight the need for directing resources toward appropriate and accessible health services[25]. It follows then that localised understanding can help determine local responses to health need[22]. Consequently, the Organisation for Economic Co-operation and Development encourages health systems to consider health care variations *within* as well as between countries[32]. Australia's Institute of Health and Welfare (AIHW) works towards this by reporting PPH time series by age group, sex, state/territory jurisdictions, socioeconomic disadvantage, remoteness and Aboriginal and Torres Strait Islander status (herein respectively referred to as "Aboriginal")[33]. Overall PPH rates are three times higher for Aboriginal compared to non-Aboriginal Australians[33 34] which supports their designation as a disadvantaged group in terms of their use of primary health care[35]. This is consistent with indigenous population comparisons in the US[36],

Canada[37] and New Zealand[38]. Chronic conditions including: angina, asthma, COPD, congestive cardiac failure, diabetes complications, hypertension, iron deficiency anaemia, nutritional deficiencies and rheumatic heart disease, account for much of PPH for which there is a five-fold differences in the hospitalisation rates by Aboriginality[33 34]. Hence, chronic health conditions represent a significant proportion of PPH with diabetes complications being most frequent PPH amongst Aboriginal Australians[33 39 40]. Similar disparities between Aboriginal and non-Aboriginal populations are reported in Victoria[41], the Northern Territory[42], Queensland[43], Western Australia[44], New South Wales[45] and South Australia (SA)[46 47].

Despite considerable evidence of variations in PPH rates and LOS, relatively little is known about how the two measures co-vary[48]. Given the extent of disparities in chronic PPH rates by Aboriginality, this appears an opportune place from which to improve understanding of *who* in the community is more likely to experience potentially unnecessary, prolonged and costly hospitalisation. The first of only two studies that considered chronic PPH and LOS together focussed on diabetes hospitalisations among older, Hawaiian people categorised as either Asian, islander or white[49]. The second, Australian study considered results for individuals on the basis of Aboriginal identity. The results affirmed higher chronic PPH rates among Aboriginal people compared to non-Aboriginal contemporaries of the same age, sex and living in the same geographic area[45]. Moreover, elevated rates were accompanied by LOS which was 4% higher on average[45]. However, neither study explicitly describes the variation of chronic PPH and LOS rates within the populations studied, yet evidence in other areas point to considerable within-population heterogeneity in health outcomes. For example, analysis of premature mortality among Aboriginal South Australians showed an interaction

between area level socioeconomic disadvantage and remoteness where the social gradient between disadvantage and premature mortality outcomes increased as remoteness increased[50].

None of the recently reviewed literature on PPH and LOS analysed the costs associated with the hospital events. Such information is critical to inform complex commissioning decisions of the opportunity cost, at least from a health system perspective, of pursuing technical and allocative efficiencies while reducing the human and societal costs represented by a person's time out of role.

If health systems are to attend to the needs of people and populations, it is important to focus on individuals and sub-populations in their localised setting. Quantifying disproportionate hospitalisation, re-hospitalisation and time spent in hospital while simultaneously describing the system resources involved can provide valuable information on which elements of the health system are working, for whom and in what context[2 51].

This study considers the disparity between rates of PPH for chronic conditions for Aboriginal and non-Aboriginal South Australians. It examines the association between area level socioeconomic disadvantage, geographic remoteness and the frequency, length, and cost of hospitalisation for chronic PPH within those populations. This paper addresses three questions. Which individuals experienced chronic PPH? How does the length of stay and cost of hospitalisation for these conditions vary between Aboriginal and non-Aboriginal populations? What is the relationship between the ecological risk factors of area level socio-economic position and remoteness with PPH for chronic diseases within these populations?

Methods

Ethics approval

Research ethics committee approvals are held from SA Health (467/08/2014) and the Aboriginal Health Council of South Australia (04-11-406).

Study design

A cross-sectional, observational study using linked, public hospital inpatient records.

Hospital separations

Chronic PPH within the Integrated South Australian Activity Collection (ISAAC) of public hospital, inpatient records for financial years 2005-06 to 2010-11 were categorised using Australian Institute of Health and Welfare's (AIHW) criteria for ICD-10 diagnoses and procedure codes[52]. ISAAC includes mandatory fields of age, Aboriginal identification and Statistical Local Area (SLA) of usual residence. Residents of the Anangu Pitjantjatjara Yankunytjatjara Lands (APY Lands) most frequently attend Alice Springs Hospital in the neighbouring jurisdiction, the Northern Territory, and their records were removed from hospital and population counts.

Hospital costs across the period were calculated in a uniform manner using Australia's National Efficient Price for health care activity provided by public hospitals in 2015-16[7] and expressed in Australian dollars. The prices associated with hospital activities are based on each separation's Australian Refined Diagnostic Related Group (AR-DRGv7.0) with loadings for outlying LOS, Aboriginality (4%) and area remoteness (ranging from 8% in outer regional to 22% for very remote).

Hospitalised individuals

Each person using a South Australian public hospital service has a medical record number unique within a hospital but varying across hospitals. SA-NT DataLink, an organisation

within Australia's data linkage network, provided probabilistically linked project keys enabling the grouping of one person's separations across hospitals and time. Each individual's records were assigned the last recorded age and the first occurring SLA. Aboriginality was categorised on the basis of a person having identified as Aboriginal in *any* hospital separation during the observation period. Identification of Aboriginal status can be difficult and introduce misclassification bias [53]. Accordingly, a more stringent definition for sensitivity analyses was based on a person identifying as Aboriginal on more than 75% of records.

Population and Statistical Geography

Population denominators were based on Australia's Census years in 2006 and 2011[54]. The relevant estimates of resident population by sex, age and Aboriginality include sex and age profiles by rurality and total population for SLAs, the smallest routinely available geographic areas for intrastate analysis[55]. The mean annual total population for each SLA was 12,584 (SD=10,029) ranging from 0 to 36,407 [56].

The Australian Bureau of Statistics (ABS) index SLAs by socio-economic characteristics[57] and geographic remoteness. Census 2011 Index of Relative Socio-economic Disadvantage (IRSD)[52 57 58] ranks SLAs whereby 1 is least disadvantage and 123 the most disadvantaged area. These are further aggregated to disadvantage quintiles of approximately equal population size[55]. SLAs with nominal population and no relative IRSD rank would not contribute to the analysis and were omitted. The Accessibility/Remoteness Index of Australia (ARIA+) uses road distance to service centres[55] to allocate a continuous measure ranging from 0 (high accessibility) to 15 (high remoteness). SLAs can be collapsed into categories of major city (ARIA+ < = 0.2), regional (ARIA+ > 0.2 & < = 5.92) and remote areas (ARIA+ > 5.92).

Data analysis

Cross tabulations summarise the number and crude, unadjusted rates of people experiencing chronic PPH with respect to Aboriginality, sex, age and area level IRSD quintiles and remoteness categories. Among these individual patients, the mean number of chronic PPH separations is described along with mean, totalled LOS and hospital costs of those separations.

The summary experience of individuals' outcomes in terms of LOS and costs were then placed into a broader population context. Indirect sex and age adjustment[59] with five year age groupings to 75+[60] controlled for confounding from sex and age variations between Aboriginal and non-Aboriginal people experiencing chronic PPH and the population more generally. Area outcomes therefore represent the ratio of observed versus expected outcome based on South Australian totals. For example, an outcome of 150 for total chronic PPH LOS among a population group indicates the ratio of observed versus expected LOS across that group was one and a half times, or 50% higher, than the South Australian average after adjusting for sex and age differences.

Outcomes of LOS and hospital cost ratios at SLA level were positively skewed and were subsequently normalised using square root transformations. The relationship between transformed outcomes and the potential covariates of SLA IRSD rank and remoteness were examined using least squares regressions[61] with each area's contribution weighted by population size. While the focus was on chronic PPH as a group, diabetes complications are over represented among Aboriginal people so records were further stratified as either diabetes complications or all other chronic PPH with analyses repeated for each. The reported coefficients and 95% confidence intervals represent the change in the standardised ratio for each one unit change in disadvantage rank and remoteness.

In sensitivity analyses, use of a more stringent definition of Aboriginality did not change our overall conclusions[62]. All analyses used Stata version 14.2[63].

Results

Separations

Of 1,828,846 public hospital separations involving usual SA residents, 117,127 (6.4%) were categorised as chronic PPH. Aboriginal people experienced these at 2.2 (95%CI 2.1-2.4) times the rate of non-Aboriginals (N=4,391 at 26.7 chronic PPH per 1,000 persons per year compared to N=112,736 at 12.1 per 1,000 persons per year).

Individuals

Chronic PPH involved 60,208 individuals 1,892, or 3.2%, of whom were Aboriginal. Table 1 quantifies aspects of their experience showing Aboriginal people were 1.8 (95%CI 1.6-2.1) times more likely hospitalised than non-Aboriginal (11.5 and 6.2 per 1,000 persons per year respectively). There were several marked differences in conditions experienced. For example, hospitalisations for diabetes complications within the Aboriginal community was 4.3 per 1,000 per year, more than three times the rate among non-Aboriginal people. Diabetes complications were diagnosed for more than one-third of Aboriginal people with chronic PPH compared to around one in five among non-Aboriginals. Chronic PPH events can involve more than one diagnosed chronic condition and this was observed more frequently among Aboriginal patients. For instance, the 2,311 diagnosed chronic conditions among 1,892 Aboriginal patients hospitalised averages 1.22 per patient. The comparison for non-Aboriginal patients was 1.14 comprising 66,343 chronic condition diagnoses among 58,316 patients.

There were substantial sex and age differences between Aboriginal and non-Aboriginal people experiencing chronic PPH with females and a much younger age profile dominant in the Aboriginal patient cohort (median ages of 48 and 70 years respectively). Forty-five percent of Aboriginal patients were in the 45 to 64 age groups which was equivalent to that of the largest, non-Aboriginal group aged 75+. Conversely, 75+ was the second smallest Aboriginal group however the rate with which Aboriginal people experienced chronic PPH remained nearly double that of non-Aboriginal people (59.7 versus 32.8 persons per 1,000 per year). The proportion of Aboriginal patients from areas of most disadvantage (54.1% versus 26.7%) or regional and remote areas (64.2% versus 35.6%) was also around double that of non-Aboriginal people.

The number of chronic PPH, associated LOS and estimated hospital cost averaged across individuals are summarised in Table 2. The dominant pattern is one of more frequent hospitalisation per Aboriginal person across sex, areas of residence and most age groupings. The average of 11.7 days LOS was 30% greater for Aboriginal patients with the differences increasing throughout adulthood to a peak in the 55-74 age ranges. Hospital costs follow a similar pattern but with more pronounced differences by Aboriginality. For example, averaged hospital costs accumulated for Aboriginal patients were 56% higher than non-Aboriginal patients ($17,928 versus $11,515) and differences were most prominent in the 55-74 age ranges with costs averaged across individual patients of $24,023 for Aboriginal versus $12,291 for non-Aboriginal. The absolute difference in excess of $11,500 represented an almost two-fold difference in relative terms.

Figure 1 illustrates the stark disparity in the rates at which Aboriginal and non-Aboriginal people of varying ages experienced chronic PPH, then overlays the mean number of separations those patients experienced. This shows Aboriginal people aged 35-44 and over

not only experienced markedly higher rates of chronic PPH but having had a first event, they were increasingly likely to experience at least one more event.

Population

Figure 2 places results for individuals hospitalised into a population context by graphing sex and age standardised outcomes by Aboriginality (LOS in Figure 2A and costs in Figure 2B) for all areas, then disadvantage quintiles and remoteness categories. Each marker is weighted by population as per Supplemental Online Table A. Figure 2A illustrates the LOS rate associated with chronic PPH within the Aboriginal population was six times more than the state average after adjusting for sex and age. While chronic PPH LOS among Aboriginal and non-Aboriginal populations progressively increased across levels of area disadvantage, change was far more pronounced within the Aboriginal population while also concentrated among the relatively larger disadvantaged populations in Quintiles 4 and 5. Similarly, from major city to remote locations involved nearly threefold higher results from 4.2 to 12.1 times the state average. Hospital costs incurred (Figure 2B) show very similar patterns with slightly higher mean differences between Aboriginal and non-Aboriginal results.

Linear regression models between the two outcomes of standardised LOS and cost ratios across three levels (all chronic PPH; diabetes complications; all other chronic PPH) and the covariates of area level disadvantage and remoteness are presented for Aboriginal and non-Aboriginal populations in Table 3. For Aboriginal people, both LOS and cost outcomes for each level varied significantly across area disadvantage and remoteness. For example, within the Aboriginal population the standardised LOS rate ratio associated with all chronic PPH was 2.09 (95%CI 0.00-5.83) times the state average (of one). The disparity in LOS rate increased by an average of 0.03 (95% CI 0.00-0.07) with each change in disadvantage rank and a further 1.04 (95%CI 0.63-1.44) as remoteness increased. These associations of

disadvantage and remoteness with LOS were consistent within stratified subgroups of diabetes complications and all other chronic PPH. However, the magnitude of change in LOS ratios was higher for diabetes complications (2.59; 95%CI 0.00-10.82) than for all other chronic PPH (1.86; 95%CI 0.43-1.21) before adjusting for the influence of area disadvantage and remoteness. The change observed in LOS for diabetes complications was around twice that for all other chronic PPH for both disadvantage (0.05; 95%CI 0.00-0.15 versus 0.02; 95%CI 0.00-0.06) and remoteness (1.62; 95%CI 0.73-2.51 versus 0.82; 95%CI 0.43-1.21). Similar variations in standardised cost ratio outcomes across levels of outcome and by disadvantage and remoteness were observed for the Aboriginal population.

Results for the non-Aboriginal population also show consistent associations between area disadvantage and each outcome and level whereby the standardised ratio increased as disadvantage increased. However, area remoteness was not associated with increased LOS or cost. Moreover, the base from which change occurred was substantially lower. For instance, the standardised LOS ratio for chronic PPH among the non-Aboriginal population before adjusting for disadvantage rank was 46% (95%CI 38%-54%), or less than half that of the state average.

Discussion

This study provides evidence of stark disparities in the rates with which Aboriginal and non-Aboriginal individuals experienced potentially preventable hospitalisation for chronic conditions. Aboriginal people had almost twice the risk of experiencing a chronic PPH overall compared to their non-Aboriginal contemporaries. Other disparities noted include higher chronic PPH rates among Aboriginal females and younger adults with rates steeply increasing from least to most disadvantaged quintiles and/or remote areas of South Australia.

Conversely, non-Aboriginal patients were more likely to be concentrated among older adults. A social gradient across disadvantage levels was also apparent however the steepness of the gradient from most to least disadvantaged areas was markedly lower for non-Aboriginal people. These findings are consistent with the wider literature focused on ethnic differences in PPH[36-38] and underpin the disproportionate population rates of chronic PPH among Aboriginal South Australians[10 52 64].

This analysis at the individual level furthers our understanding by demonstrating how, having experienced one chronic PPH event, Aboriginal patients were also more likely to endure further chronic PPH. This was associated with an increased accrual of time spent in hospital which was almost one-third higher for Aboriginal patients. Moreover, the associated hospital costs were more than 50% higher than for non-Aboriginal patients on average and more variable within the group of Aboriginal patients.

Sex and age adjusted rates of time spent in hospital for chronic PPH and expressed as rates per capita reflect the number of individuals and the length of time hospitalised. These standardised population outcomes showed LOS for chronic PPH among Aboriginal South Australians was six times higher than the state average. The best outcomes within the Aboriginal community were observed among the relatively few living in areas of least disadvantage, albeit these were still markedly higher than the state average. Diabetes complications are heavily implicated in chronic PPH for Aboriginal people. Their presence, with or without other chronic conditions, exacerbate LOS rates and hospital costs among Aboriginal people but not so within the non-Aboriginal population. Even after partitioning out diabetes related hospitalisations, substantial differences in LOS and cost remain among other chronic PPH experienced by Aboriginal people.

The results further highlight systematic inequities between populations while also highlighting substantial within-population variation whereby a relatively small number of people experienced considerable time in hospital and away from their usual societal roles because of chronic health conditions. This is consistent with recent US literature demonstrating the role of chronic PPH, and particularly diabetes, as sustaining and even increasing disparities between African Americans and whites[65]. Similarly, it affirms other Australian research highlighting widespread Aboriginal/non-Aboriginal differences and differences within the Aboriginal population in chronic PPH generally and the pervasive, adverse results of diabetes complications across geographic areas[45]. Moreover, the results identified that increased chronic PPH were accompanied by systematically increased accrual of LOS and greater hospital costs.

The extent to which these differences are amenable to change needs further discussion. By definition, chronic PPH represent opportunities for change through exposure to primary health care, notwithstanding a range of individual, societal, clinical and system level factors are related to their occurrence[66 67] and may each be associated with realising this potential. This is supported by studies of risk factor exposure across levels of socio-economic disadvantage and remoteness[34]. If hospital LOS is a proxy measure for clinical severity as suggested by some[68], then the results provide a precursor to mortality figures displaying very similar associations between premature mortality outcomes in SLAs, disadvantage and remoteness among Aboriginal South Australians and disadvantage among non-Aboriginal South Australians[69]. Whether the chronic PPH events were preventable in their immediate context is less certain. The high prevalence of diabetes complications and higher levels of chronic multi-morbidities among Aboriginal patients observed in this study suggests comparatively more advanced disease for which hospitalisations, more often, for longer

periods and at greater cost is an appropriate and expected result. A heightened need for preventive and early intervention through primary and community care is evident.

In response, promising primary healthcare interventions in chronic disease management and diabetes are available. Australia's largest randomised intervention in diabetes delivered positive outcomes in HbA1c levels, blood pressure, waist circumference, depression, care-plan take-up and chronic PPH in the trial group receiving each of five available quality improvement and flexible funding components[40]. Mainstream general practice services are less available for remote Aboriginal populations exhibiting greater need in terms of chronic PPH LOS and costs yet evidence of effective intervention among Aboriginal populations is available[70]. Randomised diabetes care led by community health workers in regional and remote areas showed promising HbA1c reductions among poorly controlled type 2 diabetes patients[71] and modest net reductions in diabetes related hospitalisation in the treatment group[72]. Nevertheless, a critical need for substantively increasing the training and supply of Aboriginal health care workers remains[73]. Generally negative evaluation of incremental cost-effectiveness assessments based on short-term, averaged and disease specific results[40 72] may impede this investment.

Our description of who is more likely to experience chronic PPH, for what conditions, with what frequency and at what direct cost to the health system suggest three areas for developing incremental cost to outcome analyses. The first is to consider flow-on benefits from disease-specific interventions to other comorbid chronic conditions, especially where disparities in condition prevalence exist. Second, evaluation based on longer term accumulated hospitalisation costs for individual trial participants is warranted. Where project term constraints apply, our results provide an initial empiric base. Finally, placing individual participant results into a population context provides an information base for allocating

resources which address health care needs for primary and community care at lower cost to individuals and acute care services[25].

Subsequent reporting of cumulative LOS and costs at a person level adds value to system performance monitoring by making the person and patient the centre of reporting and evaluation, as well as the centre of care. Providing empirical evidence of change occurring at individual and population levels will help align system activities and monitoring with the ultimate aim of providing appropriate and effective care of patients and people, equitably and efficiently.

Limitations

The study has several limitations. First, cumulative LOS as an outcome variable is influenced by the nature of admission with inter-hospital transfers having longer LOS than emergency admissions[6]. Recurrent hospital events for chronic conditions among people in regional and remote settings may involve comparatively more inter-hospital transfers or planned admissions for treatment where primary health interventions are scarce. Nevertheless, the observations summarised in this study represent an aspect of peoples' lived experience of contending with chronic disease. Continuing research will benefit from focussing on mode of admission to hospital and the local availability of primary care. Second, the propensity to identify as Aboriginal has increased across recent times and any undercounting in earlier Aboriginal population denominators would affect population rates. However, this study's population estimates are drawn from the internally consistent ABS series covering 1996 to 2011 as based on the 2011 Census and the first available set of ABS non-experimental population denominators. Thus, there is no known inflation of rates due to population undercounts. Nevertheless, estimates incorporating Census 2016 will provide a valuable reliability check when used with concurrent hospital data in future analyses. Third, the

omission of the APY Lands SLA means chronic PPH outcomes associated with a very remote area and SA's most disadvantaged are not represented[74]. Subsequent research in the area will benefit from including APY Land residents hospitalised in the Northern Territory[47] to ensure results for the most remote and disadvantaged population groups are not underestimated.

Conclusion

The results show heightened risk of chronic PPH among Aboriginal people which compounds into more re-hospitalisation and accumulated time in hospital at greater cost to the individual, their community and the health system. At a population level, the systematic change in chronic PPH and LOS by Aboriginality and area suggests efforts to address these potentially avoidable hospitalisations will benefit from targeting specific population segments, particularly in areas of greater socio-economic disadvantage and geographic remoteness. This analysis helps guide such actions by identifying sub-populations within the wider community who could most benefit from improved understanding of antecedent causes of hospitalisation. Routine, reporting across population groups and regions will help monitor progress in meeting the underlying population health needs with earlier, and perhaps lower cost, interventions.

Abbreviations

ABS: Australian Bureau of Statistics

AIHW: Australian Institute of Health and Welfare;

APY Lands: Anangu Pitjantjatjara Yankunytjatjara Lands;

ISAAC: Integrated South Australian Activity Collection;

LOS: Length of stay;

PPH: Potentially preventable hospitalisation;

SA: South Australia;

SLA: Statistical Local Areas;

Author contributions

DB conceived the project, performed the analyses and drafted the manuscript; TC contributed to literature searching and manuscript preparation; JK, AB and JL made important contributions to operationalising this study, interpreting the statistical analysis, and revised the manuscript. All authors read and approved the final version of the manuscript.

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The authors declare they have no competing interests.

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Data Sharing Statement

The study's data comprised of de-identified unit record administrative records. These were used under privileged arrangements set out in a study specific confidentiality deed. The data cannot be accessed by another party without relevant departmental and human research ethics approvals.

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Table 1 Persons, percent, and rates of chronic PPH in South Australian public hospitals, 2005-06 to 2010-11.

	Aboriginal			non-Aboriginal		
	N	%	Persons per 1000 per year	N	%	Persons per 1000 per year
Chronic PPH	1,892	100.0%	11.5	58,316	100.0%	6.2
Conditions^						
Angina	293	15.5%	1.8	10,587	18.2%	1.1
Asthma	528	27.9%	3.2	12,346	21.2%	1.3
COPD	341	18.0%	2.1	11,930	20.5%	1.3
Congestive cardiac failure	221	11.7%	1.4	11,079	19.0%	1.2
Diabetes complications	700	37.0%	4.3	12,574	21.6%	1.3
Hypertension	79	4.2%	0.5	2,199	3.8%	0.2
Iron Deficiency Anaemia	107	5.7%	0.7	4,974	8.5%	0.5
Nutritional deficiencies	0	0.0%	0.0	62	0.1%	0.0
Rheumatic heart disease	42	2.2%	0.3	592	1.0%	0.1
Gender						
Male	860	45.5%	10.6	29,970	51.4%	6.5
Female	1,032	54.5%	12.4	28,346	48.6%	6.0
Age						
0-4	167	8.8%	8.6	4,148	7.1%	8.1
5-14	137	7.2%	3.5	3,775	6.5%	3.4
15-24	92	4.9%	2.7	1,691	2.9%	1.4
25-34	115	6.1%	5.0	1,531	2.6%	1.3
35-44	264	14.0%	13.1	2,452	4.2%	1.9
45-54	429	22.7%	28.8	4,211	7.2%	3.2
55-64	355	18.8%	44.2	6,714	11.5%	5.8
65-74	223	11.8%	61.0	9,583	16.4%	12.7
75+	110	5.8%	59.7	24,211	41.5%	32.8
Area Disadvantage (2011 IRSD)						
Q1 Least Disadvantage	31	1.6%	3.7	6,298	10.8%	3.4
Q2	128	6.8%	7.7	10,799	18.5%	5.1
Q3	159	8.4%	7.6	10,918	18.7%	6.6
Q4	551	29.1%	11.6	17,739	30.4%	7.4
Q5 Most Disadvantage	1,023	54.1%	14.5	15,562	26.7%	8.9
Area Remoteness (ARIA+)						
Major cities	677	35.8%	8.0	37,532	64.4%	5.6
Regional	813	43.0%	13.7	18,329	31.4%	7.7
Remote	402	21.2%	19.4	2,455	4.2%	7.7

^Subtotals of N=2,311 and 66,343 respectively. Does not round to 100% as chronic PPH can include more than one condition

Table 2 Mean number of separations, total LOS and hospital cost associated with chronic PPH in South Australian public hospitals, 2005-06 to 2010-11

	Number of chronic PPH				LOS for chronic PPH				Costs of chronic PPH			
	Aboriginal		non-Aboriginal		Aboriginal		non-Aboriginal		Aboriginal		non-Aboriginal	
	Mean	95% CIs	Mean	95% CIs	Mean	95% CIs	Mean	95% CIs	Mean	95% CIs	Mean	95% CIs
Chronic PPH	2.6	2.4-2.8	1.9	1.9-1.9	11.7	10.6-12.7	9.0	8.9-9.2	$ 17,928	$16,367-$19,490	$ 11,515	$11,344-$11,686
Conditions												
Diabetes complications	2.4	2.1-2.6	1.8	1.8-1.9	13.3	11.7-15.0	10.0	9.7-10.3	$ 20,665	$18,253-$23,077	$ 14,601	$14,172-$15,031
Other than diabetes	2.4	2.2-2.6	1.8	1.8-1.9	9.2	8.1-10.3	8.3	8.1-8.4	$ 14,074	$12,416-$15,733	$ 10,083	$9,916-$10,250
Gender												
Male	2.7	2.5-3.0	1.9	1.9-2.0	12.2	10.7-13.7	9.1	8.9-9.3	$ 18,895	$16,794-$20,997	$ 11,993	$11,749-$12,237
Female	2.5	2.3-2.8	1.9	1.9-1.9	11.2	9.7-12.7	9.0	8.7-9.2	$ 17,121	$14,856-$19,386	$ 11,009	$10,769-$11,249
Age												
0-4	1.5	1.3-1.6	1.6	1.5-1.6	2.9	2.3-3.4	2.5	2.4-2.6	$ 5,000	$3,743-$6,256	$ 4,178	$4,041-$4,315
5-14	2.1	1.7-2.5	1.9	1.8-1.9	4.6	3.3-6.0	3.7	3.4-3.9	$ 6,700	$5,232-$8,168	$ 5,775	$5,499-$6,051
15-24	1.9	1.2-2.5	2.1	1.9-2.2	6.3	4.0-8.7	4.9	4.3-5.5	$ 14,070	$8,113-$20,028	$ 8,460	$7,524-$9,396
25-34	2.4	1.5-3.3	1.7	1.6-1.8	11.0	5.8-16.2	4.0	3.6-4.4	$ 18,513	$9,779-$27,247	$ 6,339	$5,767-$6,910
35-44	2.2	1.9-2.5	1.7	1.6-1.9	10.1	7.9-12.4	6.1	4.9-7.3	$ 15,854	$12,503-$19,206	$ 9,220	$7,878-$10,562
45-54	2.7	2.4-3.1	1.7	1.7-1.8	12.0	9.9-14.1	7.3	6.6-7.9	$ 19,096	$15,989-$22,202	$ 10,623	$9,809-$11,438
55-64	3.2	2.6-3.8	1.9	1.8-2.0	14.9	12.0-17.8	8.9	8.4-9.3	$ 24,023	$19,306-$28,740	$ 12,291	$11,696-$12,886
65-74	3.4	2.8-4.1	2.0	2.0-2.1	18.6	14.1-23.0	10.5	10.1-10.9	$ 25,820	$20,512-$31,128	$ 13,940	$13,440-$14,441
75+	2.8	2.1-3.4	2.0	2.0-2.0	17.1	11.7-22.6	11.7	11.5-11.9	$ 19,258	$13,985-$24,532	$ 13,420	$13,189-$13,651
Area Disadvantage (2011 IRSD)												
Q1 Least Disadvantage	2.4	1.4-3.3	1.8	1.7-1.8	7.1	3.3-10.8	7.9	7.5-8.3	$ 12,481	$4,338-$20,624	$ 9,908	$9,474-$10,341
Q2	2.5	2.0-3.1	1.8	1.8-1.9	10.1	7.0-13.2	8.8	8.4-9.2	$ 15,995	$10,932-$21,058	$ 11,176	$10,728-$11,625
Q3	2.4	1.9-3.0	1.9	1.9-2.0	12.3	7.9-16.8	9.5	9.1-9.8	$ 16,776	$11,410-$22,142	$ 11,788	$11,389-$12,186
Q4	2.5	2.2-2.8	1.9	1.9-1.9	10.7	9.0-12.5	8.9	8.6-9.1	$ 17,228	$14,710-$19,746	$ 11,372	$11,053-$11,691
Q5 Most Disadvantage	2.8	2.5-3.0	2.1	2.0-2.1	12.4	10.8-14.0	9.5	9.2-9.8	$ 18,503	$16,208-$20,798	$ 12,351	$12,012-$12,689
Area Remoteness (ARIA+)												
Major cities	2.5	2.2-2.8	1.9	1.9-2.0	10.8	9.0-12.6	9.3	9.2-9.5	$ 16,918	$14,110-$19,727	$ 11,892	$11,667-$12,116
Regional	2.7	2.4-3.0	1.9	1.9-1.9	11.7	10.0-13.4	8.5	8.2-8.7	$ 16,575	$14,413-$18,737	$ 10,753	$10,481-$11,024
Remote	2.7	2.3-3.1	1.8	1.7-1.9	13.1	10.8-15.4	8.5	7.9-9.1	$ 21,377	$17,931-$24,824	$ 11,490	$10,673-$12,307

Table 3 Relationship of SLA area attributes with square root transformed public hospital standardised LOS and cost ratios by Aboriginality in South Australia, 2005-06 to 2010-11

	Aboriginal				non-Aboriginal			
LOS	Change co-efficient	95%CIs	p	N (SLAs)	Change co-efficient	95%CIs	p	N (SLAs)
Chronic PPH				118				119
Constant	2.09	0.00-5.83	<0.001		0.46	0.38-0.54	<0.001	
Area disadvantage rank (2011 IRSD)[a]	0.03	0.00-0.07	0.005		0.01	0.01-0.01	<0.001	
Area remoteness (ARIA+)[b]	1.04	0.63-1.44	<0.001		0.02	0.00-0.04	0.183	
Diabetes complications PPH								
Constant	2.59	0.00-10.82	0.003		0.41	0.31-0.52	<0.001	
Area disadvantage rank (2011 IRSD)[a]	0.05	0.00-0.15	0.005		0.01	0.01-0.01	<0.001	
Area remoteness (ARIA+)[b]	1.62	0.73-2.51	<0.001		0.02	0.00-0.05	0.225	
Other chronic PPH								
Constant	1.86	0.00-5.45	<0.001		0.48	0.39-0.56	<0.001	
Area disadvantage rank (2011 IRSD)[a]	0.02	0.00-0.06	0.004		0.01	0.01-0.01	<0.001	
Area remoteness (ARIA+)[b]	0.82	0.43-1.21	<0.001		0.01	0.00-0.04	0.258	
Cost								
Chronic PPH								
Constant	2.44	0.00-5.92	<0.001		0.44	0.36-0.51	<0.001	
Area disadvantage rank (2011 IRSD)[a]	0.02	0.00-0.06	0.008		0.01	0.01-0.01	<0.001	
Area remoteness (ARIA+)[b]	1.18	0.80-1.55	<0.001		0.02	0.00-0.04	0.078	
Diabetes complications PPH								
Constant	3.95	0.00-10.88	<0.001		0.40	0.30-0.50	<0.001	
Area disadvantage rank (2011 IRSD)[a]	0.03	0.00-0.12	0.006		0.01	0.01-0.01	<0.001	
Area remoteness (ARIA+)[b]	1.43	0.68-2.18	<0.001		0.02	0.00-0.05	0.258	
Other chronic PPH								
Constant	1.74	0.77-5.40	<0.001		0.45	0.37-0.53	<0.001	
Area disadvantage rank (2011 IRSD)[a]	0.02	0.00-0.06	0.005		0.01	0.01-0.01	<0.001	
Area remoteness (ARIA+)[b]	1.08	0.69-1.48	<0.001		0.02	0.00-0.04	0.090	

[a] Change is per one unit increase in SLA disadvantage rank
[b] Change is per one unit increase in SLA ARIA+ score

Figure 1 Annual rate and mean number of chronic PPH to public hospitals by age and Aboriginality in South Australia, 2005-06 to 2010-11

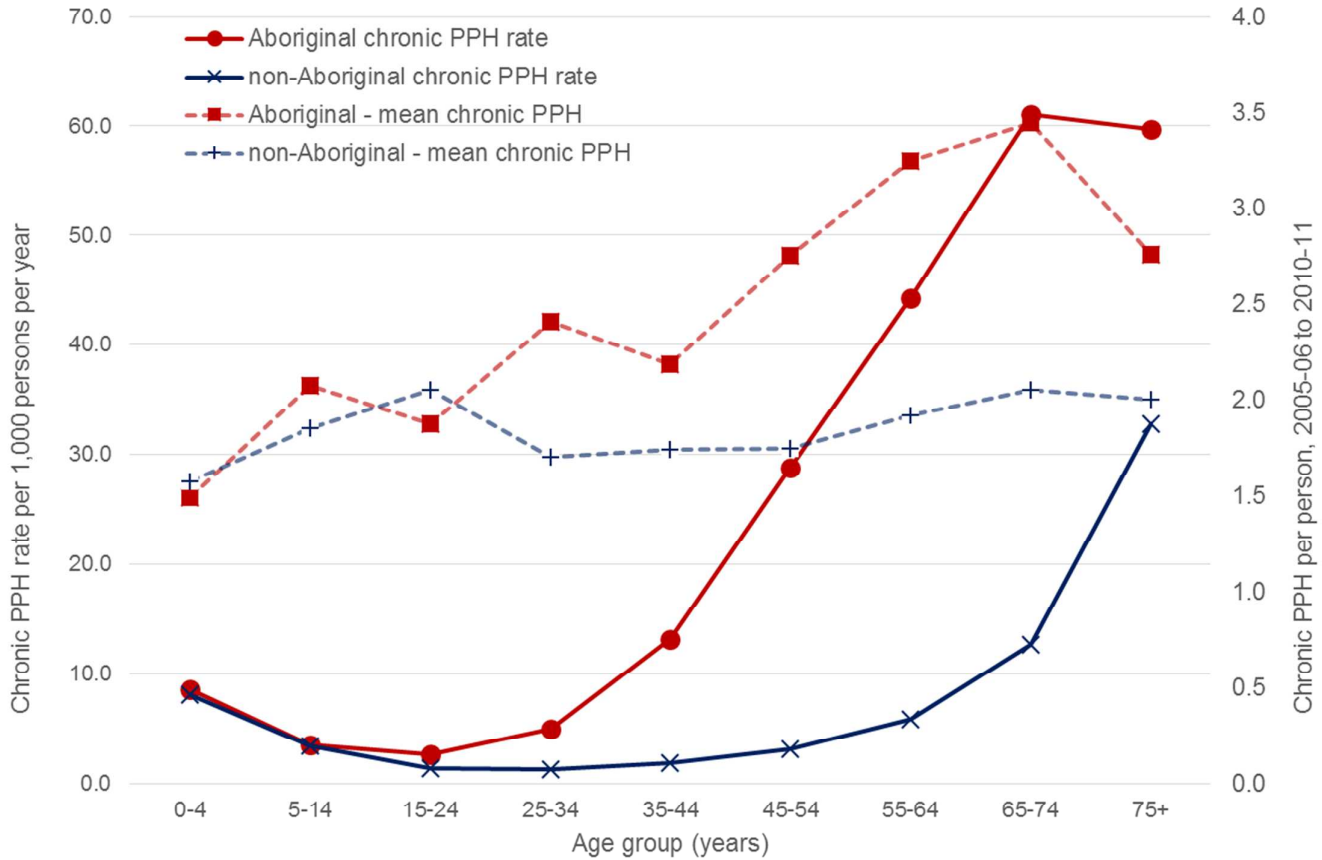
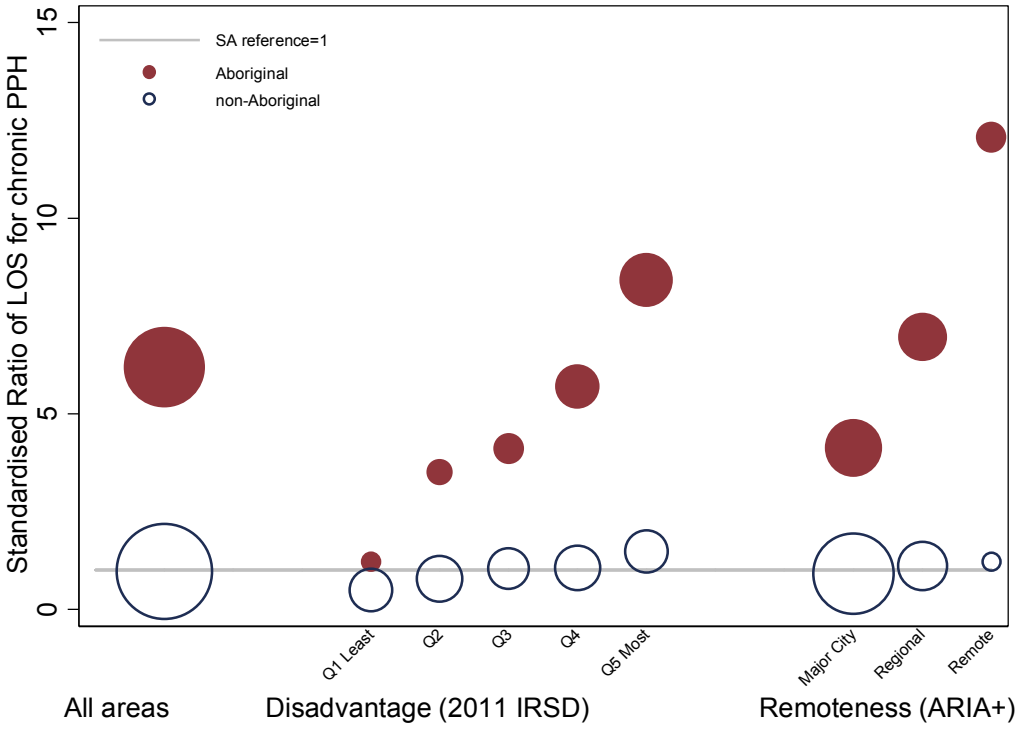
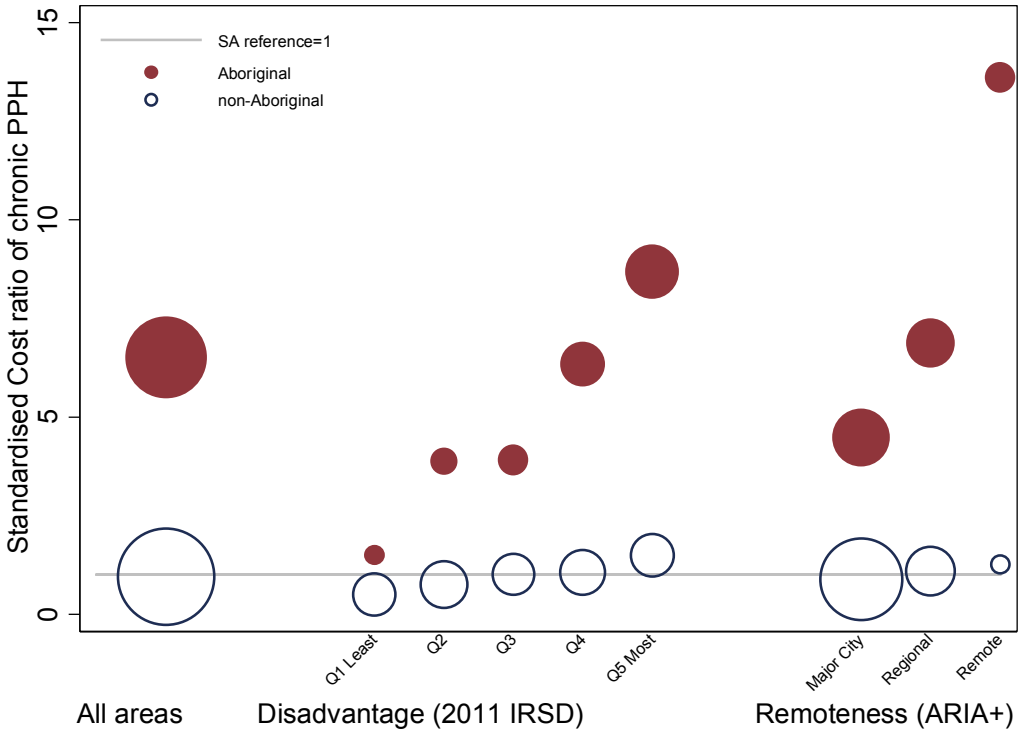


Figure 2 Sex and age adjusted public hospital LOS (Panel A) and costs (Panel B) for chronic PPH by Aboriginality in South Australia, 2005-06 to 2010-11

A. Length of stay



B. Costs



Supplemental Online Table A Distribution of population by area disadvantage, remoteness and Aboriginal status, South Australia, 2006 to 2011 average

Indigenous

	Major cities		Regional		Remote		Total	
	N	Percent	N	Percent	N	Percent	N	Percent
Age								
0-4	1,656	6.1%	1,178	4.3%	403	1.5%	3,238	11.8%
5-14	3,344	12.2%	2,335	8.5%	799	2.9%	6,479	23.7%
15-24	3,046	11.1%	2,000	7.3%	679	2.5%	5,724	20.9%
25-34	2,033	7.4%	1,322	4.8%	474	1.7%	3,828	14.0%
35-44	1,675	6.1%	1,218	4.5%	463	1.7%	3,355	12.3%
45-54	1,241	4.5%	884	3.2%	362	1.3%	2,487	9.1%
55-64	633	2.3%	541	2.0%	164	0.6%	1,338	4.9%
65-74	279	1.0%	258	0.9%	72	0.3%	609	2.2%
75+	150	0.5%	126	0.5%	32	0.1%	307	1.1%
Area Disadvantage (2011 IRSD)								
Q1 Least Disadvantage	1,051	3.8%	257	0.9%	97	0.4%	1,406	5.1%
Q2	2,154	7.9%	483	1.8%	144	0.5%	2,781	10.2%
Q3	2,517	9.2%	815	3.0%	140	0.5%	3,472	12.7%
Q4	3,588	13.1%	2,137	7.8%	2,220	8.1%	7,945	29.0%
Q5 Most Disadvantage	4,746	17.3%	6,170	22.5%	846	3.1%	11,762	43.0%
Total	**14,056**	**51.4%**	**9,862**	**36.0%**	**3,448**	**12.6%**	**27,366**	**100.0%**

non-Indigenous

	Major cities		Regional		Remote		Total	
	N	Percent	N	Percent	N	Percent	N	Percent
Age								
0-4	59,436	3.8%	22,616	1.5%	3,438	0.2%	85,490	5.5%
5-14	124,954	8.0%	52,155	3.3%	7,139	0.5%	184,249	11.8%
15-24	157,384	10.1%	46,228	3.0%	5,791	0.4%	209,403	13.4%
25-34	151,022	9.7%	42,991	2.8%	6,781	0.4%	200,794	12.9%
35-44	152,948	9.8%	53,955	3.5%	7,691	0.5%	214,594	13.8%
45-54	155,542	10.0%	58,966	3.8%	7,817	0.5%	222,326	14.3%
55-64	131,546	8.4%	53,794	3.5%	6,979	0.4%	192,319	12.3%
65-74	85,890	5.5%	35,964	2.3%	4,168	0.3%	126,022	8.1%
75+	89,966	5.8%	29,574	1.9%	3,508	0.2%	123,049	7.9%
Area Disadvantage (2011 IRSD)								
Q1 Least Disadvantage	249,709	16.0%	51,252	3.3%	6,068	0.4%	307,029	19.7%
Q2	300,646	19.3%	57,501	3.7%	7,839	0.5%	365,986	23.5%
Q3	209,834	13.5%	64,390	4.1%	13,559	0.9%	287,783	18.5%
Q4	211,354	13.6%	105,166	6.7%	21,091	1.4%	337,611	21.7%
Q5 Most Disadvantage	175,782	11.3%	122,500	7.9%	3,703	0.2%	301,985	19.4%
Total	**1,108,690**	**71.1%**	**396,244**	**25.4%**	**53,312**	**3.4%**	**1,558,246**	**100.0%**

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1&2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7&8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	7&8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8&9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7&8
Bias	9	Describe any efforts to address potential sources of bias	8
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8&9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8&9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	N/A Study uses mandatory fields within administrative data.

		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	8&9
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	Not considered appropriate
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9&10
		(*b*) Report category boundaries when continuous variables were categorized	Defined p8; Reported pp10-13
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10-13
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Socio-demographic variations in the amount, duration and cost of potentially preventable hospitalisation for chronic conditions amongst Aboriginal and non-Aboriginal Australians: a period prevalence study of linked public hospital data

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Keywords:	length of stay, hospital costs, potentially preventable hospitalisation, PRIMARY CARE, Indigenous population

Title: Socio-demographic variations in the amount, duration and cost of potentially preventable hospitalisation for chronic conditions amongst Aboriginal and non-Aboriginal Australians: a period prevalence study of linked public hospital data

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Word count: 4481 words

Keywords: potentially preventable hospitalisation; length of stay; hospital costs; primary care; Indigenous population.

Abstract

Objectives:

To determine disparities in rates, length of stay and hospital costs of potentially preventable hospitalisations (PPH) for selected chronic conditions among Aboriginal and non-Aboriginal South Australians (SA), then examine associations with area level socio-economic disadvantage and remoteness.

Setting:

Period prevalence study using linked, administrative public hospital records.

Participants:

Participants included all SA residents in 2005-06 to 2010-11. Analysis focused on those individuals experiencing chronic PPH as defined by the Australian Institute of Health and Welfare.

Primary outcome measures:

Number and rates (unadjusted, then adjusted for sex and age) of chronic PPH, total length of stay (LOS) and direct hospital costs by Aboriginality.

Results:

Aboriginal South Australians experienced higher risk of index chronic PPH compared to non-Aboriginals (11.5 and 6.2 per 1,000 persons per year respectively) and at younger ages (median age 48 versus 70 years). Once hospitalised, Aboriginal people experienced more chronic PPH events, longer total LOS with higher costs than non-Aboriginal people (2.6 versus 1.9 PPH per person; 11.7 versus 9.0 days LOS; at AUD$17,928 versus AUD$11,515 respectively). Compared to population average LOS, the standardised rate ratio of LOS among Aboriginal people increased by 0.03 (95%CI 0.00-0.07) as disadvantage rank increased and 1.04 (95%CI 0.63-1.44) as remoteness increased. Non-Aboriginal LOS also increased as disadvantage increased but at a lower rate, 0.01 (95%CI 0.01-0.01). Costs of Aboriginal chronic PPH increased by 0.02 (95%CI 0.00-0.06) for each increase in disadvantage and 1.18 (95%CI 0.80-1.55) for increased remoteness. Non-Aboriginal costs also increased as disadvantage increased but at lower rates, 0.01 (95%CI 0.01-0.01).

Conclusion:

Aboriginal people's heightened risk of chronic PPH resulted in more time in hospital and greater cost. Systematic disparities in chronic PPH by Aboriginality, area disadvantage and remoteness highlight the need for improved uptake of effective primary care. Routine, regional reporting will help monitor progress in meeting these population needs.

Strengths and limitations of this study:

- This is the first study to examine variations of total length of stay and direct hospital costs associated with chronic PPH among Aboriginal and non-Aboriginal Australians.
- The study uses a complete collection of person-linked public hospital records over a six year period from 2005-06 to 2010-2011.
- The study provides a baseline for reporting of a health system performance measure focussing on individuals as well as populations experiencing chronic PPH.
- Person-linked private hospital records and death records were not available to the study.
- Hospital records for a group of the most vulnerable residents living in very remote areas and hospitalised in other jurisdictions were not included.

Background

Chronic health conditions are increasingly important contributors to poor population health throughout the world[1]. The increased prevalence and duration of these conditions adds to the mounting pressure on health systems to respond to those needs. Hospital expenditures are a key component of these systems[2]. Australia is an example of a developed and advantaged setting where annual hospital expenditure represents the largest recurrent and growing contribution[3 4] to the average health expenditure of $6,639 per person[5].

In constrained budgetary environments, hospital performance measures are constantly scrutinised for efficiency gains. For example, inpatient length of stay (LOS) is closely associated with hospital cost[6] and reimbursements[7] and Australia employs LOS in a suite of health system performance measures[3 8]. From a hospital's perspective, LOS indicates production of care adequate to meet clinical need while maximising bed availability and minimising treatment costs. From a patient perspective, hospital LOS means maximising quality outcomes from care while minimising risk of exposure to adverse events in hospital and time away from usual, societal roles.

Potentially Preventable Hospitalisations (PPH) are another performance indicator making use of administrative data[9-11]. Under different names such as potentially avoidable hospitalisations or ambulatory care sensitive conditions, and with some variations in conditions and coding[12-14], PPH are widely adopted as an indicator of a community's capacity to benefit from available and effective[15-18] primary health care by: "preventing the onset of an illness or condition, controlling an acute episodic illness or condition, or managing a chronic disease or condition" p163[19]. Primary health care is the second most expensive component of Australia's health system at almost $55 billion annually[4]. Recent expert commentary argued

Australia's primary health system provides around half the level of care recommended for chronic conditions which contributes to chronic PPH $2 billion annual cost to the health system[20]. Therefore, PPH provide an important junction between two critical system components in which policy makers and health planners can consider both the technical efficiency of one sector, its effect on another sector and opportunities to adjust allocations across sectors. Efficient use of healthcare resources can maximise health outcomes in the community served[21].

Equitable distribution of health is another challenging[21-24] but high priority[21] for contemporary health systems. PPH result from a complex interplay of person-related[25 26], health system, geographical[27] and socio-economic factors[28-30] which highlight the need for directing resources toward appropriate and accessible health services[24]. Localised understanding can help inform local responses to health need[21 31]. While their underlying data does not refer to individuals, Australia's Institute of Health and Welfare (AIHW) does work towards this by reporting aggregated PPH time series by age group, sex, state/territory jurisdictions, socioeconomic disadvantage, remoteness and Aboriginal and Torres Strait Islander status (herein respectively referred to as "Aboriginal")[32]. Overall PPH rates are three times higher for the Aboriginal population compared to non-Aboriginal Australians[32 33] which supports their designation as a disadvantaged group in terms of their use of primary health care[34]. This is consistent with indigenous population comparisons in the US[35], Canada[36] and New Zealand[37]. Chronic PPH conditions account for much of PPH for which there is a five-fold differences in the hospitalisation rates by Aboriginality[32 33]. Australian reporting of chronic PPH conditions[9] focusses on primary diagnoses of: angina, asthma, COPD, congestive cardiac failure, diabetes complications, hypertension, iron deficiency anaemia, nutritional deficiencies and rheumatic heart disease (specific diagnosis and procedural criteria

for chronic PPH are listed in Supplemental Online Table A). While the indicator could be further developed by including other conditions such as chronic kidney disease[38], discrete chronic PPH conditions currently reported for angina, COPD[38], congestive cardiac failure[39 40] and rheumatic heart disease[41] are each associated with disparities between Aboriginal and non-Aboriginal populations. A particularly significant area is that of PPH from diabetes complications, the most frequently reported chronic PPH amongst Aboriginal Australians[32 42-45]. Similar disparities in chronic PPH between Aboriginal and non-Aboriginal populations are reported across Australia's states and territories of Victoria[45], the Northern Territory[44], Queensland[46], Western Australia[47], New South Wales[48] and South Australia (SA)[49 50].

Despite considerable evidence of variations in PPH rates and LOS, relatively little is known about how the two measures co-vary[51]. Given the extent of disparities in chronic PPH rates by Aboriginality, this appears an opportune place from which to improve understanding of *who* in the community is more likely to experience potentially unnecessary, prolonged and costly hospitalisation. The first of only two studies that considered chronic PPH and LOS together focussed on diabetes hospitalisations among older, Hawaiian people categorised as either Asian, islander or white[52]. The second, Australian study considered results for individuals on the basis of Aboriginal identity[48]. The results affirmed higher chronic PPH rates among Aboriginal people compared to non-Aboriginal contemporaries of the same age, sex and living in the same geographic area. Moreover, elevated rates were accompanied by LOS which was 4% higher on average[48]. However, neither study explicitly describes the variation of chronic PPH and LOS rates within the populations studied, yet evidence in other areas point to considerable within-population heterogeneity in health outcomes. For example, analysis of premature mortality among Aboriginal South Australians showed an interaction

between area level socioeconomic disadvantage and remoteness where the social gradient between disadvantage and premature mortality outcomes increased as remoteness increased[53].

None of the recently reviewed literature on PPH and LOS analysed the costs associated with the hospital events. Such information is critical to inform complex commissioning decisions of the opportunity cost, at least from a health system perspective, of pursuing technical and allocative efficiencies while reducing the human and societal costs represented by a person's time out of role.

If health systems are to attend to the needs of people and populations, it is important to focus on individuals and sub-populations in their localised setting. This focus will benefit from supplementing AIHW reporting, based on unlinked data, with administrative records linked to individuals and their use of services. The latter are becoming more routinely available in Australian states and territories. Using these in quantifying disproportionate hospitalisation, re-hospitalisation and time spent in hospital while simultaneously describing the system resources involved can provide valuable information on which elements of the health system are working, for whom and in what context[2 54].

This study considers the disparity between rates of PPH for chronic conditions for Aboriginal and non-Aboriginal South Australians. It examines the association between area level socioeconomic disadvantage, geographic remoteness and the frequency, length, and cost of hospitalisation for chronic PPH within those populations. This paper addresses three questions. Which individuals experienced chronic PPH? How does the length of stay and cost of hospitalisation for these conditions vary between Aboriginal and non-Aboriginal

populations? What is the relationship between the ecological risk factors of area level socio-economic position and remoteness with PPH for chronic diseases within these populations?

Methods

Ethics approval

Research ethics committee approvals are held from SA Health (467/08/2014) and the Aboriginal Health Council of South Australia (04-11-406).

Study design

A period prevalence study using linked, public hospital administrative records.

Data sources

Hospital separations

Details of the universally available healthcare for patients admitted to public hospitals are collated at time of their discharge, or separation, from hospital then added to the Integrated South Australian Activity Collection (ISAAC) maintained by SA Health, the state government's lead health agency. The term 'separations' is used synonymously with 'admissions'[14 51 55 56] and 'hospitalisations'[12 18 25 30 40 45 48 52] reported in other research referenced by our study. Chronic PPH within ISAAC records for financial years 2005-06 to 2010-11 were categorised using AIHW criteria for ICD-10 primary diagnoses and relevant procedure codes[57]. ISAAC includes mandatory fields of age, Aboriginal identification and Statistical Local Area (SLA) of usual residence. Residents of the Anangu Pitjantjatjara Yankunytjatjara Lands (APY Lands) access over 95% of their hospital services in the neighbouring jurisdiction (at Alice Springs Hospital in the Northern Territory)[58]. This activity

is not recorded within ISAAC so any residual APY resident hospitalisations were removed from hospital and population denominator counts.

Hospital costs across the period were calculated in a uniform manner using Australia's National Efficient Price for public hospital health care activity in 2015-16[7] and expressed in Australian dollars. These prices are based on each separation's Australian Refined Diagnostic Related Group (AR-DRGv7.0) with loadings for outlying LOS, Aboriginality (4%) and area remoteness (ranging from an additional 8% in outer regional to 22% for very remote areas).

Hospital separations for individuals

Analysis of separations for individual people was facilitated by probabilistically linked project keys from SA-NT DataLink, an organisation within Australia's data linkage network. These keys enabled grouping of each person's separations across hospitals and time. Each individual's records were assigned the last recorded age and the SLA recorded in that person's index, or first occurring, separation. Aboriginality was categorised on the basis of a person having identified as Aboriginal in *any* hospital separation during the observation period. Identification of Aboriginal status can be difficult and introduce misclassification bias [59]. Accordingly, a more stringent definition for sensitivity analyses was based on a person identifying as Aboriginal on more than 75% of records.

Population and Statistical Geography

South Australia is in southern, central Australia. Comprising a land area of almost one million square kilometres and a resident population of 1.64 million[60], 71% in the capital's metropolitan area, SA has a low population density of 1.67 persons per square kilometre. The Aboriginal population comprised 2.3% of population with one half residing in the metropolitan area[60].

The study's population denominators were based on Australia's Census years in 2006 and 2011[61]. The relevant estimates of resident population by sex, age and Aboriginality include sex and age profiles by rurality and total population for SLAs, the smallest routinely available geographic areas for intrastate analysis[62]. The mean annual total population for each SLA was 12,584 (SD=10,029) ranging from 0 to 36,407 [63].

The Australian Bureau of Statistics (ABS) index SLAs by socio-economic characteristics[64] and geographic remoteness. Census 2011 Index of Relative Socio-economic Disadvantage (IRSD)[57 64 65] ranks SLAs whereby 1 is least disadvantaged and 123 the most disadvantaged area. These are further aggregated to disadvantage quintiles of approximately equal population size[62]. SLAs with nominal population and no relative IRSD rank would not contribute to the analysis and were omitted. The Accessibility/Remoteness Index of Australia (ARIA+) uses road distance to service centres[62] to allocate a continuous measure ranging from 0 (high accessibility) to 15 (high remoteness). SLAs can be collapsed into categories of major city (ARIA+ < = 0.2), regional (ARIA+ > 0.2 & < = 5.92) and remote areas (ARIA+ > 5.92).

Data analysis

Crude, unadjusted rates of individuals experiencing chronic PPH with respect to Aboriginality, sex, age and area level IRSD quintiles and remoteness categories were summarised using cross-tabulations. Among these individual patients, the mean number of chronic PPH separations experienced is initially described. The mean, totalled LOS and hospital costs associated with those separations is then added.

LOS and cost outcomes were then placed into a broader, population context. Indirect sex and age adjustment[66] with five year age groupings to 75+[67] controlled for confounding from sex and age variations between Aboriginal and non-Aboriginal people experiencing chronic PPH

and the population more generally. Area outcomes therefore represent the ratio of observed versus expected outcome based on South Australian totals. For example, an outcome of 1.50 for total chronic PPH LOS among a population group indicates the ratio of observed versus expected LOS across that group was one and a half times, or 50% higher, than the South Australian average after adjusting for sex and age differences.

Outcomes of LOS and hospital cost ratios observed among the population of each SLA were positively skewed and subsequently normalised using square root transformations. The relationship between transformed outcomes and the potential covariates of SLA IRSD rank and remoteness were examined using least squares regressions[68] with each SLA's contribution weighted by population size. While the focus was on chronic PPH as a group, diabetes complications are known to be nationally over represented among Aboriginal people[69] as the largest single chronic PPH condition and up to 10 times the rate of the non-Aboriginal population. To examine any potential bias introduced by an association between diabetes complications, area disadvantage and remoteness, records were further stratified as either diabetes complications or all other chronic PPH with analyses repeated for each. The reported coefficients and 95% confidence intervals represent the change in the standardised ratio for each one unit change in disadvantage rank and remoteness.

All analyses used Stata version 14.2[70].

Results

Crude Separations

Of 1,828,846 public hospital separations involving usual SA residents, 117,127 (6.4%) were categorised as chronic PPH. Aboriginal people experienced these at 2.2 (95%CI 2.1-2.4)

times the rate of non-Aboriginals (N=4,391 at 26.7 chronic PPH per 1,000 persons per year compared to N=112,736 at 12.1 per 1,000 persons per year).

Demographic and diagnostic profile (Person-based analysis)

Chronic PPH involved 60,208 individuals 1,892, or 3.2%, of whom were Aboriginal. Table 1 quantifies aspects of their experience showing Aboriginal people were 1.8 (95%CI 1.6-2.1) times more likely to be hospitalised than non-Aboriginal people. There were several marked differences in conditions responsible for hospitalisation with diabetes complications being the primary diagnosis for more than one-third of Aboriginal patients with chronic PPH compared to around one in five non-Aboriginal patients. Chronic PPH events can involve more than one diagnosed chronic condition and this was observed more frequently among Aboriginal patients. For instance, the 2,311 diagnosed chronic conditions among 1,892 Aboriginal patients hospitalised averages 1.22 per patient. The comparison for non-Aboriginal patients was 1.14 comprising 66,343 chronic condition diagnoses among 58,316 patients.

Aboriginal patients experiencing chronic PPH were more likely to be female and of a much younger age compared to non-Aboriginal patients (median ages of 48 and 70 years respectively). The proportion of individual Aboriginal patients from areas of most disadvantage (54.1% versus 26.7%) or regional and remote areas (64.2% versus 35.6%) was around double that of non-Aboriginal people.

The number of chronic PPH, associated LOS and estimated hospital costs averaged across individual patients are summarised in Table 2. The dominant pattern is one of more frequent hospitalisation per Aboriginal person by sex, and across areas of residence and most age groupings. The average of 11.7 days LOS was 30% greater for Aboriginal patients with the differences peaking in the 55-74 age ranges. Hospital costs follow a similar pattern but with more pronounced differences by Aboriginality. For example, averaged hospital costs

accumulated for Aboriginal patients were 56% higher than non-Aboriginal patients ($17,928 versus $11,515) with differences were most prominent in the 55-74 age ranges. The absolute difference in excess of $11,500 represented an almost two-fold difference in relative terms.

Figure 1A illustrates the stark disparity in the age at which Aboriginal and non-Aboriginal people experienced a first chronic PPH. Figure 1B then illustrates the mean number of separations those individual patients experienced. Aboriginal people aged 35-44 or more not only experienced markedly higher rates of chronic PPH but having had a first event, they were increasingly likely to experience at least one more event.

Sex and age standardised LOS and costs

Figure 2 places results for individuals hospitalised into a population context by graphing sex and age standardised outcomes by Aboriginality (LOS in Figure 2A and costs in Figure 2B) for all areas, then disadvantage quintiles and remoteness categories. Each marker is weighted by area population as per Supplemental Online Table B. Figure 2A illustrates the LOS rate associated with chronic PPH within the Aboriginal population was six times more than the state average after adjusting for sex and age. Chronic PPH LOS among Aboriginal and non-Aboriginal populations progressively increased across levels of area disadvantage but change was far more pronounced within the Aboriginal population and concentrated among the relatively larger disadvantaged populations in Quintiles 4 and 5. Similarly, comparison of major city with remote locations involved nearly threefold higher results from 4.2 to 12.1 times the state average. Hospital costs incurred (Figure 2B) show very similar patterns with slightly higher mean differences between Aboriginal and non-Aboriginal results.

Linear regression models between the two sex and age standardised outcomes of LOS and cost ratios across three levels (all chronic PPH; diabetes complications; all other chronic PPH) and the covariates of area level disadvantage and remoteness are presented for

Aboriginal and non-Aboriginal populations in Table 3. After allowing for sex and age differences, Aboriginal people's LOS and cost outcomes, for each level, varied significantly across area disadvantage and remoteness. For example, within the Aboriginal population the standardised LOS rate ratio associated with all chronic PPH was 2.09 (95%CI 0.00-5.83) times the state average (of one). The disparate LOS rate increased by an average of 0.03 (95% CI 0.00-0.07) with each change in disadvantage rank and a further 1.04 (95%CI 0.63-1.44) as remoteness increased. These associations of disadvantage and remoteness with LOS were consistent within stratified subgroups of diabetes complications and all other chronic PPH. However, the magnitude of change in LOS ratios was higher for diabetes complications (2.59; 95%CI 0.00-10.82) than for all other chronic PPH (1.86; 95%CI 0.43-1.21) before adjusting for the influence of area disadvantage and remoteness. The change observed in LOS for diabetes complications was around twice that for all other chronic PPH for both disadvantage (0.05; 95%CI 0.00-0.15 versus 0.02; 95%CI 0.00-0.06) and remoteness (1.62; 95%CI 0.73-2.51 versus 0.82; 95%CI 0.43-1.21). Similar variations in standardised cost ratio outcomes across levels of outcome and by disadvantage and remoteness were observed for the Aboriginal population.

Results for the non-Aboriginal population also show consistent associations between area disadvantage and each outcome and level whereby the standardised ratio increased as disadvantage increased. However, area remoteness was not associated with increased LOS or cost. Moreover, the base from which change occurred was substantially lower. For instance, the standardised LOS ratio for chronic PPH among the non-Aboriginal population before adjusting for disadvantage rank was less than half (95%CI 38%-54%) of the state average.

The potential for interaction between area disadvantage and remoteness was examined without result. Sensitivity analyses using a more stringent definition of Aboriginality were also conducted but did not change our overall conclusions[71].

Discussion

This study provides evidence of stark disparities in the rates with which Aboriginal and non-Aboriginal individuals experienced potentially preventable hospitalisation for chronic conditions. Aboriginal people had almost twice the risk of experiencing a chronic PPH overall compared to their non-Aboriginal contemporaries. Other disparities noted include higher chronic PPH rates among Aboriginal females and younger adults with rates steeply increasing from least to most disadvantaged quintiles and/or remote areas of South Australia. Conversely, non-Aboriginal patients were more likely to be concentrated among older adults. A social gradient across disadvantage levels was also apparent however the steepness of the gradient from most to least disadvantaged areas was markedly lower for non-Aboriginal people. These findings are consistent with the wider literature focused on ethnic differences in PPH[35-37] and underpin the disproportionate population rates of chronic PPH among Aboriginal South Australians[9 57 69].

This analysis at the individual level furthers our understanding by demonstrating how, having experienced one chronic PPH event, Aboriginal patients were also more likely to endure further chronic PPH. This was associated with an increased accrual of time spent in hospital which was almost one-third higher for Aboriginal patients. Moreover, the associated hospital costs were more than 50% higher than for non-Aboriginal patients on average and more variable within the group of Aboriginal patients.

Sex and age adjusted rates of time spent in hospital for chronic PPH and expressed as rates per capita reflect the number of individuals and the length of time hospitalised. These standardised population outcomes showed LOS for chronic PPH among Aboriginal South Australians was six times higher than the state average. The best outcomes within the

Aboriginal community were observed among the relatively few living in areas of least disadvantage, albeit these were still markedly higher than the state average. Diabetes complications are heavily implicated in chronic PPH for Aboriginal people. Their presence, with or without other chronic conditions, exacerbate LOS rates and hospital costs among Aboriginal people but not so within the non-Aboriginal population. Even after partitioning out diabetes related hospitalisations, substantial differences in LOS and cost remain among other chronic PPH experienced by Aboriginal people.

The results further highlight systematic inequities between populations while also highlighting substantial within-population variation whereby a relatively small number of people experienced considerable time in hospital and away from their usual societal roles because of chronic health conditions. This is consistent with recent US literature demonstrating the role of chronic PPH, and particularly diabetes, as sustaining and even increasing disparities between African Americans and whites[56]. Similarly, it affirms other Australian research highlighting widespread Aboriginal/non-Aboriginal differences and differences within the Aboriginal population in chronic PPH generally and the pervasive, adverse results of diabetes complications across geographic areas[48]. Moreover, the results identified that increased chronic PPH were accompanied by systematically increased accrual of LOS and greater hospital costs.

The extent to which these differences are amenable to change needs further discussion. By definition, chronic PPH represent opportunities for change through exposure to primary health care, notwithstanding a range of individual, societal, clinical and system level factors are related to their occurrence[72 73] and may each be associated with realising this potential. This is supported by studies of risk factor exposure across levels of socio-economic

disadvantage and remoteness[33]. Whether the chronic PPH events were preventable in their immediate context is less certain. The high prevalence of diabetes complications and higher levels of chronic multi-morbidities among Aboriginal patients observed in this study suggests comparatively more advanced disease for which hospitalisations, more often, for longer periods and at greater cost is an appropriate and expected result. A heightened need for preventive and early intervention through primary and community care is evident.

Authoritative reviews of the international literature found chronic PPH[74 75], and unplanned hospitalisation more generally[76] among selected patient groups, were reduced by interventions promoting self-management support, continuity of care with a general practitioner, and integration of primary and secondary care. Other interventions, such as case management, appear to reduce LOS[74-76]. However, each review was restricted by a relative lack of robust evaluation of interventions as they are introduced into health systems. Such evaluations are emerging and indicate promising primary healthcare interventions in chronic disease management and diabetes are available. Australia's largest randomised intervention in diabetes delivered positive outcomes in HbA1c levels, blood pressure, waist circumference, depression, care-plan take-up and chronic PPH in the trial group receiving each of five available quality improvement and flexible funding components[43]. Mainstream general practice services are less available for remote Aboriginal populations exhibiting greater need in terms of chronic PPH LOS and costs yet evidence of effective intervention among Aboriginal populations is available[77]. Randomised diabetes care led by community health workers in regional and remote areas showed promising HbA1c reductions among poorly controlled type 2 diabetes patients[78] and modest net reductions in diabetes related hospitalisation in the treatment group[79]. Nevertheless, a critical need for substantively increasing the training and supply of Aboriginal health care workers remains[80]. Generally

negative evaluation of incremental cost-effectiveness assessments based on short-term, averaged and disease specific results[43 79] may impede this investment.

Our description of who is more likely to experience chronic PPH, for what conditions, with what frequency and at what direct cost to the health system suggest three areas for developing incremental cost to outcome analyses. The first is to consider flow-on benefits from disease-specific interventions to other comorbid chronic conditions, especially where disparities in condition prevalence exist. Second, evaluation based on longer term accumulated hospitalisation costs for individual trial participants is warranted. Where project term constraints apply, our results provide an initial empiric base. Finally, placing individual participant results into a population context provides an information base for allocating resources which address health care needs for primary and community care at lower cost to individuals and acute care services[24].

Subsequent reporting of cumulative LOS and costs at a person level adds value to system performance monitoring by making the person and patient the centre of reporting and evaluation, as well as the centre of care. Providing empirical evidence of change occurring at individual and population levels will help align system activities and monitoring with the ultimate aim of providing appropriate and effective care of patients and people, equitably and efficiently.

Limitations

The study has several limitations. First, cumulative LOS as an outcome variable is influenced by the nature of admission with inter-hospital transfers having longer LOS than emergency admissions[6]. Recurrent hospital events for chronic conditions among people in regional and remote settings may involve comparatively more inter-hospital transfers or planned admissions for treatment where primary health interventions are scarce. Nevertheless, the

observations summarised in this study represent an aspect of peoples' lived experience of contending with chronic disease. Continuing research will benefit from focussing on mode of admission to hospital and the local availability of primary care. Second, the propensity to identify as Aboriginal has increased across recent times and any undercounting in earlier Aboriginal population denominators would affect population rates. However, this study's population estimates are drawn from the internally consistent ABS series covering 1996 to 2011 as based on the 2011 Census and the first available set of ABS non-experimental population denominators. Accordingly, there are no known inflation of rates due to population undercounts. Nevertheless, estimates incorporating Census 2016 will provide a valuable reliability check when used with concurrent hospital data in future analyses. Third, while public hospital care is universally available in SA and estimating rates makes appropriate use of population denominators, the omission of private hospital separations undercounts some chronic PPH, particularly among relatively advantaged citizens. Further studies will benefit from including these private hospital separations and from exploring whether chronic PPH were associated with planned care or the result of emergency presentations. Finally, the omission of the APY Lands SLA means chronic PPH outcomes associated with a very remote area and SA's most disadvantaged are not represented[81]. Subsequent research in the area will benefit from including APY Land residents hospitalised in the Northern Territory[50] to ensure results for the most remote and disadvantaged population groups are not underestimated.

Conclusion

The results show heightened risk of chronic PPH among Aboriginal individuals which compounds into more re-hospitalisation and accumulated time in hospital at greater cost to

the person, their community and the health system. At a population level, the systematic change in chronic PPH and LOS by Aboriginality and area suggests efforts to address these potentially avoidable hospitalisations will benefit from targeting specific population segments, particularly in areas of greater socio-economic disadvantage and geographic remoteness. This analysis helps guide such actions by identifying sub-populations within the wider community who could most benefit from improved understanding of antecedent causes of hospitalisation. Routine, reporting across population groups and regions will help monitor progress in meeting the underlying population health needs with earlier, and perhaps lower cost, interventions.

Abbreviations

ABS: Australian Bureau of Statistics

AIHW: Australian Institute of Health and Welfare;

APY Lands: Anangu Pitjantjatjara Yankunytjatjara Lands;

ISAAC: Integrated South Australian Activity Collection;

LOS: Length of stay;

PPH: Potentially preventable hospitalisation;

SA: South Australia;

SLA: Statistical Local Areas;

Author contributions

DB conceived the project, performed the analyses and drafted the manuscript; TC contributed to literature searching and manuscript preparation; JK, AB and JL made important

contributions to operationalising this study, interpreting the statistical analysis, and revised the manuscript. All authors read and approved the final version of the manuscript.

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The authors declare they have no competing interests.

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Data Sharing Statement

The study's data comprised of de-identified unit record administrative records. These were used under privileged arrangements set out in a study specific confidentiality deed. The data cannot be accessed by another party without relevant departmental and human research ethics approvals.

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Table 1 Demographic and diagnostic distribution of Aboriginal and non-Aboriginal patients experiencing a first chronic PPH in SA public hospitals, 2005-06 to 2010-11

	Aboriginal			non-Aboriginal		
	N	%	Patients per 1000 population each year	N	%	Patients per 1000 population each year
Chronic PPH	1,892	100.0%	11.5	58,316	100.0%	6.2
Conditions^						
Angina	293	15.5%	1.8	10,587	18.2%	1.1
Asthma	528	27.9%	3.2	12,346	21.2%	1.3
COPD	341	18.0%	2.1	11,930	20.5%	1.3
Congestive cardiac failure	221	11.7%	1.4	11,079	19.0%	1.2
Diabetes complications	700	37.0%	4.3	12,574	21.6%	1.3
Hypertension	79	4.2%	0.5	2,199	3.8%	0.2
Iron Deficiency Anaemia	107	5.7%	0.7	4,974	8.5%	0.5
Nutritional deficiencies	0	0.0%	0.0	62	0.1%	0.0
Rheumatic heart disease	42	2.2%	0.3	592	1.0%	0.1
Gender						
Male	860	45.5%	10.6	29,970	51.4%	6.5
Female	1,032	54.5%	12.4	28,346	48.6%	6.0
Age						
0-4	167	8.8%	8.6	4,148	7.1%	8.1
5-14	137	7.2%	3.5	3,775	6.5%	3.4
15-24	92	4.9%	2.7	1,691	2.9%	1.4
25-34	115	6.1%	5.0	1,531	2.6%	1.3
35-44	264	14.0%	13.1	2,452	4.2%	1.9
45-54	429	22.7%	28.8	4,211	7.2%	3.2
55-64	355	18.8%	44.2	6,714	11.5%	5.8
65-74	223	11.8%	61.0	9,583	16.4%	12.7
75+	110	5.8%	59.7	24,211	41.5%	32.8
Area Disadvantage (2011 IRSD)						
Q1 Least Disadvantage	31	1.6%	3.7	6,298	10.8%	3.4
Q2	128	6.8%	7.7	10,799	18.5%	5.1
Q3	159	8.4%	7.6	10,918	18.7%	6.6
Q4	551	29.1%	11.6	17,739	30.4%	7.4
Q5 Most Disadvantage	1,023	54.1%	14.5	15,562	26.7%	8.9
Area Remoteness (ARIA+)						
Major cities	677	35.8%	8.0	37,532	64.4%	5.6
Regional	813	43.0%	13.7	18,329	31.4%	7.7
Remote	402	21.2%	19.4	2,455	4.2%	7.7

^Subtotals of N=2,311 and 66,343 respectively. Does not round to 100% as chronic PPH can include more than one condition

Table 2 Mean number of separations, total LOS and hospital cost associated with chronic PPH in South Australian public hospitals, 2005-06 to 2010-11

	Number of chronic PPH				LOS for chronic PPH				Costs of chronic PPH			
	Aboriginal		non-Aboriginal		Aboriginal		non-Aboriginal		Aboriginal		non-Aboriginal	
	Mean	95% CIs	Mean	95% CIs	Mean	95% CIs	Mean	95% CIs	Mean	95% CIs	Mean	95% CIs
Chronic PPH	2.6	2.4-2.8	1.9	1.9-1.9	11.7	10.6-12.7	9.0	8.9-9.2	$ 17,928	$16,367-$19,490	$ 11,515	$11,344-$11,686
Conditions												
Diabetes complications	2.4	2.1-2.6	1.8	1.8-1.9	13.3	11.7-15.0	10.0	9.7-10.3	$ 20,665	$18,253-$23,077	$ 14,601	$14,172-$15,031
Other than diabetes	2.4	2.2-2.6	1.8	1.8-1.9	9.2	8.1-10.3	8.3	8.1-8.4	$ 14,074	$12,416-$15,733	$ 10,083	$9,916-$10,250
Gender												
Male	2.7	2.5-3.0	1.9	1.9-2.0	12.2	10.7-13.7	9.1	8.9-9.3	$ 18,895	$16,794-$20,997	$ 11,993	$11,749-$12,237
Female	2.5	2.3-2.8	1.9	1.9-1.9	11.2	9.7-12.7	9.0	8.7-9.2	$ 17,121	$14,856-$19,386	$ 11,009	$10,769-$11,249
Age												
0-4	1.5	1.3-1.6	1.6	1.5-1.6	2.9	2.3-3.4	2.5	2.4-2.6	$ 5,000	$3,743-$6,256	$ 4,178	$4,041-$4,315
5-14	2.1	1.7-2.5	1.9	1.8-1.9	4.6	3.3-6.0	3.7	3.4-3.9	$ 6,700	$5,232-$8,168	$ 5,775	$5,499-$6,051
15-24	1.9	1.2-2.5	2.1	1.9-2.2	6.3	4.0-8.7	4.9	4.3-5.5	$ 14,070	$8,113-$20,028	$ 8,460	$7,524-$9,396
25-34	2.4	1.5-3.3	1.7	1.6-1.8	11.0	5.8-16.2	4.0	3.6-4.4	$ 18,513	$9,779-$27,247	$ 6,339	$5,767-$6,910
35-44	2.2	1.9-2.5	1.7	1.6-1.9	10.1	7.9-12.4	6.1	4.9-7.3	$ 15,854	$12,503-$19,206	$ 9,220	$7,878-$10,562
45-54	2.7	2.4-3.1	1.7	1.7-1.8	12.0	9.9-14.1	7.3	6.6-7.9	$ 19,096	$15,989-$22,202	$ 10,623	$9,809-$11,438
55-64	3.2	2.6-3.8	1.9	1.8-2.0	14.9	12.0-17.8	8.9	8.4-9.3	$ 24,023	$19,306-$28,740	$ 12,291	$11,696-$12,886
65-74	3.4	2.8-4.1	2.0	2.0-2.1	18.6	14.1-23.0	10.5	10.1-10.9	$ 25,820	$20,512-$31,128	$ 13,940	$13,440-$14,441
75+	2.8	2.1-3.4	2.0	2.0-2.0	17.1	11.7-22.6	11.7	11.5-11.9	$ 19,258	$13,985-$24,532	$ 13,420	$13,189-$13,651
Area Disadvantage (2011 IRSD)												
Q1 Least Disadvantage	2.4	1.4-3.3	1.8	1.7-1.8	7.1	3.3-10.8	7.9	7.5-8.3	$ 12,481	$4,338-$20,624	$ 9,908	$9,474-$10,341
Q2	2.5	2.0-3.1	1.8	1.8-1.9	10.1	7.0-13.2	8.8	8.4-9.2	$ 15,995	$10,932-$21,058	$ 11,176	$10,728-$11,625
Q3	2.4	1.9-3.0	1.9	1.9-2.0	12.3	7.9-16.8	9.5	9.1-9.8	$ 16,776	$11,410-$22,142	$ 11,788	$11,389-$12,186
Q4	2.5	2.2-2.8	1.9	1.9-1.9	10.7	9.0-12.5	8.9	8.6-9.1	$ 17,228	$14,710-$19,746	$ 11,372	$11,053-$11,691
Q5 Most Disadvantage	2.8	2.5-3.0	2.1	2.0-2.1	12.4	10.8-14.0	9.5	9.2-9.8	$ 18,503	$16,208-$20,798	$ 12,351	$12,012-$12,689
Area Remoteness (ARIA+)												
Major cities	2.5	2.2-2.8	1.9	1.9-2.0	10.8	9.0-12.6	9.3	9.2-9.5	$ 16,918	$14,110-$19,727	$ 11,892	$11,667-$12,116
Regional	2.7	2.4-3.0	1.9	1.9-1.9	11.7	10.0-13.4	8.5	8.2-8.7	$ 16,575	$14,413-$18,737	$ 10,753	$10,481-$11,024
Remote	2.7	2.3-3.1	1.8	1.7-1.9	13.1	10.8-15.4	8.5	7.9-9.1	$ 21,377	$17,931-$24,824	$ 11,490	$10,673-$12,307

Table 3 Relationship of SLA attributes with standardised ratios[#] of LOS and cost by Aboriginality, SA public hospitals 2005-06 to 2010-11

	Aboriginal				non-Aboriginal			
LOS	Change co-efficient	95%CIs	p	N (SLAs)	Change co-efficient	95%CIs	p	N (SLAs)
Chronic PPH				118				119
Constant	2.09	0.00-5.83	<0.001		0.46	0.38-0.54	<0.001	
Area disadvantage rank (2011 IRSD)[a]	0.03	0.00-0.07	0.005		0.01	0.01-0.01	<0.001	
Area remoteness (ARIA+)[b]	1.04	0.63-1.44	<0.001		0.02	0.00-0.04	0.183	
Diabetes complications PPH								
Constant	2.59	0.00-10.82	0.003		0.41	0.31-0.52	<0.001	
Area disadvantage rank (2011 IRSD)[a]	0.05	0.00-0.15	0.005		0.01	0.01-0.01	<0.001	
Area remoteness (ARIA+)[b]	1.62	0.73-2.51	<0.001		0.02	0.00-0.05	0.225	
Other chronic PPH								
Constant	1.86	0.00-5.45	<0.001		0.48	0.39-0.56	<0.001	
Area disadvantage rank (2011 IRSD)[a]	0.02	0.00-0.06	0.004		0.01	0.01-0.01	<0.001	
Area remoteness (ARIA+)[b]	0.82	0.43-1.21	<0.001		0.01	0.00-0.04	0.258	
Cost								
Chronic PPH								
Constant	2.44	0.00-5.92	<0.001		0.44	0.36-0.51	<0.001	
Area disadvantage rank (2011 IRSD)[a]	0.02	0.00-0.06	0.008		0.01	0.01-0.01	<0.001	
Area remoteness (ARIA+)[b]	1.18	0.80-1.55	<0.001		0.02	0.00-0.04	0.078	
Diabetes complications PPH								
Constant	3.95	0.00-10.88	<0.001		0.40	0.30-0.50	<0.001	
Area disadvantage rank (2011 IRSD)[a]	0.03	0.00-0.12	0.006		0.01	0.01-0.01	<0.001	
Area remoteness (ARIA+)[b]	1.43	0.68-2.18	<0.001		0.02	0.00-0.05	0.258	
Other chronic PPH								
Constant	1.74	0.77-5.40	<0.001		0.45	0.37-0.53	<0.001	
Area disadvantage rank (2011 IRSD)[a]	0.02	0.00-0.06	0.005		0.01	0.01-0.01	<0.001	
Area remoteness (ARIA+)[b]	1.08	0.69-1.48	<0.001		0.02	0.00-0.04	0.090	

[#] Square root transformed

[a] Change is per one unit increase in SLA disadvantage rank

[b] Change is per one unit increase in SLA ARIA+ score

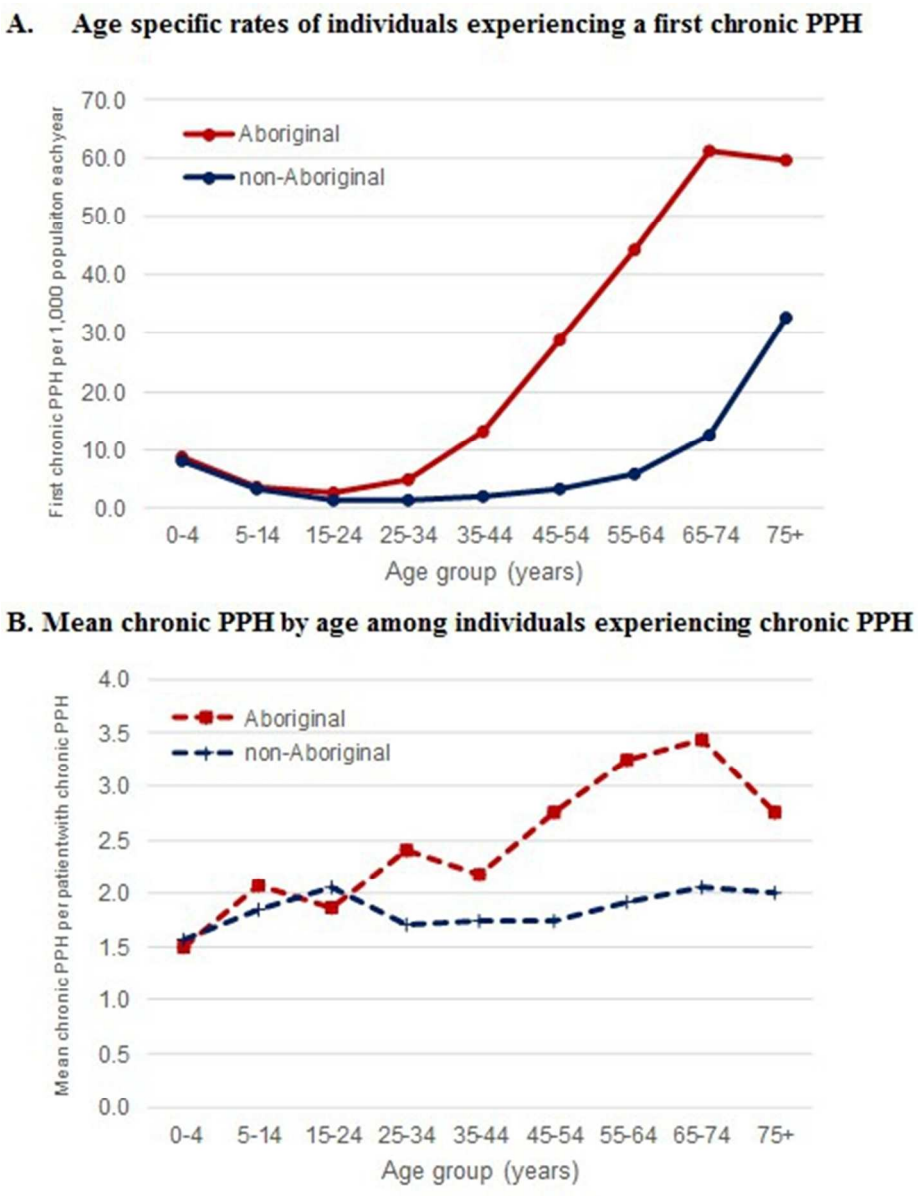

Figure 1 Rate of individuals with first chronic PPH and subsequent mean of chronic PPH by age and Aboriginality, SA public hospitals 2005-06 to 2010-11

132x165mm (98 x 98 DPI)

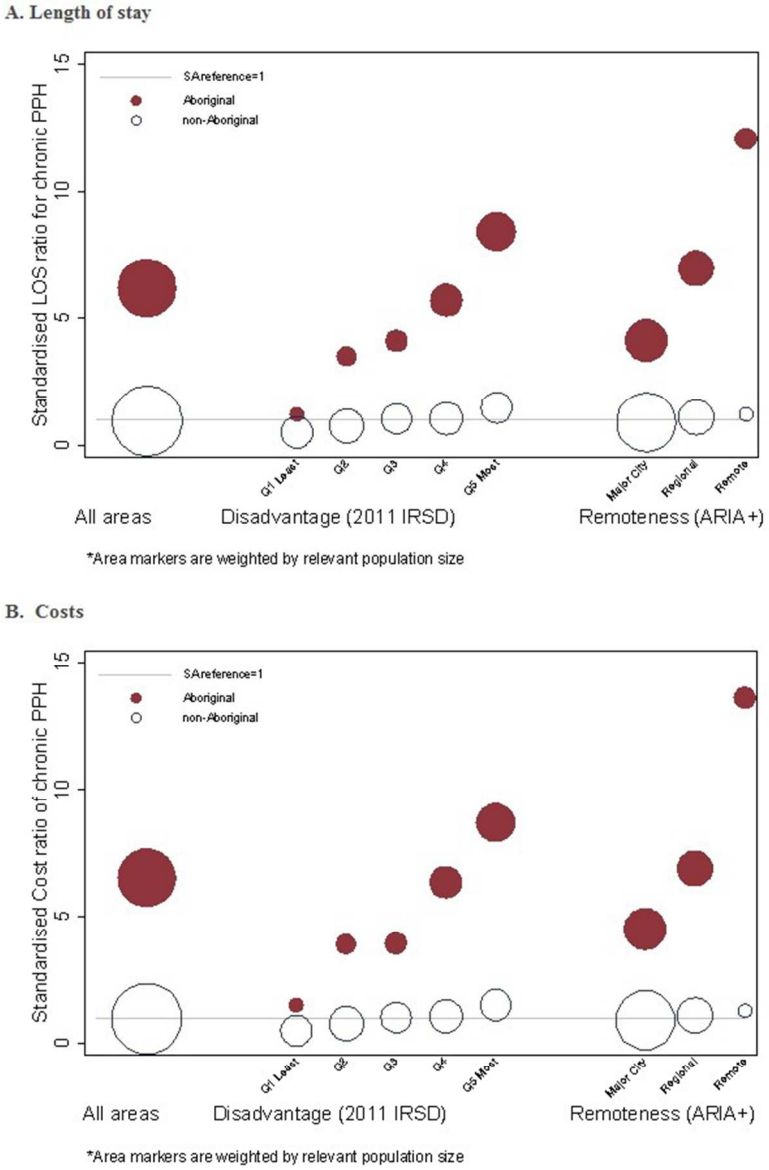

Figure 2 Ratio of sex and age adjusted public hospital LOS (Panel A) and costs (Panel B) for chronic PPH by Aboriginality, disadvantage and remoteness in SA, 2005-06 to 2010-11*

161x243mm (96 x 96 DPI)

Supplemental Online Table A ICD-10-AM codes for chronic potentially preventable hospitalisations (PPH)*

Chronic condition	ICD-10-AM codes
Asthma	J45, J46 as principal diagnosis only
Congestive cardiac failure	I50, I11.0, J81 as principal diagnosis only, exclude cases with the following procedure codes: 33172-00, 38256-00, 38270-01, 38456-19, 38456-15, 38456-12, 38456-11, 38456-10, 38470-00, 38475-00, 38480-02, 38480-01, 38480-00, 38488-06, 38488-04, 38489-04, 38488-02, 38489-03, 38489-02, 38488-00, 38489-00, 38490-00, 38493-00, 38497-04, 38497-03, 38497-02, 38497-01, 38456-01, 38487-00, 38497-00, 38500-00, 38503-00, 38505-00, 38612-00, 38615-00, 38653-00, 38700-02, 38700-00, 38739-00, 38742-02, 38742-00, 38745-00, 38751-02, 38751-00, 38757-02, 38757-01, 38757-00, 90204-00, 90205-00, 90219-00, 90224-00.
Diabetes complications	E10–E14.9 as principal diagnoses
COPD	J20, J41, J42, J43, J44, J47 as principal diagnosis only, J20 only with additional diagnoses of J41, J42, J43,J44, J47
Angina	I20, I24.0, I24.8, I24.9 as principal diagnosis only, exclude cases with procedure codes not in blocks [1820] to [2016]
Iron deficiency anaemia	D50.1, D50.8, D50.9 as principal diagnosis only.
Hypertension	I10, I11.9 as principal diagnosis only, exclude cases with procedure codes according to the list of procedures excluded from the Congestive cardiac failure category above.
Nutritional deficiencies	E40, E41, E42, E43, E55.0, E64.3 as principal diagnosis only.
Rheumatic heart disease	I00 to I09 as principal diagnosis only. (Note: includes acute rheumatic fever)

*Australian Institute of Health and Welfare codes used for identifying chronic potentially preventable hospitalisations within SA Health records released in 4/2015.

Supplemental Online Table B Distribution of population by area disadvantage, remoteness and Aboriginal status, South Australia, 2006 to 2011 average excluding APY Lands

Aboriginal

	Major cities		Regional		Remote		Total	
	N	Percent	N	Percent	N	Percent	N	Percent
Age								
0-4	1,656	6.1%	1,178	4.3%	403	1.5%	3,238	11.8%
5-14	3,344	12.2%	2,335	8.5%	799	2.9%	6,479	23.7%
15-24	3,046	11.1%	2,000	7.3%	679	2.5%	5,724	20.9%
25-34	2,033	7.4%	1,322	4.8%	474	1.7%	3,828	14.0%
35-44	1,675	6.1%	1,218	4.5%	463	1.7%	3,355	12.3%
45-54	1,241	4.5%	884	3.2%	362	1.3%	2,487	9.1%
55-64	633	2.3%	541	2.0%	164	0.6%	1,338	4.9%
65-74	279	1.0%	258	0.9%	72	0.3%	609	2.2%
75+	150	0.5%	126	0.5%	32	0.1%	307	1.1%
Area Disadvantage (2011 IRSD)								
Q1 Least Disadvantage	1,051	3.8%	257	0.9%	97	0.4%	1,406	5.1%
Q2	2,154	7.9%	483	1.8%	144	0.5%	2,781	10.2%
Q3	2,517	9.2%	815	3.0%	140	0.5%	3,472	12.7%
Q4	3,588	13.1%	2,137	7.8%	2,220	8.1%	7,945	29.0%
Q5 Most Disadvantage	4,746	17.3%	6,170	22.5%	846	3.1%	11,762	43.0%
Total	**14,056**	**51.4%**	**9,862**	**36.0%**	**3,448**	**12.6%**	**27,366**	**100.0%**

non-Aboriginal

	Major cities		Regional		Remote		Total	
	N	Percent	N	Percent	N	Percent	N	Percent
Age								
0-4	59,436	3.8%	22,616	1.5%	3,438	0.2%	85,490	5.5%
5-14	124,954	8.0%	52,155	3.3%	7,139	0.5%	184,249	11.8%
15-24	157,384	10.1%	46,228	3.0%	5,791	0.4%	209,403	13.4%
25-34	151,022	9.7%	42,991	2.8%	6,781	0.4%	200,794	12.9%
35-44	152,948	9.8%	53,955	3.5%	7,691	0.5%	214,594	13.8%
45-54	155,542	10.0%	58,966	3.8%	7,817	0.5%	222,326	14.3%
55-64	131,546	8.4%	53,794	3.5%	6,979	0.4%	192,319	12.3%
65-74	85,890	5.5%	35,964	2.3%	4,168	0.3%	126,022	8.1%
75+	89,966	5.8%	29,574	1.9%	3,508	0.2%	123,049	7.9%
Area Disadvantage (2011 IRSD)								
Q1 Least Disadvantage	249,709	16.0%	51,252	3.3%	6,068	0.4%	307,029	19.7%
Q2	300,646	19.3%	57,501	3.7%	7,839	0.5%	365,986	23.5%
Q3	209,834	13.5%	64,390	4.1%	13,559	0.9%	287,783	18.5%
Q4	211,354	13.6%	105,166	6.7%	21,091	1.4%	337,611	21.7%
Q5 Most Disadvantage	175,782	11.3%	122,500	7.9%	3,703	0.2%	301,985	19.4%
Total	**1,108,690**	**71.1%**	**396,244**	**25.4%**	**53,312**	**3.4%**	**1,558,246**	**100.0%**

*Sourced from ABS 3238.0.55.001

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1&2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7&8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	7&8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8&9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7&8
Bias	9	Describe any efforts to address potential sources of bias	8
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8&9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8&9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	N/A Study uses mandatory fields within administrative data.

		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	8&9
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	Not considered appropriate
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9&10
		(*b*) Report category boundaries when continuous variables were categorized	Defined p8; Reported pp10-13
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10-13
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.