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Geographical disparities in acute respiratory infections in Western Australian emergency departments and risk factors for presenting

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ABSTRACT

Studies examining Acute Respiratory Infections (ARIs) in Emergency Department (EDs), particularly in rural and remote areas, are rare. This study aimed to examine the burden of ARIs among Aboriginal and non-Aboriginal children presenting to Western Australian (WA) EDs from 2002 to 2012.

Method Using a retrospective population-based cohort study linking ED records to birth and perinatal records, we examined presentation rates for metropolitan, rural and remote Aboriginal and non-Aboriginal children from 469,589 births. We used ED diagnosis information to categorise presentations into ARI groups and calculated age-specific rates. Negative binomial regression was used to investigate association between risk factors and frequency of ARI presentation.

Results Overall 26% of presentations were for ARIs. For Aboriginal children, the highest rates were for those aged <12 months in the Great Southern (1,233 per 1,000 child-years) and Pilbara regions (1,088 per 1,000 child-years). Rates for non-Aboriginal children were highest in children <12 months in the Southwest and Kimberley (400 and 375 per 1,000 child-years respectively). Presentation rates for ARI in children from rural and remote WA significantly increased over time in all age groups <5 years. Risk factors for children presenting to ED with ARI were: male, prematurity, Caesarean delivery, and residence in the Kimberley region and lower socio-economic areas.

Conclusion One-in-four ED presentations in WA children are for ARIs, representing a significant out-of-hospital burden with some evidence of geographical disparity. Planned linkages with hospital discharge and laboratory detection data will aid in assessing the sensitivity and specificity of ARI diagnoses in ED.

Keywords: Child health, epidemiology, infection, respiratory DI, primary health care

Strengths and limitations of this study

- This study demonstrates that emergency department presentation for acute respiratory infections is common in children and identifies population subgroups which utilise emergency services more frequently than others.
- We have conducted a state-wide in-depth investigation into the diagnostic information available from the emergency department data systems with regard to respiratory infections and provided age-specific presentation rates by condition and by geographic location, which can inform future disease control strategies.
- As emergency department location was not available the postcode of the child at birth was used to stratify data by location, which is a limitation of this study.

INTRODUCTION

Globally, acute respiratory infections (ARIs) are responsible for approximately one-in-five deaths in children aged <5 five years and are a major cause of childhood morbidity.[1] Most literature on the burden of ARI in Australian children comes from studies examining hospitalisation data, limiting knowledge to the severe end of the clinical spectrum.[2-9] In Western Australia (WA), 25% of Aboriginal children and 6.5% of non-Aboriginal children are hospitalised at least once for ARI, with infant hospitalisation rates of 276.1/1,000 child-years in Aboriginal children and 44.7/1,000 child-years in non-Aboriginal children.[7] A higher infant hospitalisation rate for ARI of 426.7/1,000 child-years in Aboriginal children was identified in the Northern Territory.[4]

Community-level data on the burden of ARI are important for prevention and policy development. Emergency Department (ED) data is not widely available but data systems exist in the US, Canada, England and Australia with data availability increasing across jurisdictions. In Australia, parent-reported data from both Melbourne and Brisbane has indicated an incidence rate of 0.56 ARIs per child-month in children <2 years.[3, 9] In New South Wales (NSW), Australia, the ED presentation rate

for pertussis in children aged <15 years was 6/100,000 person years[5] and 11,400 ED presentations for influenza were reported among all ages (including adults) between 2005 and 2008.[8] In metropolitan WA, approximately 17-45% of ED presentations in children aged <15 years between 2000 and 2003 were for acute upper respiratory infections[2] and 53% of ED presentations in children <17 years old between 2001 and 2005 were for acute lower respiratory infections (ALRI).[6]

A further knowledge gap is the frequency of ARI in EDs in rural and remote Australia, where higher hospitalisation rates have been reported.[7] ED ARI burden data are essential to inform health service planning and need to be considered when assessing the economic impact of interventions including vaccination.

The Western Australian Data Linkage System (WADLS) combines individual-level data across administrative datasets through probabilistic record linkage using a range of identifying variables and continuously updates datasets.[10] We aimed to examine diagnosis information from ED presentation records in order to describe the overall and age-specific burden of ARIs among Aboriginal and non-Aboriginal children presenting to WA EDs from 2002 to 2012, and compare presentation rates across WA regions. Further, we aimed to examine the monthly distribution and temporal trends of ARI presentations across geographical regions and identify infant, maternal and socio-demographic risk factors for presenting to ED with ARI in WA.

METHODS

Study population, design and setting

We conducted a population-based retrospective cohort study of births in WA between 1996 and 2012. Of WA's total population of 2.6 million, 79% reside in the capital city Perth, and 6.4% are Aboriginal or Torres Strait Islanders (herein referred to as Aboriginal).[11] The climate varies across WA from a Mediterranean climate in metropolitan WA (Perth and its surrounds) and the south of the

State, to dry desert climate in the central regions and tropical climate in the northern regions (Supplementary Figure 1).

Data linkage and population-based datasets

Data were extracted from the Midwives Notification System, Birth and Death Registries and the Emergency Department Data Collection (EDDC) and probabilistically linked through the Western Australian Data Linkage System (WADLS).[10, 12] The EDDC comprises data on ED activity from WA's public and private hospitals.[13] The Midwives Notification System records information on pregnancy, labour and birth and infant and maternal factors and is complete for over 99% of WA births.[14] Our assembled linked dataset contained information on births and deaths in WA from 1996 to 2012 and ED presentations from across the State from birth up to age 17 years from 2002 to 2012 for children in the birth cohort.

Coding of clinical data

Five variables in the ED dataset were used to categorise ED presentations to identify the cause of presentation and specifically identify presentation for an ARI: (1) an International Classification of Diseases (ICD), version 10 code of the principal diagnosis (one code only per presentation), (2) a symptom code (one code per presentation), (3) diagnosis at discharge text, (4) presenting complaint (symptom) text and (5) a major diagnostic category ('diseases and disorders of the respiratory system'). A hierarchy was applied in the order of variables presented above, where those presentations missing a *principal diagnosis* were classified using the *symptom code*, those missing both a *principal diagnosis* and *symptom code* were classified using the *diagnosis at discharge* and so on. We maintained specific diseases as their own category if the group was large enough to analyse (category size ranged from 710 to 118,251 presentations). Other less common conditions were grouped with similar conditions, for example, sinusitis and pharyngitis were included in *other upper*

respiratory diseases. We also identified presentations that could be related to respiratory infections (e.g., *febrile convulsions*) and respiratory infection symptoms (e.g., *wheeze/cough/crackles*). Finally, some chronic conditions were specifically included to capture conditions which may have been masking other acute respiratory conditions or been inaccurately diagnosed due to similar symptoms (e.g., chronic bronchitis). Our coding of the clinical diagnosis and symptom information resulted in 17 ARI categories. Supplementary Table 1 lists the categories with the numbers of associated presentations, the proportion of ED records which the category represented and the variables and codes used to populate the category. A hierarchy was applied in the order presented to make the categories mutually exclusive as text variables could potentially place records in two or more categories. In the final categories, ICD codes identified 66.4% of ARI presentations, symptom codes identified a further 1.0%, text variables 5.4% and the major diagnostic category 27.2% (Figure 1).

Exposure variables

The following risk factors were identified *a priori* for their association with hospitalisation for ARI: sex, mode of delivery, gestational age, percent optimal birth weight (POBW), number of previous pregnancies, maternal age, maternal smoking, Socio-Economic Index for Area (SEIFA), season of birth and geographical region of residence. The POBW measure was used as an appropriate measure of foetal growth as it takes into account the gestational duration, foetal gender, maternal age, maternal height and parity.[15] As the location of the ED departments were not available, residential postcode at birth was used to stratify data into geographical regions. The SEIFA used for this study was the Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD) which indicates relative access to resources and ability to participate in society for households within the same collection district (approximately 200 dwellings) using information from the latest census.[16] The IRSAD incorporates measures of disadvantage which can be offset by the included measures of advantage. The SEIFA score was measured at the time of the child's birth and grouped into quintiles.

Statistical analysis

Dates of birth and death were used to calculate age-specific person-time-at-risk denominators and ARI presentation rates per 1,000 child-years and 95% confidence intervals for Aboriginal and non-Aboriginal children presenting between 2002 and 2012 in each WA region: Metropolitan; South-West; Great Southern; Midwest-Murchison; Wheatbelt; Kimberley; Pilbara; and Goldfields (Supplementary Figure 1). To limit the likelihood that children presenting to ED may have moved from their geographical region at birth, we restricted analyses presented by region to children aged <5 years at time of presentation. Aboriginal status was identified using a validated algorithm in all available records for an individual.[17] Seasonal distributions of presentations were examined by stratifying records by month of presentation. Annual presentation rates were calculated using the year of presentation and tested for linear age-specific annual trends over the study period using negative binomial regression. We also used negative binomial regression to calculate incidence rate ratios for the frequency of ARI presentations in the first five years of life for the infant, maternal and socio-demographic risk factors, entering all potential factors at the same time in separate models for Aboriginal and non-Aboriginal children. To account for intragroup correlation with children presenting multiple times we used the clustered sandwich estimator. Data cleaning was completed using IBM SPSS Statistics, version 24, with statistical analyses conducted in STATA version 14 and EpiBasic version 3.[18] Ethical approval was obtained from the Western Australian Department of Health Human Research Ethics Committee and the WA Aboriginal Health Ethics Committee.

Patient and public involvement

This is a total population-based study examining patient records retrospectively. A community reference group of parents and other members of the general public were consulted prior to project commencement to ensure broad project outcomes were a priority to the community.

RESULTS

Almost all ED presentations (n=1,607,825; 99.5%) between 2002 and 2012 linked to the birth cohort dataset. The remaining records were excluded due to inconsistent date of birth information or being related to children who were not born in WA. Records missing a postcode at the time of birth were also excluded (n=1,568) leaving 1,606,257 ED records pertaining to 337,201 children who presented to ED before age 17 years during the study period (Figure 1). For analyses by geographical region the cohort was restricted to children presenting to ED in the first five years of life (n=1,034,924 records for 269,740 children).

Presentations for ARI

Overall 26% of ED presentations between 2002 and 2012 in children aged <17 years were for ARI (n=418,755) and among presentations for children aged <5 years, 32% were for ARI (n=332,149). Almost three quarters (72%) of children from the birth cohort presented to ED at least once, 40% of children presented to ED at least once for an ARI before age 17 years and 33% of children presented to ED with an ARI before their fifth birthday. There were 90,421 children <17 years with repeat presentations for ARI (range 1-85) and in both Aboriginal and non-Aboriginal children the median number of presentations for ARI per child was one (lower quartile=1, upper quartile=3).

The most common diagnostic categories were *respiratory disease* (n=118,251), *viral illness* (n=72,927), *other upper respiratory disease* (n=61,563), *croup* (n=32,480) and *bronchiolitis* (n=22,446). Approximately 42% of all presentations (n=670,116) only had a *major diagnostic category* as diagnosis information, of which 2,035 presentations were classified as 'unknown'. The *major diagnostic category* variable was used to classify the vast majority (96%) of records which made up the *respiratory disease* category.

Table 1 presents the numbers and rates of presentations for WA children aged < 17 years for each ARI category. Rates were higher for Aboriginal children for most ARI categories except croup and fever, where rates were higher in non-Aboriginal children. The overall presentation rate for ARI in Aboriginal children was 282/1,000 child-years and in Aboriginal children <12 months was 1,028/1,000 child-years. For non-Aboriginal children the overall rate was 116/1,000 child-years and in those <12 months was 297/1,000 child-years.

The *respiratory disease* category had the highest presentation rates for Aboriginal children in each age group, far higher than any other category (185/1,000 child-years overall; Table 1). The highest rates overall were observed in children <12 months old. For most infections or symptoms affecting the lower respiratory system including *pneumonia*, *bronchiolitis*, *pertussis*, *unspecified ALRI*, *bronchitis* and *wheeze/cough/crackles*, rates in Aboriginal children were 2-3 times higher than in non-Aboriginal children under 12 months, but similar in the older age groups.

Presentation for ARI across WA regions

Diagnosis and symptom information available varied between geographical areas. In the metropolitan area, ICD coding was available for 81% of records, whereas use of these codes in EDs outside the metropolitan area ranged from 26% in the South-West to 3.4% in the Kimberley (data not shown). The South-West had the largest proportions of text variable information available (14.6% for diagnosis at discharge text and 16.4% for presenting complaint text).

Table 2 presents the numbers and rates of total ARI presentations in each geographical region. When combined, the overall rates for non-metropolitan areas were higher than metropolitan for non-Aboriginal children (IRR for non-metropolitan to metropolitan=1.19 in children aged <12 months and 1.14 in children aged 1-4 years). The highest rates in Aboriginal children were for those aged <12 months in the Great Southern and Pilbara regions with rates of 1,233 and 1,088 per 1,000 child-years respectively. For non-Aboriginal children, the highest rate was in the South-West in children aged

<12 months (400.3/1,000 child-years). The lowest rates were observed in the Goldfields in children aged 1-4 years (274.9/1,000 child-years in Aboriginal children and 164.4/1,000 child-years in non-Aboriginal children). In Aboriginal children, ARI rates for those <12 months were approximately 2-3 times that of children 1-4 years, whereas in non-Aboriginal children rates for those <12 months were 1.7 times the rates for children 1-4 years.

Figure 2 shows the monthly distribution of the number of presentations for the top five categories of ARI. In the metropolitan area a clear peak of ARI presentation to ED was observed from June to September with the most number of presentations in July/August. The Midwest-Murchison with much fewer presentations showed a similar distribution, peaking in July/August. Monthly presentations in the South-West, Great Southern, Wheatbelt, Goldfields and Pilbara peaked a little later in August, and the Kimberley was the only region with a bimodal distribution peaking in March and July/August. In all regions except metropolitan Perth, the majority of ED presentations were coded *respiratory disease* (Figure 2).

Figure 3 presents the annual age-specific rates for overall ARI in Aboriginal and non-Aboriginal in metropolitan, rural and remote WA by year of presentation. There was an overall increase in ARI over time in all children from rural and remote regions. In non-Aboriginal children from the metropolitan area, increases in ARI rates were observed in those aged 1-5 and 6-11 months. No significant trends were observed in overall ED presentations (data not shown). ARI rates did fluctuate over time, particularly in Aboriginal children in the younger age groups, however rates appear to increase in later years of the study.

Infant, maternal and socio-demographic risk factors for ARI presentation rates were similar in Aboriginal and non-Aboriginal children (Table 3). The strongest risk factors associated with ARI rates in both Aboriginal and non-Aboriginal children were male sex, prematurity, caesarean delivery, birth in the Kimberley and birth in a lower socio-economic area. Maternal age <30 years was also a risk factor in non-Aboriginal children and birth in the Great Southern was a risk factor in Aboriginal

children. The strongest risk factor was gestational age where compared with children born ≥37 weeks, the IRR for Aboriginal children born <29 weeks was 2.70 and for non-Aboriginal children born <29 weeks was 2.60.

DISCUSSION

Our findings suggest a substantial burden on WA emergency departments with approximately one-in-four presentations for ARI and evidence that presentation rates are increasing in children from rural and remote areas. The most common ARI presentation was respiratory disease, with *bronchiolitis* the most common specific diagnosis. Rates for overall ARI ED presentations were high (ranging from 25/1,000 child-years in non-Aboriginal children aged 10-16 years to 1,027/1,000 child-years in Aboriginal children aged <12 months). The burden in Aboriginal children was especially high, with similar disparity to non-Aboriginal children as is observed in hospitalisation rates,[7] demonstrating the ongoing burden of disease in this population. There was some evidence of geographical disparity with the highest rates observed in the Northern and Southern rural regions. The monthly distributions depicted one late winter peak in numbers of ARI presentations (in July/August) in metropolitan WA and most of the rural and remote geographical regions except the Kimberley, with its tropical climate, having a bimodal distribution peaking in March and August. Risk factors for presenting to ED with an ARI were similar in Aboriginal and non-Aboriginal children. The geographical disparity in ED presentation rates, with higher rates observed in children from most rural and remote regions in WA was consistent with findings focused on influenza among all ages in NSW.[8] Reasons for the disparities include relative access to general practitioners and hospitals in the different regions. In particular we have seen here, increases in ED presentation rates in remote areas across all ages. It is unclear whether these increases represent a true increase in disease burden, or increases in data capture in remote areas, and there is a lack of primary health care data from general practices and rural and remote health clinics for comparison.

Seasonal distribution of ED presentations were consistent with patterns we have seen in metropolitan WA respiratory viral detections for Respiratory Syncytial Virus (RSV) and influenza A and B[19] and hospitalisations in NSW for ALRI.[20] The bimodal seasonal distribution of ARI presentations in the far north of WA (remote Kimberley region with a tropical climate) is similar to the distribution of RSV detections in the region and seasonal patterns observed in ARI hospitalisation in the Northern Territory of Australia.[4, 21]

There are subgroups of the population which utilise the ED more frequently than others. While for some groups the higher risk of presentation to ED for an ARI is likely because the disease incidence is higher (e.g., preterm children) for others it could be lack of access to other providers (e.g., general practitioners in rural and remote areas). The risk factors for presenting with ARI to ED were similar to those previously reported risk factors for admission to hospital for ALRI including being male, being born preterm, being from a low socioeconomic area and maternal age <20 years.[7] Two previously observed risk factors for ALRI hospitalisation, maternal smoking and higher number of previous pregnancies,[7] were not risk factors for presenting to ED with overall ARI. This suggests maternal smoking is associated with increased severity of disease or specifically with lower respiratory infections. Different to hospitalisation, presentation to ED may be more influenced by individual psychological and social factors of the child's parents or carers. Parents may be less likely to take their child to ED if they have had experiences with similar conditions in their older children and are more confident to manage their child's illness at home. Conditions presented to ED are likely to vary more in severity whereas hospitalisations tend to be only the very severe cases and the decision to hospitalise is more likely to be made by a clinician.

Croup is a major reason for presentation to ED but has not been found to be a common diagnosis in hospitalisation.[7] Rates for other specific conditions seemed low when compared with hospitalisations. This is likely a result of the high use of non-specific codes in ED, as most cases of respiratory infections are admitted with non-specific diagnoses and either discharged without

testing or admitted while investigations or results are still pending. Most patients in ED will be managed based on clinical presentation and specific diagnoses might be left to the admitting team to clarify. Rates for specific conditions are therefore likely to underestimate the burden and comparisons with hospitalisation rates for specific conditions should be made with caution. The uncertain accuracy of ICD codes in administrative datasets has previously been documented in other data linkage studies.[5, 8, 22] McCallum and colleagues (2014)[5] noted from data linkage work that ED presentations for pertussis were likely to be missed if only coded pertussis is included, due to misclassifications with other respiratory conditions and use of symptom codes for diagnosis coding. Similar results have been found when routine laboratory data are linked with hospital diagnosis data, with certain respiratory pathogens identified across a range of respiratory diagnoses[23] and 38% of laboratory-confirmed hospital admissions for respiratory infections not having a respiratory infection ICD hospital diagnosis.[22] The non-specific nature of the diagnostic coding also makes the severity of conditions in the ED unclear. While some presentations for severe conditions have an ICD code indicating this (e.g., Whooping cough) others could be just as severe but be coded as 'respiratory disease'. This is particularly likely in some remote regions which do not appear to use ICD-coding. Across regions, ICD coding was available for 81% of records in metropolitan WA, and in rural and remote areas ranged from 26% in the South-West to 3.4% in the Kimberley. In contrast, use of the very broad major diagnostic category in rural and remote areas ranged from 56% in the South-West to 96% in the Kimberley, versus only 12% in metropolitan WA. This highlights the inconsistencies in diagnostic practices across WA that make regional comparisons difficult and are important considerations for population-based surveillance in WA. Sufficiently sensitive diagnosis of ARIs in ED is likely to improve the ability to survey and manage specific conditions. The level of laboratory testing in ED is currently unknown and linkages with laboratory data will aid in understanding the burden of specific respiratory infections. While testing results will underestimate the true burden of the specific ARIs because only a proportion of children who present are likely to be hospitalised or tested, it will help us to interpret the non-specific coding used in ED.

ED presentation for ARIs is common and has an enormous impact on the healthcare system. The data from EDs across geographical areas provide essential information for ED planning (both within season and by site) and to use when exploring the impact of specific interventions (e.g., vaccination) or modifications to community health services (e.g., establishing general practitioner after-hours clinics). There is a lack of primary healthcare data with diagnostic information in the community in general and these ED data will be important for understanding where to target prevention strategies and form the baseline for evaluating policies.

Contributors

RB, CCB, NdK, PR and HCM contributed to study design, methods and planning. RB completed all statistical analyses, drafted the manuscript and managed revisions. All authors provided interpretation of the data and revisions and approved the final manuscript.

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Competing interests

HCM reports receiving grants to their institution from the NHMRC during the conduct of this study.

Data sharing statement

No additional data available.

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Figure 1. Selection of participants and coding of acute respiratory infections

Table 1. Number and rate of emergency department presentations for acute respiratory infections in Western Australian Aboriginal and non-Aboriginal children aged <17 years (2002-2012)

Diagnosis	Age group	Aboriginal			Non-Aboriginal		
		n	Rate[a]	95% CI	n	Rate[a]	95% CI
Pertussis	< 12 months	62	3.0	(2.3, 3.8)	302	1.0	(0.9, 1.2)
	1-4 years	26	0.3	(0.2, 0.5)	195	0.2	(0.2, 0.2)
	5-9 years	<5	-	-	72	0.1	(0.1, 0.1)
	10-16 years	<5	-	-	50	0.1	(0.1, 0.1)
	Total	91	0.4	(0.3, 0.5)	619	0.2	(0.2, 0.2)
Pneumonia	< 12 months	241	11.6	(10.2, 13.2)	1,079	3.7	(3.5, 3.9)
	1-4 years	564	7.0	(6.4, 7.6)	5,985	5.4	(5.3, 5.6)
	5-9 years	142	1.8	(1.5, 2.1)	1,791	1.6	(1.5, 1.7)
	10-16 years	82	2.1	(1.6, 2.5)	438	0.8	(0.7, 0.9)
	Total	1,029	4.6	(4.4, 4.9)	9,293	3.0	(3.0, 3.1)
Bronchiolitis	< 12 months	2,342	112.9	(108.4, 117.6)	16,252	55.7	(54.9, 56.6)
	1-4 years	388	4.8	(4.3, 5.3)	3,441	3.1	(3.0, 3.2)
	5-9 years	0	-	-	21	0.0	(0.0, 0.0)
	10-16 years	0	-	-	<5	-	-
	Total	2,730	12.3	(11.8, 12.7)	19,720^	6.4	(6.3, 6.5)
Influenza	< 12 months	25	1.2	(0.8, 1.8)	215	0.7	(0.6, 0.8)
	1-4 years	53	0.7	(0.5, 0.9)	690	0.6	(0.6, 0.7)
	5-9 years	30	0.4	(0.3, 0.5)	451	0.4	(0.4, 0.5)
	10-16 years	26	0.7	(0.4, 1.0)	284	0.5	(0.5, 0.6)
	Total	134	0.6	(0.5, 0.7)	1,640	0.5	(0.5, 0.6)
Unspecified ALRI	< 12 months	98	4.7	(3.8, 5.8)	656	2.2	(2.1, 2.4)
	1-4 years	197	2.4	(2.1, 2.8)	2,114	1.9	(1.8, 2.0)
	5-9 years	39	0.5	(0.3, 0.7)	562	0.5	(0.5, 0.6)
	10-16 years	15	0.4	(0.2, 0.6)	99	0.2	(0.1, 0.2)
	Total	349	1.6	(1.4, 1.7)	3,431	1.1	(1.1, 1.2)
Bronchitis	< 12 months	40	1.9	(1.4, 2.6)	223	0.8	(0.7, 0.9)
	1-4 years	52	0.6	(0.5, 0.8)	567	0.5	(0.5, 0.6)
	5-9 years	17	0.2	(0.1, 0.3)	210	0.2	(0.2, 0.2)
	10-16 years	11	0.3	(0.1, 0.5)	114	0.2	(0.2, 0.2)
	Total	120	0.5	(0.5, 0.6)	1,114	0.4	(0.3, 0.4)
Croup	< 12 months	260	12.5	(11.1, 14.2)	4,662	16.0	(15.5, 16.4)
	1-4 years	899	11.2	(10.4, 11.9)	21,133	19.2	(18.9, 19.4)
	5-9 years	239	2.9	(2.6, 3.3)	5,000	4.5	(4.4, 4.7)
	10-16 years	13	0.3	(0.1, 0.5)	274	0.0	(0.4, 0.5)
	Total	1,411	6.3	(6.0, 6.7)	31,069	10.1	(10.0, 10.3)
Febrile convulsion	< 12 months	83	4.0	(3.2, 5.0)	996	3.4	(3.2, 3.6)
	1-4 years	355	4.4	(4.0, 4.9)	6,948	6.3	(6.2, 6.5)
	5-9 years	90	1.1	(0.9, 1.4)	783	0.7	(0.7, 0.8)
	10-16 years	36	0.9	(0.6, 1.2)	263	0.5	(0.4, 0.5)
	Total	564	2.5	(2.3, 2.8)	8,990	2.9	(2.9, 3.0)
Wheeze/ cough/ crackles	< 12 months	359	17.3	(15.6, 19.2)	2,503	8.6	(8.3, 8.9)
	1-4 years	370	4.6	(4.1, 5.1)	4,870	4.4	(4.3, 4.5)
	5-9 years	111	1.4	(1.1, 1.6)	1,776	1.6	(1.5, 1.7)
	10-16 years	38	1.0	(0.7, 1.3)	537	1.0	(0.9, 1.0)
	Total	878	3.9	(3.7, 4.2)	9,686	3.2	(3.1, 3.2)
Viral illness	< 12 months	1,443	69.6	(66.0, 73.3)	17,163	58.9	(58.0, 59.7)
	1-4 years	2,013	25.0	(23.9, 26.1)	38,024	34.5	(34.2, 34.9)
	5-9 years	746	9.2	(8.6, 9.9)	10,861	9.8	(9.6, 10.0)
	10-16 years	222	5.6	(4.9, 6.3)	2,455	4.3	(4.2, 4.5)
	Total	4,424	19.9	(19.3, 20.5)	68,503	22.4	(22.2, 22.5)

Diagnosis	Age group	Aboriginal			Non-Aboriginal		
		n	Rate[a]	95% CI	n	Rate[a]	95% CI
Fever	< 12 months	298	14.4	(12.8, 16.1)	5,344	18.3	(17.8, 18.8)
	1-4 years	495	6.1	(5.6, 6.7)	9,592	8.7	(34.2, 34.9)
	5-9 years	151	1.9	1.6, 2.2	2,072	1.9	(1.8, 2.0)
	10-16 years	36	0.9	(0.6, 1.2)	435	0.8	(0.7, 0.8)
	Total	980	4.4	(4.1, 4.7)	17,443	5.7	(5.6, 5.8)
Otitis media	< 12 months	236	11.4	(10.0, 12.9)	1,575	5.4	(5.1, 5.7)
	1-4 years	668	8.3	(7.7, 8.9)	8,630	7.8	(7.7, 8.0)
	5-9 years	313	3.9	(3.4, 4.3)	3,845	3.5	(3.4, 3.6)
	10-16 years	71	1.8	(1.4, 2.2)	535	0.9	(0.9, 1.0)
	Total	1,288	5.8	(5.5, 6.1)	14,585	4.8	(4.7, 4.8)
Tonsillitis	< 12 months	56	2.7	(2.0, 3.5)	1,267	4.3	(4.1, 4.6)
	1-4 years	369	4.6	(4.1, 5.1)	9,844	8.9	(8.8, 9.1)
	5-9 years	325	4.0	(3.6, 4.5)	3,361	3.0	(2.9, 3.1)
	10-16 years	237	5.9	(5.2, 6.7)	1,082	1.9	(1.8, 2.0)
	Total	987	4.4	(4.2, 4.7)	15,554	5.1	(5.0, 5.2)
Other upper respiratory disease	< 12 months	1,889	91.1	(87.0, 95.3)	17,040	58.4	(57.6, 59.3)
	1-4 years	2,256	28.0	(26.9, 29.2)	30,464	27.7	(27.3, 28.0)
	5-9 years	602	7.4	(6.8, 8.0)	7,228	6.5	(6.4, 6.7)
	10-16 years	247	6.2	(5.4, 7.0)	1,837	3.3	(3.1, 3.4)
	Total	4,994	22.5	(21.8, 23.1)	56,569	18.5	(18.3, 18.6)
Other lower respiratory disease	< 12 months	15	0.7	(0.4, 1.2)	67	0.2	(0.2, 0.3)
	1-4 years	44	0.5	(0.4, 0.7)	205	0.2	(0.2, 0.2)
	5-9 years	16	0.2	(0.1, 0.3)	109	0.1	(0.1, 0.1)
	10-16 years	10	0.3	(0.1, 0.5)	77	0.1	(0.1, 0.2)
	Total	85	0.4	(0.3, 0.5)	458	0.1	(0.1, 0.2)
Respiratory disease	< 12 months	13,817	666.1	(655.1, 677.3)	17,009	58.3	(57.5, 59.2)
	1-4 years	18,762	232.9	(229.5, 236.2)	40,461	36.7	(36.4, 37.1)
	5-9 years	6,520	80.4	(78.5, 82.4)	15,280	13.8	(13.6, 14.0)
	10-16 years	2,169	54.3	(52.1, 56.7)	4,233	7.5	(7.3, 7.7)
	Total	41,268	185.6	(183.8, 187.4)	76,983	25.1	(25.0, 25.3)
Asthma	< 12 months	52	2.5	(1.9, 3.3)	357	1.2	(1.1, 1.4)
	1-4 years	870	10.8	(10.1, 11.5)	12,579	11.4	(11.2, 11.6)
	5-9 years	358	4.4	(4.0, 4.9)	6,026	5.5	(5.3, 5.6)
	10-16 years	90	2.3	(1.8, 2.8)	1,438	2.5	(2.4, 2.7)
	Total	1,370	6.2	(5.8, 6.5)	20,400	6.7	(6.6, 6.8)
Total ARI	<12 months	21,316	1,027.6	(1,013.9, 1,041.5)	86,710	297.4	(295.4, 299.3)
	1-4 years	28,381	352.2	(348.2, 356.4)	195,742	177.7	(176.9, 178.5)
	5-9 years	9,702	119.7	(117.3, 122.1)	59,448	53.8	(53.4, 54.2)
	10-16 years	3,303	82.7	(79.9, 85.6)	14,153	25.1	(24.6, 25.5)
	Total	62,702	282.0	(279.8, 284.3)	356,053	116.2	(115.8, 116.6)

[a]Rate per 1,000 child-years at risk from Western Australian live births. ^This total has been rounded to the nearest five to conceal small cell size numbers. CI=Confidence interval. ALRI=Acute lower respiratory infections. ARI-Acute respiratory infections.

Table 2. Number and rate of emergency department presentations for acute respiratory infections in Western Australian Aboriginal and non-Aboriginal children aged <5 years (2002-2012) by Western Australian region

Western Australian region	Aboriginal				Non-Aboriginal			
	N	Rate[a]	IRR	(IRR 95% CI)	N	Rate[a]	IRR	(IRR 95% CI)
< 12 months								
Metropolitan	6,941	910.8	Reference		66,143	289.0	Reference	
South-West	729	934.9	1.03	(0.95, 1.11)	6,729	400.3	1.39	(1.35, 1.42)
Great Southern	752	1,233.6	1.35	(1.26, 1.46)	2,345	314.3	1.09	(1.04, 1.13)
Wheatbelt	1,029	1,009.9	1.11	(1.04, 1.18)	2,886	293.3	1.01	(0.98, 1.05)
Midwest-Murchison	2,583	991.3	1.09	(1.04, 1.14)	2,813	355.3	1.23	(1.18, 1.28)
Goldfields	1,409	912.1	1.00	(0.95, 1.06)	2,768	316.0	1.09	(1.05, 1.14)
Pilbara	2,136	1,088.4	1.19	(1.14, 1.25)	2,007	324.8	1.12	(1.07, 1.17)
Kimberley	5,737	900.0	0.99	(0.95, 1.02)	1,019	375.7	1.30	(1.22, 1.38)
(Non-metropolitan)	14,375	965.1	1.06	(1.03, 1.09)	20,567	344.6	1.19	(1.17, 1.21)
1-4 years								
Metropolitan	9,085	311.8	Reference		148,211	173.7	Reference	
South-West	1,071	356.5	1.14	(1.07, 1.22)	16,281	244.2	1.41	(1.38, 1.43)
Great Southern	1,098	456.7	1.46	(1.38, 1.56)	5,540	184.4	1.06	(1.03, 1.09)
Wheatbelt	1,375	352.5	1.13	(1.07, 1.20)	7,011	170.5	0.98	(0.96, 1.01)
Midwest-Murchison	3,414	336.3	1.08	(1.04, 1.12)	6,365	197.3	1.14	(1.11, 1.16)
Goldfields	1,706	274.9	0.88	(0.84, 0.93)	5,925	164.4	0.95	(0.92, 0.97)
Pilbara	2,736	364.6	1.17	(1.12, 1.22)	4,113	172.8	1.00	(0.96, 1.03)
Kimberley	7,896	322.4	1.03	(1.00, 1.07)	2,296	216.4	1.25	(1.20, 1.30)
(Non-metropolitan)	19,296	334.7	1.07	(1.05, 1.10)	47,531	197.6	1.14	(1.13, 1.15)

[a]Rates per 1,000 child-years at risk from Western Australian live births. IRR=Incidence rate ratio. CI=Confidence interval.

Figure 2. Monthly distribution of emergency department presentations for acute respiratory infections in Aboriginal and non-Aboriginal children aged <5 years

Figure 3. Annual age-specific presentation rates for acute respiratory infections in Aboriginal and non-Aboriginal children aged <5 years

Table 3. Infant, maternal and socio-demographic risk factors for presenting to ED with acute respiratory infections between 2002-2012 among Western Australian-born Aboriginal and non-Aboriginal children <5 years

Risk factor	Aboriginal			Non-Aboriginal		
	N	IRR	(95% CI)	N	IRR	(95% CI)
Sex						
Female	22,066	Reference		120,746	Reference	
Male	27,631	1.22	(1.17, 1.28)	161,706	1.28	(1.26, 1.29)
Mode of delivery						
Vaginal	33,002	Reference		144,830	Reference	
Instrumental	3,331	1.15	(1.02, 1.06)	35,055	1.10	(1.08, 1.12)
Elective caesarean	4,118	1.20	(1.11, 1.30)	48,785	1.16	(1.13,1.18)
Emergency caesarean	8,132	1.17	(1.11, 1.25)	46,062	1.22	(1.19, 1.24)
Percent Optimal Birth Weight						
Low (<85%)	11,697	1.08	(1.03, 1.14)	31,587	1.03	(1.01, 1.05)
Normal (85-114%)	29,073	Reference		192,862	Reference	
High (≥115%)	3,441	1.01	(0.93, 1.10)	25,568	1.04	(1.02, 1.06)
Gestational age						
≥37 weeks	40,646	Reference		250,591	Reference	
33-36 weeks	6,269	1.13	(1.07, 1.21)	23,979	1.29	(1.26, 1.33)
29-32 weeks	1,618	1.61	(1.43, 1.83)	4,895	1.82	(1.71, 1.94)
<29 weeks	1,164	2.70	(2.23, 3.27)	2,987	2.60	(2.41, 2.82)
Maternal age						
≥35 years	3,399	Reference		48,479	Reference	
30-34 years	6,337	0.98	(0.90, 1.08)	79,776	1.04	(1.02, 1.07)
25-29 years	11,399	1.05	(0.96, 1.15)	82,427	1.23	(1.21, 1.26)
20-24 years	16,150	1.09	(1.00, 1.20)	54,601	1.52	(1.48, 1.56)
<20 years	12,412	1.18	(1.06, 1.30)	17,169	1.80	(1.73, 1.86)
Number of Previous pregnancies						
0	12,987	Reference		89,891	Reference	
1	10,094	0.89	(0.83, 0.95)	86,126	1.01	(0.99, 1.02)
2	7,994	0.92	(0.86, 1.00)	50,911	1.02	(1.00, 1.04)
≥3	18,622	0.95	(0.88, 1.02)	55,524	1.09	(1.07, 1.12)
Maternal smoking during pregnancy						
No	23,843	Reference		224,791	Reference	
Yes	24,278	1.03	(0.99, 1.08)	50,713	1.14	(1.12, 1.16)
Season of birth						
Spring	11,157	Reference		68,433	Reference	
Summer	12,491	1.08	(1.01, 1.14)	69,096	1.05	(1.03, 1.07)
Autumn	13,684	1.10	(1.04, 1.17)	75,151	1.09	(1.07, 1.11)
Winter	12,365	1.08	(1.02, 1.15)	69,772	1.03	(1.01, 1.05)
Socio-economic index[a]						
91-100%	205	Reference		15,029	Reference	
76-90%	1,313	1.09	(0.86, 1.38)	36,429	1.10	(1.07, 1.14)
26-75%	13,946	1.21	(0.98, 1.50)	134,195	1.28	(1.24, 1.31)
11-25%	11,291	1.30	(1.05, 1.61)	48,811	1.47	(1.43, 1.52)
0-10%	14,102	1.19	(0.96, 1.48)	27,059	1.57	(1.52, 1.63)
Region						
Metropolitan	16,026	Reference		214,354	Reference	
South-West	1,800	0.92	(0.98, 1.21)	23,010	1.13	(1.10, 1.16)
Great Southern	1,850	1.43	(1.27, 1.61)	7,885	0.99	(0.94, 1.04)
Midwest-Murchison	5,997	1.11	(1.02, 1.20)	9,178	1.11	(1.05, 1.16)
Wheatbelt	2,404	1.17	(1.07, 1.29)	9,897	0.95	(0.91, 1.00)
Kimberley	13,633	1.35	(1.27, 1.43)	3,315	1.46	(1.33, 1.61)
Pilbara	4,872	1.18	(1.09, 1.28)	6,120	1.11	(0.05, 1.17)
Goldfields	3,115	0.92	(0.85, 1.01)	8,693	0.96	(0.92, 1.00)

All models adjusted for year of birth. IRR=Incidence rate ratio. CI=Confidence interval. [a] 91-100% represents the least disadvantaged and 0-10% represents the most disadvantaged.

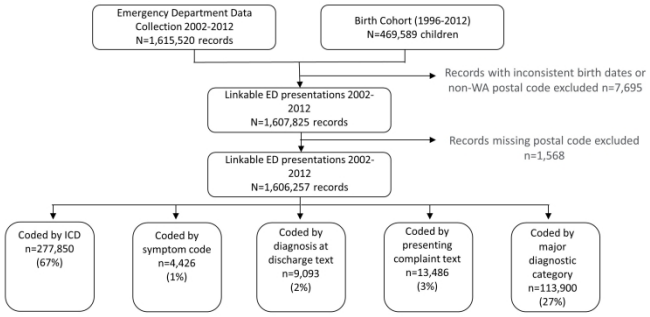

Figure 1. Selection of participants and coding of acute respiratory infections

338x190mm (300 x 300 DPI)

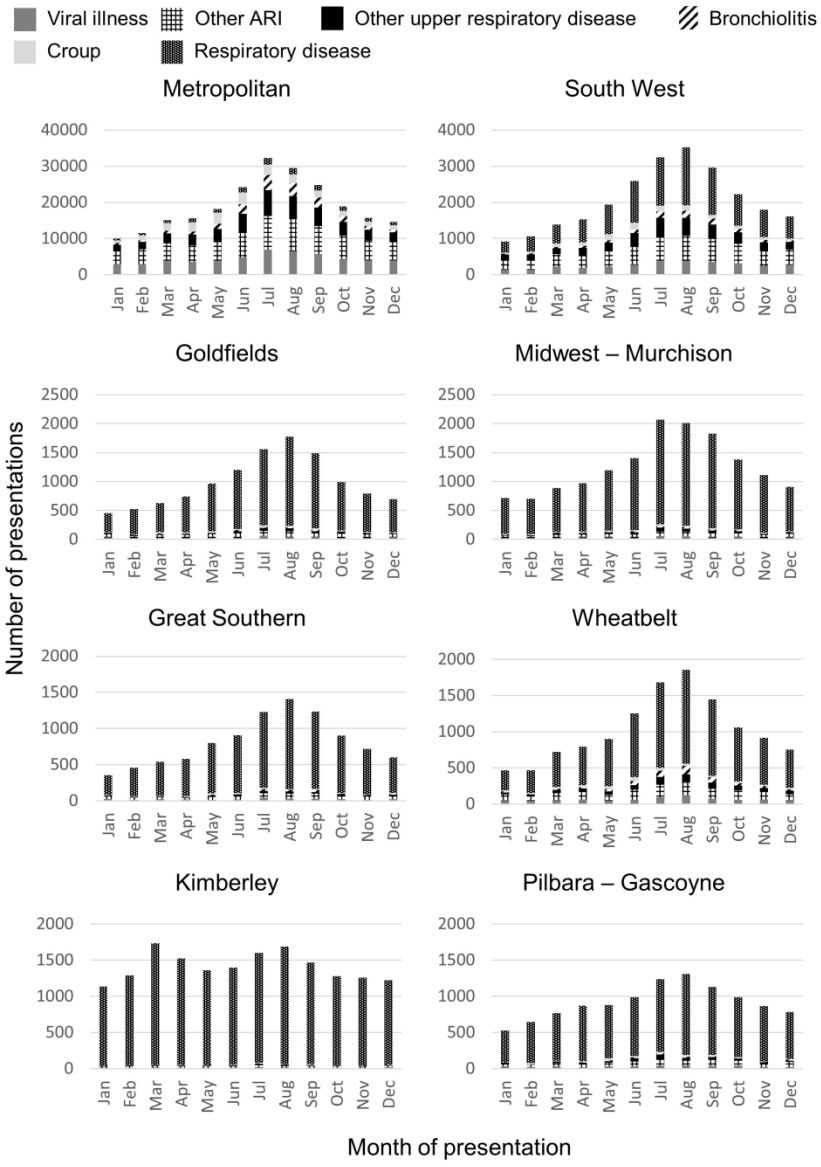

Figure 2. Monthly distribution of emergency department presentations for acute respiratory infections in Aboriginal and non-Aboriginal children aged <5 years

190x275mm (300 x 300 DPI)

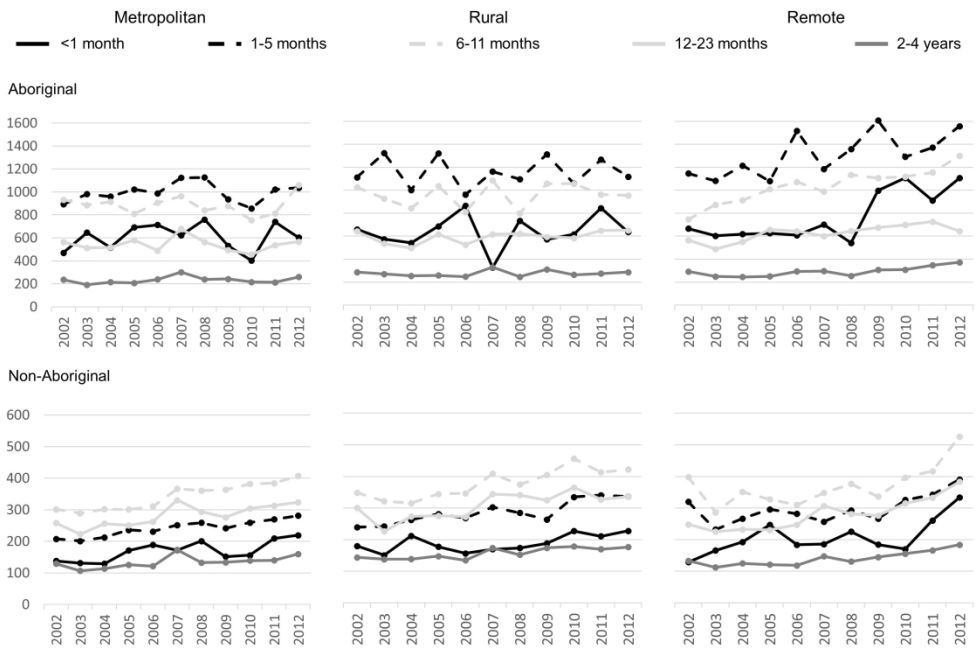

Figure 3. Annual age-specific presentation rates for acute respiratory infections in Aboriginal and non-Aboriginal children aged <5 years

275x190mm (300 x 300 DPI)

Supplementary Figure 1. Western Australian regions

Supplementary table 1. Emergency department acute respiratory infections categories and variable components

Category	N	Percentage of presentations	International Classification of Diseases or Major Diagnostic Category	Symptom code	Key words for text variables
1. Pertussis/Whooping cough	710	0.0	A37 Whooping cough	SNJ Pertussis/whooping cough	Pertussis; whooping cough; post-tussive vomiting
2. Pneumonia	10,322	0.6	J12 Viral pneumonia, not elsewhere classified J13 Pneumonia due to Streptococcus pneumoniae J14 Pneumonia due to Haemophilus influenzae J15 Bacterial pneumonia, not elsewhere classified J16 Pneumonia due to other infectious organisms, not elsewhere classified J17 Pneumonia in diseases classified elsewhere J18 Pneumonia, organism unspecified J10.0 Influenza with pneumonia, other influenza identified J11.0 Influenza with pneumonia, virus not identified	SQJ Pneumonia	Pneumonia
3. Bronchiolitis	22,446	1.4	J21 Acute bronchiolitis		Bronchiolitis
4. Influenza	1,774	0.1	J09 Influenza due to certain identified influenza virus J10.1 Influenza with other respiratory manifestations, other influenza virus identified J10.8 Influenza with other manifestations, other influenza virus identified J11.1 Influenza with other respiratory manifestations, virus not identified J11.8 Influenza with other manifestations, virus not identified	AAV Flu Like Symptoms	Influenza; flu; flu-like symptoms

Category	N	Percentage of presentations	International Classification of Diseases or Major Diagnostic Category	Symptom code	Key words for text variables
5. Unspecified ALRI (includes chest infection & LRTI)	3,780	0.2	J22 Unspecified acute lower respiratory infection	SQD Chest infection	Unspecified Acute Lower Respiratory Infection; LRTI; lower respiratory tract infection; chest infection
6. Bronchitis	1,234	0.1	J20 Acute bronchitis J40 Bronchitis, not specified as acute or chronic	SQC Bronchitis	Bronchitis
7. Croup	32,480	2.0	J05.0 Acute obstructive laryngitis [croup] R06.1 Stridor	CG Stridor	Croup; Laryngotracheobronchitis; barking cough; stridor
8. Convulsions/Febrile convulsions	9,554	0.6	R56.0 Febrile convulsions R56.8 Other and unspecified convulsions	SNG Febrile convulsion	Febrile convulsion; convulsion
9. Wheeze/cough/ crackles	10,564	0.7	R06.2 Wheezing R05 Cough	CH Wheeze CC Cough	Wheeze; wheezing; cough; crackles
10. Viral illness	72,927	4.5	B34 Viral infection of unspecified site		Viral respiratory infection; viral respiratory tract infection; rhinorrhoea; acute viral infection; viral infection; viral illness
11. Fever/Pyrexia	18,423	1.1	R50 Fever of other and unknown origin	S2B Pyrexia of unknown origin VP Pyrexia of unknown origin VD Fever PG Febrile AAU Fever	Fever; pyrexia; febrile; high temperature
12. Otitis Media	15,873	1.0	H65-H67 Otitis media		Otitis media
13. Tonsillitis	16,541	1.0	J03 Acute tonsillitis		Tonsillitis
14. Other upper respiratory diseases	61,563	3.8	J06 Acute Upper Respiratory Infections J00 Acute nasopharyngitis J01 Acute sinusitis	FE Nasal discharge	Upper respiratory tract infection; URTI; nasopharyngitis; sinusitis;

Category	N	Percentage of presentations	International Classification of Diseases or Major Diagnostic Category	Symptom code	Key words for text variables
			J02 Acute pharyngitis J04 Acute laryngitis and tracheitis J05.1 Acute epiglottitis J30-J39 Other diseases of upper respiratory tract		pharyngitis; laryngitis; tracheitis; epiglottitis; rhinitis; runny nose, nasal discharge
15. Other lower respiratory diseases	543	0.0	J41 Simple and mucopurulent chronic bronchitis J42 Unspecified chronic bronchitis J43 Emphysema J44 Other chronic obstructive pulmonary disease J47 Bronchiectasis J60-J70 Lung diseases due to external agents J80-J84 Other respiratory diseases principally affecting the interstitium J85-J86 Suppurative and necrotic conditions of lower respiratory tract J90-J94 Other diseases of pleura		Bronchiectasis; chronic bronchitis; chronic obstructive pulmonary disease; emphysema
16. Respiratory disease	118,251	7.4	MDC 4 Diseases and disorders of the respiratory system J95-J99 Other diseases of the respiratory system	C0000 Respiratory CJ Respiratory distress	Respiratory tract infection; RTI; respiratory infection; respiratory problems; respiratory distress
17. Asthma	21,770	1.4	J45 Asthma J46 Status asthmaticus	SQA Asthma & Status asthmaticus	Asthma
Total ARI	418,755	26.1			

ALRI=Acute lower respiratory infections. LRTI=Lower respiratory tract infections. ARI=Acute respiratory infections.

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort 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	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4-7, fig.1
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7, supplementary table 1
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	5-7
Bias	9	Describe any efforts to address potential sources of bias	7-8
Study size	10	Explain how the study size was arrived at	8, Fig 1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-7, supplementary table 1
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	8, fig. 1
		(*d*) If applicable, explain how loss to follow-up was addressed	NA
		(*e*) Describe any sensitivity analyses	NA
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	8, Fig 1
		(b) Give reasons for non-participation at each stage	Fig 1
		(c) Consider use of a flow diagram	Fig1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8, 18-20
		(b) Indicate number of participants with missing data for each variable of interest	9, 13, 18-20, 23
		(c) Summarise follow-up time (eg, average and total amount)	8
Outcome data	15*	Report numbers of outcome events or summary measures over time	18-20, 23
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	18-20, 23
		(*b*) Report category boundaries when continuous variables were categorized	23
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	3, 11-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	3
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	14

*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.

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Geographical disparities in emergency department presentations for acute respiratory infections and risk factors for presenting: a population-based cohort study of Western Australian children

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Geographical disparities in emergency department presentations for acute respiratory infections and risk factors for presenting: a population-based cohort study of Western Australian children

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ABSTRACT

Studies examining Acute Respiratory Infections (ARIs) in Emergency Department (EDs), particularly in rural and remote areas, are rare. This study aimed to examine the burden of ARIs among Aboriginal and non-Aboriginal children presenting to Western Australian (WA) EDs from 2002 to 2012.

Method Using a retrospective population-based cohort study linking ED records to birth and perinatal records, we examined presentation rates for metropolitan, rural and remote Aboriginal and non-Aboriginal children from 469,589 births. We used ED diagnosis information to categorise presentations into ARI groups and calculated age-specific rates. Negative binomial regression was used to investigate association between risk factors and frequency of ARI presentation.

Results Overall 26% of presentations were for ARIs. For Aboriginal children, the highest rates were for those aged <12 months in the Great Southern (1,233 per 1,000 child-years) and Pilbara regions (1,088 per 1,000 child-years). Rates for non-Aboriginal children were highest in children <12 months in the Southwest and Kimberley (400 and 375 per 1,000 child-years respectively). Presentation rates for ARI in children from rural and remote WA significantly increased over time in all age groups <5 years. Risk factors for children presenting to ED with ARI were: male, prematurity, Caesarean delivery, and residence in the Kimberley region and lower socio-economic areas.

Conclusion One-in-four ED presentations in WA children are for ARIs, representing a significant out-of-hospital burden with some evidence of geographical disparity. Planned linkages with hospital discharge and laboratory detection data will aid in assessing the sensitivity and specificity of ARI diagnoses in ED.

Keywords: Child health, epidemiology, infection, respiratory disease, primary health care

Strengths and limitations of this study

- This study demonstrates that emergency department presentation for acute respiratory infections is common in children and identifies population subgroups which utilise emergency services more frequently than others.
- We have conducted a state-wide in-depth investigation into the diagnostic information available from the emergency department data systems with regard to respiratory infections and provided age-specific presentation rates by condition and by geographic location, which can inform future disease control strategies.
- As emergency department location was not available the postcode of the child at birth was used to stratify data by location, which is a limitation of this study.

INTRODUCTION

Globally, acute respiratory infections (ARIs) are responsible for approximately one-in-five deaths in children aged <5 years and are a major cause of childhood morbidity.[1] Most literature on the burden of ARI in Australian children comes from studies examining hospitalisation data, limiting knowledge to the severe end of the clinical spectrum.[2-9] In Western Australia (WA), 25% of Aboriginal children and 6.5% of non-Aboriginal children are hospitalised at least once for ARI, with infant hospitalisation rates of 276.1/1,000 child-years in Aboriginal children and 44.7/1,000 child-years in non-Aboriginal children.[7] A higher infant hospitalisation rate for ARI of 426.7/1,000 child-years in Aboriginal children was identified in the Northern Territory.[4]

Community-level data on the burden of ARI are important for prevention and policy development. Emergency Department (ED) data is not widely available but data systems exist in the US, Canada, England and Australia with data availability increasing across jurisdictions.[8, 10, 11] In Australia, parent-reported data from both Melbourne and Brisbane has indicated an incidence rate of 0.56 ARIs per child-month in children <2 years.[3, 9] In New South Wales, Australia, the ED presentation rate for

pertussis in children aged <15 years was 6/100,000 person years[5] and 11,400 ED presentations for influenza were reported among all ages (including adults) between 2005 and 2008.[8] In metropolitan WA, approximately 17-45% of ED presentations in children aged <15 years between 2000 and 2003 were for acute upper respiratory infections[2] and 53% of ED presentations in children <17 years old between 2001 and 2005 were for acute lower respiratory infections (ALRI).[6]

A further knowledge gap is the frequency of ARI in EDs in rural and remote Australia, where higher hospitalisation rates have been reported.[7] Emergency department ARI burden data are essential to inform health service planning and need to be considered when assessing the economic impact of interventions including vaccination.

The Western Australian Data Linkage System (WADLS) combines individual-level data across administrative datasets through probabilistic record linkage, matching records using a range of identifying variables (e.g., patient name) and continuously updates datasets.[12] It is one of few comprehensive systems worldwide and consistent with international benchmarks.[12, 13] We aimed to examine diagnosis information from ED presentation records in order to describe the overall and age-specific burden of ARIs among Aboriginal and non-Aboriginal children presenting to WA EDs from 2002 to 2012, and compare presentation rates across WA regions. Further, we aimed to examine the monthly distribution and temporal trends of ARI presentations across geographical regions and identify infant, maternal and socio-demographic risk factors for presenting to ED with ARI in WA.

METHODS

Study population, design and setting

We conducted a population-based retrospective cohort study of births in WA between 1996 and 2012. Of WA's total population of 2.6 million, 79% reside in the capital city Perth, and 6.4% are Aboriginal or Torres Strait Islanders (herein referred to as Aboriginal).[14] Over 60% of Aboriginal people reside in rural and remote regions compared with approximately 27% of non-Aboriginal people.[15] The climate

varies across WA from a Mediterranean climate in metropolitan WA (Perth and its surrounds) and the south of the State, to dry desert climate in the central regions and tropical climate in the northern regions (Supplementary Figure 1).

Data linkage and population-based datasets

Data were extracted from the Midwives Notification System, Birth and Death Registries and the Emergency Department Data Collection (EDDC) and probabilistically linked through the Western Australian Data Linkage System (WADLS).[12, 16] The EDDC comprises data on ED activity from WA's public and private hospitals.[17] The Midwives Notification System records information on pregnancy, labour and birth, and infant and maternal factors and is complete for over 99% of WA births.[13] Our assembled linked dataset contained information on births and deaths in WA from 1996 to 2012 and ED presentations from across the State from birth up to age 17 years from 2002 to 2012 for children in the birth cohort.

Coding of clinical data

Five variables in the ED dataset were used to categorise ED presentations to identify the cause of presentation and specifically identify presentation for an ARI: (1) an International Classification of Diseases (ICD), version 10 code which was the principal diagnosis, (2) a symptom code, (3) diagnosis at discharge text, (4) presenting complaint (symptom) text and (5) a major diagnostic category ('diseases and disorders of the respiratory system'). The ICD code was the most specific diagnosis variable, however only one, if any, ICD code was recorded for a presentation. A hierarchy was applied in the order of variables presented above, where presentations were first classified using the principal diagnosis. Those presentations which were missing a principal diagnosis were classified using the symptom code, those missing both a principal diagnosis and symptom code were classified using the diagnosis at discharge and so on down the hierarchy. We maintained specific diseases as their own

category if the group was large enough to analyse (category size ranged from 710 to 118,251 presentations). Other less common conditions were grouped with similar conditions, for example, sinusitis and pharyngitis were included in *other upper respiratory diseases*. We also identified presentations that could be related to respiratory infections (e.g., *febrile convulsions*) and respiratory infection symptoms (e.g., *wheeze/cough/crackles*). Finally, some chronic conditions were specifically included to capture conditions which may have been masking other acute respiratory conditions or been inaccurately diagnosed due to similar symptoms (e.g., chronic bronchitis). Our coding of the clinical diagnosis and symptom information resulted in 17 ARI categories. Supplementary Table 1 lists the categories with the numbers of associated presentations, the proportion of ED records which the category represented and the variables and codes used to populate the category. A hierarchy was applied in the order presented to make the categories mutually exclusive as text variables could potentially place records in two or more categories.

Exposure variables

We examined for potential risk factors for presenting to emergency with ARI in children aged <5 years. The following risk factors were identified *a priori* for their association with hospitalisation for ARI: sex, mode of delivery, gestational age, percent optimal birth weight (POBW), number of previous pregnancies, maternal age, maternal smoking, Socio-Economic Index for Area (SEIFA), season of birth and geographical region of residence. The POBW measure was used as an appropriate measure of foetal growth as it takes into account the gestational duration, foetal gender, maternal age, maternal height and parity.[18] As the location of the emergency departments were not available, residential postcode at birth was used to stratify data into geographical regions. The SEIFA used for this study was the Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD) which indicates relative access to resources and ability to participate in society for households within the same collection district (approximately 200 dwellings) using information from the latest census.[19] The IRSAD

incorporates measures of disadvantage which can be offset by the included measures of advantage. The SEIFA score was measured at the time of the child's birth and grouped into quintiles.

Statistical analysis

Dates of birth and death were used to calculate age-specific person-time-at-risk denominators and ARI presentation rates per 1,000 child-years and 95% confidence intervals for Aboriginal and non-Aboriginal children presenting between 2002 and 2012 in each WA region: Metropolitan; South-West; Great Southern; Midwest-Murchison; Wheatbelt; Kimberley; Pilbara; and Goldfields (Supplementary Figure 1). To limit the likelihood that children presenting to ED may have moved from their geographical region at birth, we restricted analyses presented by region and risk factor analysis to children aged <5 years at time of presentation. Aboriginal status was identified using a validated algorithm in all available records for an individual.[20] Seasonal distributions of presentations were examined by stratifying records by month of presentation. Annual presentation rates were calculated using the year of presentation and tested for linear age-specific annual trends over the study period using negative binomial regression. We also used negative binomial regression to calculate adjusted incidence rate ratios where the outcome is the frequency (number) of ARI presentations in the first five years of life for the infant and the exposures are maternal and socio-demographic risk factors. We explore the impact of all potential exposure factors at the same time in separate models for Aboriginal and non-Aboriginal children. To account for intragroup correlation with children presenting multiple times we used the clustered sandwich estimator.[21] Data cleaning was completed using IBM SPSS Statistics, version 24, with statistical analyses conducted in STATA version 14 and EpiBasic version 3.[22] Ethical approval was obtained from the Western Australian Department of Health Human Research Ethics Committee and the WA Aboriginal Health Ethics Committee.

Patient and public involvement

This is a total population-based study examining patient records retrospectively. A community reference group of parents and other members of the general public were consulted prior to project commencement to ensure broad project outcomes were a priority to the community.

RESULTS

Almost all ED presentations (n=1,607,825; 99.5%) between 2002 and 2012 successfully linked to the birth cohort dataset. The remaining records were excluded due to inconsistent date of birth information or being related to children who were not born in WA. Records missing a postcode at the time of birth were also excluded (n=1,568) leaving 1,606,257 ED records pertaining to 337,201 children who presented to ED before age 17 years during the study period (Figure 1). In the final categories, ICD codes identified 66.4% of ARI presentations, symptom codes identified a further 1.0%, text variables 5.4% and the major diagnostic category 27.2%. For analyses by geographical region the cohort was restricted to children presenting to ED in the first five years of life (n=1,034,924 records for 269,740 children).

Presentations for ARI

Overall 26% of ED presentations between 2002 and 2012 in children aged <17 years were for ARI (n=418,755) and among presentations for children aged <5 years, 32% were for ARI (n=332,149). Almost three quarters (72%) of children from the birth cohort presented to ED at least once, 40% of children presented to ED at least once for an ARI before age 17 years and 33% of children presented to ED with an ARI before their fifth birthday. There were 90,421 children <17 years with repeat presentations for ARI (range 1-85) and in both Aboriginal and non-Aboriginal children the median number of presentations for ARI per child was one (lower quartile=1, upper quartile=3).

The most common diagnostic categories were *respiratory disease* (n=118,251), *viral illness* (n=72,927), *other upper respiratory disease* (n=61,563), *croup* (n=32,480) and *bronchiolitis* (n=22,446).

Approximately 42% of all presentations (n=670,116) only had a *major diagnostic category* as diagnosis information, of which 2,035 presentations were classified as 'unknown'. The *major diagnostic category* variable was used to classify the vast majority (96%) of records which made up the *respiratory disease* category.

Table 1 presents the numbers and rates of presentations for WA children aged < 17 years for each ARI category. Rates were higher for Aboriginal children for most ARI categories except croup and fever, where rates were higher in non-Aboriginal children. The overall presentation rate for ARI in Aboriginal children was 282/1,000 child-years and in Aboriginal children <12 months was 1,028/1,000 child-years. For non-Aboriginal children the overall rate was 116/1,000 child-years and in those <12 months was 297/1,000 child-years.

The *respiratory disease* category had the highest presentation rates for Aboriginal children in each age group, far higher than any other category (185/1,000 child-years overall; Table 1). The highest rates overall were observed in children <12 months old. For most infections or symptoms affecting the lower respiratory system including *pneumonia*, *bronchiolitis*, *pertussis*, *unspecified ALRI*, *bronchitis* and *wheeze/cough/crackles*, rates in Aboriginal children were 2-3 times higher than in non-Aboriginal children under 12 months, but similar in the older age groups.

Presentation for ARI across WA regions

Diagnosis and symptom information available varied between geographical areas. In the metropolitan area, ICD coding was available for 81% of records, whereas use of these codes in EDs outside the metropolitan area ranged from 26% in the South-West to 3.4% in the Kimberley (data not shown). The South-West had the largest proportions of text variable information available (14.6% for diagnosis at discharge text and 16.4% for presenting complaint text).

Table 2 presents the numbers and rates of total ARI presentations in each geographical region. When combined, the overall rates for non-metropolitan areas were higher than metropolitan for non-

Aboriginal children (IRR for non-metropolitan to metropolitan=1.19 in children aged <12 months and 1.14 in children aged 1-4 years). The highest rates in Aboriginal children were for those aged <12 months in the Great Southern and Pilbara regions with rates of 1,233 and 1,088 per 1,000 child-years respectively. For non-Aboriginal children, the highest rate was in the South-West in children aged <12 months (400.3/1,000 child-years). The lowest rates were observed in the Goldfields in children aged 1-4 years (274.9/1,000 child-years in Aboriginal children and 164.4/1,000 child-years in non-Aboriginal children). In Aboriginal children, ARI rates for those <12 months were approximately 2-3 times that of children 1-4 years, whereas in non-Aboriginal children rates for those <12 months were 1.7 times the rates for children 1-4 years.

Figure 2 shows the monthly distribution of the number of presentations for the top five categories of ARI. In the metropolitan area a clear peak of ARI presentation to ED was observed from June to September with the most number of presentations in July/August. The Midwest-Murchison with much fewer presentations showed a similar distribution, peaking in July/August. Monthly presentations in the South-West, Great Southern, Wheatbelt, Goldfields and Pilbara peaked a little later in August, and the Kimberley was the only region with a bimodal distribution peaking in March and July/August. In all regions except metropolitan Perth, the majority of ED presentations were coded *respiratory disease* (Figure 2).

Figure 3 presents the annual age-specific rates for overall ARI in Aboriginal and non-Aboriginal in metropolitan, rural and remote WA by year of presentation. There was an overall increase in ARI over time in all children from rural and remote regions. In non-Aboriginal children from the metropolitan area, increases in ARI rates were observed in those aged 1-5 and 6-11 months. No significant trends were observed in overall ED presentations (data not shown). Rates did fluctuate over time, particularly in Aboriginal children in the younger age groups, however rates appear to increase in later years of the study.

Infant, maternal and socio-demographic risk factors for ARI presentation rates were similar in Aboriginal and non-Aboriginal children (Table 3). The strongest risk factors associated with ARI rates in both Aboriginal and non-Aboriginal children were male sex, prematurity, caesarean delivery, birth in the Kimberley and birth in a lower socio-economic area. Maternal age <30 years was also a risk factor in non-Aboriginal children and birth in the Great Southern was a risk factor in Aboriginal children. The strongest risk factor was gestational age where compared with children born ≥37 weeks, the IRR for Aboriginal children born <29 weeks was 2.70 and for non-Aboriginal children born <29 weeks was 2.60.

DISCUSSION

Our findings suggest a substantial burden on WA emergency departments with approximately one-in-four presentations for ARI and evidence that presentation rates are increasing in children from rural and remote areas. The most common ARI presentation was respiratory disease, with *bronchiolitis* the most common specific diagnosis. Rates for overall ARI ED presentations were high (ranging from 25/1,000 child-years in non-Aboriginal children aged 10-16 years to 1,027/1,000 child-years in Aboriginal children aged <12 months). The burden in Aboriginal children was especially high, with similar disparity to non-Aboriginal children as is observed in hospitalisation rates,[7] demonstrating the ongoing burden of disease in this population. There was some evidence of geographical disparity with the highest rates observed in the Northern and Southern rural regions. The monthly distributions depicted one late winter peak in numbers of ARI presentations (in July/August) in metropolitan WA and most of the rural and remote geographical regions except the Kimberley, with its tropical climate, having a bimodal distribution peaking in March and August. Risk factors for presenting to emergency with an ARI were similar in Aboriginal and non-Aboriginal children. The geographical disparity in ED presentation rates, with higher rates observed in children from most rural and remote regions in WA was consistent with findings focused on influenza among all ages in New South Wales.[8] Reasons for

the disparities include relative access to general practitioners and hospitals in the different regions. In particular we have seen here, increases in ED presentation rates in remote areas across all ages. It is unclear whether these increases represent a true increase in disease burden, or increases in data capture in remote areas, and there is a lack of primary health care data from general practices and rural and remote health clinics for comparison.

Seasonal distribution of ED presentations were consistent with patterns we have seen in metropolitan WA respiratory viral detections for Respiratory Syncytial Virus (RSV) and influenza A and B[23] and hospitalisations in New South Wales for ALRI.[24] The bimodal seasonal distribution of ARI presentations in the far north of WA (remote Kimberley region with a tropical climate) is similar to the distribution of RSV detections in the region and seasonal patterns observed in ARI hospitalisation in the Northern Territory of Australia.[4, 25]

There are subgroups of the population which utilise the ED more frequently than others. While for some groups the higher risk of presentation to ED for an ARI is likely because the disease incidence is higher (e.g., preterm children) for others it could be lack of access to other primary healthcare providers, such as general practitioners in rural and remote areas. Indeed, the rate of general practitioners in rural and remote areas ranges from 53/100,000 population in the Pilbara to 141/100,000 population in the Kimberley compared with up to 171/100,000 population in Perth's inner metropolitan area.[26] The risk factors for presenting with ARI to ED were similar to those previously reported risk factors for admission to hospital for ALRI including being male, being born preterm, being from a low socioeconomic area and maternal age <20 years.[7] Two previously observed risk factors for ALRI hospitalisation, maternal smoking and higher number of previous pregnancies,[7] were not risk factors for presenting to ED with overall ARI. This suggests maternal smoking is associated with increased severity of disease or specifically with lower respiratory infections. Different to hospitalisation, presentation to ED may be more influenced by individual psychological and social factors of the child's parents or carers. Parents may be less likely to take their child to ED if they have

had experiences with similar conditions in their older children and are more confident to manage their child's illness at home. Conditions presented to ED are likely to vary more in severity whereas hospitalisations tend to be only the very severe cases and the decision to hospitalise is more likely to be made by a clinician.

Croup is a major reason for presentation to ED but has not been found to be a common diagnosis in hospitalisation.[7] Rates for other specific conditions seemed low when compared with hospitalisations. This is likely a result of the high use of non-specific codes in ED, as most cases of respiratory infections are admitted with non-specific diagnoses and either discharged without testing or admitted while investigations or results are still pending. Most patients in ED will be managed based on clinical presentation and specific diagnoses might be left to the admitting team to clarify. Rates for specific conditions are therefore likely to underestimate the burden and comparisons with hospitalisation rates for specific conditions should be made with caution. The uncertain accuracy of ICD codes in administrative datasets has previously been documented in other data linkage studies.[5, 8, 27] McCallum and colleagues (2014)[5] noted from data linkage work that ED presentations for pertussis were likely to be missed if only coded pertussis is included, due to misclassifications with other respiratory conditions and use of symptom codes for diagnosis coding. Similar results have been found when routine laboratory data are linked with hospital diagnosis data, with certain respiratory pathogens identified across a range of respiratory diagnoses[28] and 38% of laboratory-confirmed hospital admissions for respiratory infections not having a respiratory infection ICD hospital diagnosis.[27] The non-specific nature of the diagnostic coding also makes the severity of conditions in the ED unclear. While some presentations for severe conditions have an ICD code indicating this (e.g., Whooping cough) others could be just as severe but be coded as 'respiratory disease'. This is particularly likely in some remote regions which do not appear to use ICD-coding. Across regions, ICD coding was available for 81% of records in metropolitan WA, and in rural and remote areas ranged from 26% in the South-West to 3.4% in the Kimberley. In contrast, use of the very broad major diagnostic category in rural and remote areas ranged from 56% in the South-West to 96% in the Kimberley, versus only 12% in

metropolitan WA. This highlights the inconsistencies in diagnostic practices across WA that make regional comparisons difficult and are important considerations for population-based surveillance in WA. As relatively higher proportions of Aboriginal people live in rural and remote areas compared with non-Aboriginal, rates for specific conditions may be highly underestimated in Aboriginal children. This may be why rates for some conditions, such as croup, were higher in non-Aboriginal children. Use of ICD coding in the data systems also changed over the period, with a notable increase occurring in the rural systems. Sufficiently sensitive diagnosis of ARIs in ED is likely to improve the ability to survey and manage specific conditions. The level of laboratory testing in ED is currently unknown and linkages with laboratory data will aid in understanding the burden of specific respiratory infections. While testing results will underestimate the true burden of the specific ARIs because only a proportion of children who present are likely to be hospitalised or tested, it will help us to interpret the non-specific coding used in ED.

There are other limitations to our study and these data. Although the risk factor analysis was restricted to children aged less than five years, birth-level information, such as maternal postcode of residence at the time of her child's birth used to determine the socio-economic index score, may not be relevant to children from older age groups. A further limitation is a lack of co-morbidity information in the ED data to enable identification of children at higher risk of respiratory infections, such as those with immunocompromising conditions, chronic lung disease or neurological diseases who may experience different frequencies of ED presentations for ARI.

ED presentation for ARIs is common and has an enormous impact on the healthcare system. We have provided a comprehensive analysis of the ED burden across Western Australia using population-based data linkage. These data from EDs across geographical areas provide essential information for ED planning, both within season and by site and to use when exploring the impact of specific interventions

(e.g., vaccination) or modifications to community health services (e.g., establishing general practitioner after-hours clinics). Notwithstanding the limitations of clinical diagnostic accuracy, these data provide a more community-based level of the ARI burden of disease to complement previous studies assessing only hospitalisation and death at the tip of the burden of disease pyramid. There is a lack of primary healthcare data with diagnostic information in the community in general and these ED data will be important for understanding where to target prevention strategies and form the baseline for evaluating policies.

Contributors

RB, CCB, NdK, PR and HCM contributed to study conception, design, methods and planning. RB completed all statistical analyses, drafted the manuscript and managed revisions. CCB, WHL and PR provided expert clinical advice and NdK and HCM provided statistical advice. RB, CCB, NdK, WHL, MB, PR, FJL, PF and HCM provided interpretation of the data and revisions and approved the final manuscript.

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Competing interests

HCM reports receiving grants to their institution from the NHMRC during the conduct of this study.

Data sharing statement

No additional data available.

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Figure 1. Selection of participants and coding of acute respiratory infections

Table 1. Number and rate of emergency department presentations for acute respiratory infections in Western Australian Aboriginal and non-Aboriginal children aged <17 years (2002-2012)

Diagnosis	Age group	Aboriginal			Non-Aboriginal		
		n	Rate[a]	95% CI	n	Rate[a]	95% CI
Pertussis	< 12 months	62	3.0	(2.3, 3.8)	302	1.0	(0.9, 1.2)
	1-4 years	26	0.3	(0.2, 0.5)	195	0.2	(0.2, 0.2)
	5-9 years	<5	-	-	72	0.1	(0.1, 0.1)
	10-16 years	<5	-	-	50	0.1	(0.1, 0.1)
	Total	91	0.4	(0.3, 0.5)	619	0.2	(0.2, 0.2)
Pneumonia	< 12 months	241	11.6	(10.2, 13.2)	1,079	3.7	(3.5, 3.9)
	1-4 years	564	7.0	(6.4, 7.6)	5,985	5.4	(5.3, 5.6)
	5-9 years	142	1.8	(1.5, 2.1)	1,791	1.6	(1.5, 1.7)
	10-16 years	82	2.1	(1.6, 2.5)	438	0.8	(0.7, 0.9)
	Total	1,029	4.6	(4.4, 4.9)	9,293	3.0	(3.0, 3.1)
Bronchiolitis	< 12 months	2,342	112.9	(108.4, 117.6)	16,252	55.7	(54.9, 56.6)
	1-4 years	388	4.8	(4.3, 5.3)	3,441	3.1	(3.0, 3.2)
	5-9 years	0	-	-	21	0.0	(0.0, 0.0)
	10-16 years	0	-	-	<5	-	-
	Total	2,730	12.3	(11.8, 12.7)	19,720^	6.4	(6.3, 6.5)
Influenza	< 12 months	25	1.2	(0.8, 1.8)	215	0.7	(0.6, 0.8)
	1-4 years	53	0.7	(0.5, 0.9)	690	0.6	(0.6, 0.7)
	5-9 years	30	0.4	(0.3, 0.5)	451	0.4	(0.4, 0.5)
	10-16 years	26	0.7	(0.4, 1.0)	284	0.5	(0.5, 0.6)
	Total	134	0.6	(0.5, 0.7)	1,640	0.5	(0.5, 0.6)
Unspecified ALRI	< 12 months	98	4.7	(3.8, 5.8)	656	2.2	(2.1, 2.4)
	1-4 years	197	2.4	(2.1, 2.8)	2,114	1.9	(1.8, 2.0)
	5-9 years	39	0.5	(0.3, 0.7)	562	0.5	(0.5, 0.6)
	10-16 years	15	0.4	(0.2, 0.6)	99	0.2	(0.1, 0.2)
	Total	349	1.6	(1.4, 1.7)	3,431	1.1	(1.1, 1.2)
Bronchitis	< 12 months	40	1.9	(1.4, 2.6)	223	0.8	(0.7, 0.9)
	1-4 years	52	0.6	(0.5, 0.8)	567	0.5	(0.5, 0.6)
	5-9 years	17	0.2	(0.1, 0.3)	210	0.2	(0.2, 0.2)
	10-16 years	11	0.3	(0.1, 0.5)	114	0.2	(0.2, 0.2)
	Total	120	0.5	(0.5, 0.6)	1,114	0.4	(0.3, 0.4)
Croup	< 12 months	260	12.5	(11.1, 14.2)	4,662	16.0	(15.5, 16.4)
	1-4 years	899	11.2	(10.4, 11.9)	21,133	19.2	(18.9, 19.4)
	5-9 years	239	2.9	(2.6, 3.3)	5,000	4.5	(4.4, 4.7)
	10-16 years	13	0.3	(0.1, 0.5)	274	0.0	(0.4, 0.5)
	Total	1,411	6.3	(6.0, 6.7)	31,069	10.1	(10.0, 10.3)
Febrile convulsion	< 12 months	83	4.0	(3.2, 5.0)	996	3.4	(3.2, 3.6)
	1-4 years	355	4.4	(4.0, 4.9)	6,948	6.3	(6.2, 6.5)
	5-9 years	90	1.1	(0.9, 1.4)	783	0.7	(0.7, 0.8)
	10-16 years	36	0.9	(0.6, 1.2)	263	0.5	(0.4, 0.5)
	Total	564	2.5	(2.3, 2.8)	8,990	2.9	(2.9, 3.0)
Wheeze/ cough/ crackles	< 12 months	359	17.3	(15.6, 19.2)	2,503	8.6	(8.3, 8.9)
	1-4 years	370	4.6	(4.1, 5.1)	4,870	4.4	(4.3, 4.5)
	5-9 years	111	1.4	(1.1, 1.6)	1,776	1.6	(1.5, 1.7)
	10-16 years	38	1.0	(0.7, 1.3)	537	1.0	(0.9, 1.0)
	Total	878	3.9	(3.7, 4.2)	9,686	3.2	(3.1, 3.2)
Viral illness	< 12 months	1,443	69.6	(66.0, 73.3)	17,163	58.9	(58.0, 59.7)
	1-4 years	2,013	25.0	(23.9, 26.1)	38,024	34.5	(34.2, 34.9)
	5-9 years	746	9.2	(8.6, 9.9)	10,861	9.8	(9.6, 10.0)
	10-16 years	222	5.6	(4.9, 6.3)	2,455	4.3	(4.2, 4.5)
	Total	4,424	19.9	(19.3, 20.5)	68,503	22.4	(22.2, 22.5)

Diagnosis	Age group	Aboriginal			Non-Aboriginal		
		n	Rate[a]	95% CI	n	Rate[a]	95% CI
Fever	< 12 months	298	14.4	(12.8, 16.1)	5,344	18.3	(17.8, 18.8)
	1-4 years	495	6.1	(5.6, 6.7)	9,592	8.7	(34.2, 34.9)
	5-9 years	151	1.9	1.6, 2.2	2,072	1.9	(1.8, 2.0)
	10-16 years	36	0.9	(0.6, 1.2)	435	0.8	(0.7, 0.8)
	Total	980	4.4	(4.1, 4.7)	17,443	5.7	(5.6, 5.8)
Otitis media	< 12 months	236	11.4	(10.0, 12.9)	1,575	5.4	(5.1, 5.7)
	1-4 years	668	8.3	(7.7, 8.9)	8,630	7.8	(7.7, 8.0)
	5-9 years	313	3.9	(3.4, 4.3)	3,845	3.5	(3.4, 3.6)
	10-16 years	71	1.8	(1.4, 2.2)	535	0.9	(0.9, 1.0)
	Total	1,288	5.8	(5.5, 6.1)	14,585	4.8	(4.7, 4.8)
Tonsillitis	< 12 months	56	2.7	(2.0, 3.5)	1,267	4.3	(4.1, 4.6)
	1-4 years	369	4.6	(4.1, 5.1)	9,844	8.9	(8.8, 9.1)
	5-9 years	325	4.0	(3.6, 4.5)	3,361	3.0	(2.9, 3.1)
	10-16 years	237	5.9	(5.2, 6.7)	1,082	1.9	(1.8, 2.0)
	Total	987	4.4	(4.2, 4.7)	15,554	5.1	(5.0, 5.2)
Other upper respiratory disease	< 12 months	1,889	91.1	(87.0, 95.3)	17,040	58.4	(57.6, 59.3)
	1-4 years	2,256	28.0	(26.9, 29.2)	30,464	27.7	(27.3, 28.0)
	5-9 years	602	7.4	(6.8, 8.0)	7,228	6.5	(6.4, 6.7)
	10-16 years	247	6.2	(5.4, 7.0)	1,837	3.3	(3.1, 3.4)
	Total	4,994	22.5	(21.8, 23.1)	56,569	18.5	(18.3, 18.6)
Other lower respiratory disease	< 12 months	15	0.7	(0.4, 1.2)	67	0.2	(0.2, 0.3)
	1-4 years	44	0.5	(0.4, 0.7)	205	0.2	(0.2, 0.2)
	5-9 years	16	0.2	(0.1, 0.3)	109	0.1	(0.1, 0.1)
	10-16 years	10	0.3	(0.1, 0.5)	77	0.1	(0.1, 0.2)
	Total	85	0.4	(0.3, 0.5)	458	0.1	(0.1, 0.2)
Respiratory disease	< 12 months	13,817	666.1	(655.1, 677.3)	17,009	58.3	(57.5, 59.2)
	1-4 years	18,762	232.9	(229.5, 236.2)	40,461	36.7	(36.4, 37.1)
	5-9 years	6,520	80.4	(78.5, 82.4)	15,280	13.8	(13.6, 14.0)
	10-16 years	2,169	54.3	(52.1, 56.7)	4,233	7.5	(7.3, 7.7)
	Total	41,268	185.6	(183.8, 187.4)	76,983	25.1	(25.0, 25.3)
Asthma	< 12 months	52	2.5	(1.9, 3.3)	357	1.2	(1.1, 1.4)
	1-4 years	870	10.8	(10.1, 11.5)	12,579	11.4	(11.2, 11.6)
	5-9 years	358	4.4	(4.0, 4.9)	6,026	5.5	(5.3, 5.6)
	10-16 years	90	2.3	(1.8, 2.8)	1,438	2.5	(2.4, 2.7)
	Total	1,370	6.2	(5.8, 6.5)	20,400	6.7	(6.6, 6.8)
Total ARI	<12 months	21,316	1,027.6	(1,013.9, 1,041.5)	86,710	297.4	(295.4, 299.3)
	1-4 years	28,381	352.2	(348.2, 356.4)	195,742	177.7	(176.9, 178.5)
	5-9 years	9,702	119.7	(117.3, 122.1)	59,448	53.8	(53.4, 54.2)
	10-16 years	3,303	82.7	(79.9, 85.6)	14,153	25.1	(24.6, 25.5)
	Total	62,702	282.0	(279.8, 284.3)	356,053	116.2	(115.8, 116.6)

[a]Rate per 1,000 child-years at risk from Western Australian live births. ^This total has been rounded to the nearest five to conceal small cell size numbers. CI=Confidence interval. ALRI=Acute lower respiratory infections. ARI=Acute respiratory infections.

Table 2. Number and rate of emergency department presentations for acute respiratory infections in Western Australian Aboriginal and non-Aboriginal children aged <5 years (2002-2012) by Western Australian region

Western Australian region	Aboriginal				Non-Aboriginal			
	N	Rate[a]	IRR	(IRR 95% CI)	N	Rate[a]	IRR	(IRR 95% CI)
< 12 months								
Metropolitan	6,941	910.8	Reference		66,143	289.0	Reference	
South-West	729	934.9	1.03	(0.95, 1.11)	6,729	400.3	1.39	(1.35, 1.42)
Great Southern	752	1,233.6	1.35	(1.26, 1.46)	2,345	314.3	1.09	(1.04, 1.13)
Wheatbelt	1,029	1,009.9	1.11	(1.04, 1.18)	2,886	293.3	1.01	(0.98, 1.05)
Midwest-Murchison	2,583	991.3	1.09	(1.04, 1.14)	2,813	355.3	1.23	(1.18, 1.28)
Goldfields	1,409	912.1	1.00	(0.95, 1.06)	2,768	316.0	1.09	(1.05, 1.14)
Pilbara	2,136	1,088.4	1.19	(1.14, 1.25)	2,007	324.8	1.12	(1.07, 1.17)
Kimberley	5,737	900.0	0.99	(0.95, 1.02)	1,019	375.7	1.30	(1.22, 1.38)
(Non-metropolitan)	14,375	965.1	1.06	(1.03, 1.09)	20,567	344.6	1.19	(1.17, 1.21)
1-4 years								
Metropolitan	9,085	311.8	Reference		148,211	173.7	Reference	
South-West	1,071	356.5	1.14	(1.07, 1.22)	16,281	244.2	1.41	(1.38, 1.43)
Great Southern	1,098	456.7	1.46	(1.38, 1.56)	5,540	184.4	1.06	(1.03, 1.09)
Wheatbelt	1,375	352.5	1.13	(1.07, 1.20)	7,011	170.5	0.98	(0.96, 1.01)
Midwest-Murchison	3,414	336.3	1.08	(1.04, 1.12)	6,365	197.3	1.14	(1.11, 1.16)
Goldfields	1,706	274.9	0.88	(0.84, 0.93)	5,925	164.4	0.95	(0.92, 0.97)
Pilbara	2,736	364.6	1.17	(1.12, 1.22)	4,113	172.8	1.00	(0.96, 1.03)
Kimberley	7,896	322.4	1.03	(1.00, 1.07)	2,296	216.4	1.25	(1.20, 1.30)
(Non-metropolitan)	19,296	334.7	1.07	(1.05, 1.10)	47,531	197.6	1.14	(1.13, 1.15)

[a]Rates per 1,000 child-years at risk from Western Australian live births. IRR=Incidence rate ratio. CI=Confidence interval.

Figure 2. Monthly distribution of emergency department presentations for acute respiratory infections in Aboriginal and non-Aboriginal children aged <5 years

Figure 3. Annual age-specific presentation rates for acute respiratory infections in Aboriginal and non-Aboriginal children aged <5 years

Table 3. Infant, maternal and socio-demographic risk factors for presenting to ED with acute respiratory infections between 2002-2012 among Western Australian-born Aboriginal and non-Aboriginal children <5 years

Risk factor	Aboriginal			Non-Aboriginal		
	N	IRR	(95% CI)	N	IRR	(95% CI)
Sex						
Female	22,066	Reference		120,746	Reference	
Male	27,631	1.22	(1.17, 1.28)	161,706	1.28	(1.26, 1.29)
Mode of delivery						
Vaginal	33,002	Reference		144,830	Reference	
Instrumental	3,331	1.15	(1.02, 1.06)	35,055	1.10	(1.08, 1.12)
Elective caesarean	4,118	1.20	(1.11, 1.30)	48,785	1.16	(1.13,1.18)
Emergency caesarean	8,132	1.17	(1.11, 1.25)	46,062	1.22	(1.19, 1.24)
Percent Optimal Birth Weight						
Low (<85%)	11,697	1.08	(1.03, 1.14)	31,587	1.03	(1.01, 1.05)
Normal (85-114%)	29,073	Reference		192,862	Reference	
High (≥115%)	3,441	1.01	(0.93, 1.10)	25,568	1.04	(1.02, 1.06)
Gestational age						
≥37 weeks	40,646	Reference		250,591	Reference	
33-36 weeks	6,269	1.13	(1.07, 1.21)	23,979	1.29	(1.26, 1.33)
29-32 weeks	1,618	1.61	(1.43, 1.83)	4,895	1.82	(1.71, 1.94)
<29 weeks	1,164	2.70	(2.23, 3.27)	2,987	2.60	(2.41, 2.82)
Maternal age						
≥35 years	3,399	Reference		48,479	Reference	
30-34 years	6,337	0.98	(0.90, 1.08)	79,776	1.04	(1.02, 1.07)
25-29 years	11,399	1.05	(0.96, 1.15)	82,427	1.23	(1.21, 1.26)
20-24 years	16,150	1.09	(1.00, 1.20)	54,601	1.52	(1.48, 1.56)
<20 years	12,412	1.18	(1.06, 1.30)	17,169	1.80	(1.73, 1.86)
Number of Previous pregnancies						
0	12,987	Reference		89,891	Reference	
1	10,094	0.89	(0.83, 0.95)	86,126	1.01	(0.99, 1.02)
2	7,994	0.92	(0.86, 1.00)	50,911	1.02	(1.00, 1.04)
≥3	18,622	0.95	(0.88, 1.02)	55,524	1.09	(1.07, 1.12)
Maternal smoking during pregnancy						
No	23,843	Reference		224,791	Reference	
Yes	24,278	1.03	(0.99, 1.08)	50,713	1.14	(1.12, 1.16)
Season of birth						
Spring	11,157	Reference		68,433	Reference	
Summer	12,491	1.08	(1.01, 1.14)	69,096	1.05	(1.03, 1.07)
Autumn	13,684	1.10	(1.04, 1.17)	75,151	1.09	(1.07, 1.11)
Winter	12,365	1.08	(1.02, 1.15)	69,772	1.03	(1.01, 1.05)
Socio-economic index[a]						
91-100%	205	Reference		15,029	Reference	
76-90%	1,313	1.09	(0.86, 1.38)	36,429	1.10	(1.07, 1.14)
26-75%	13,946	1.21	(0.98, 1.50)	134,195	1.28	(1.24, 1.31)
11-25%	11,291	1.30	(1.05, 1.61)	48,811	1.47	(1.43, 1.52)
0-10%	14,102	1.19	(0.96, 1.48)	27,059	1.57	(1.52, 1.63)
Region						
Metropolitan	16,026	Reference		214,354	Reference	
South-West	1,800	0.92	(0.98, 1.21)	23,010	1.13	(1.10, 1.16)
Great Southern	1,850	1.43	(1.27, 1.61)	7,885	0.99	(0.94, 1.04)
Midwest-Murchison	5,997	1.11	(1.02, 1.20)	9,178	1.11	(1.05, 1.16)
Wheatbelt	2,404	1.17	(1.07, 1.29)	9,897	0.95	(0.91, 1.00)
Kimberley	13,633	1.35	(1.27, 1.43)	3,315	1.46	(1.33, 1.61)
Pilbara	4,872	1.18	(1.09, 1.28)	6,120	1.11	(1.05, 1.17)
Goldfields	3,115	0.92	(0.85, 1.01)	8,693	0.96	(0.92, 1.00)

All models adjusted for year of birth. IRR=Incidence rate ratio. CI=Confidence interval. [a] 91-100% represents the least disadvantaged and 0-10% represents the most disadvantaged.

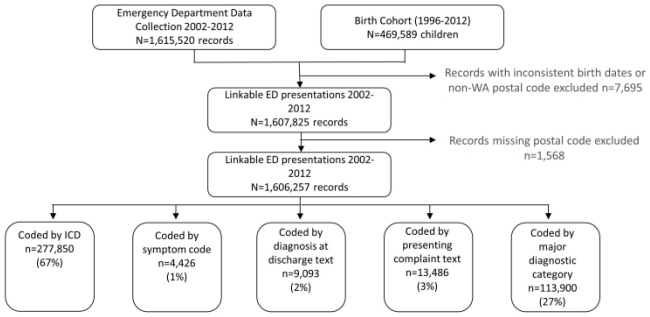

Figure 1. Selection of participants and coding of acute respiratory infections

338x190mm (300 x 300 DPI)

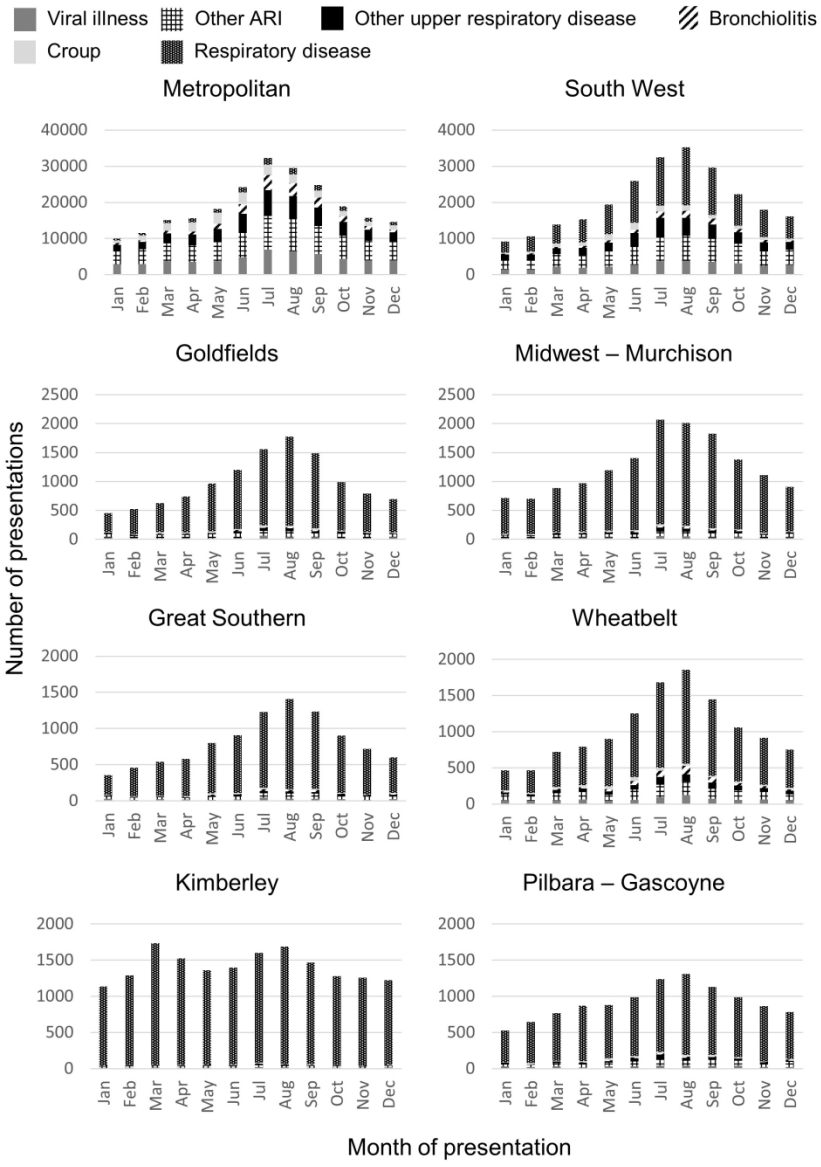

Figure 2. Monthly distribution of emergency department presentations for acute respiratory infections in Aboriginal and non-Aboriginal children aged <5 years

190x275mm (300 x 300 DPI)

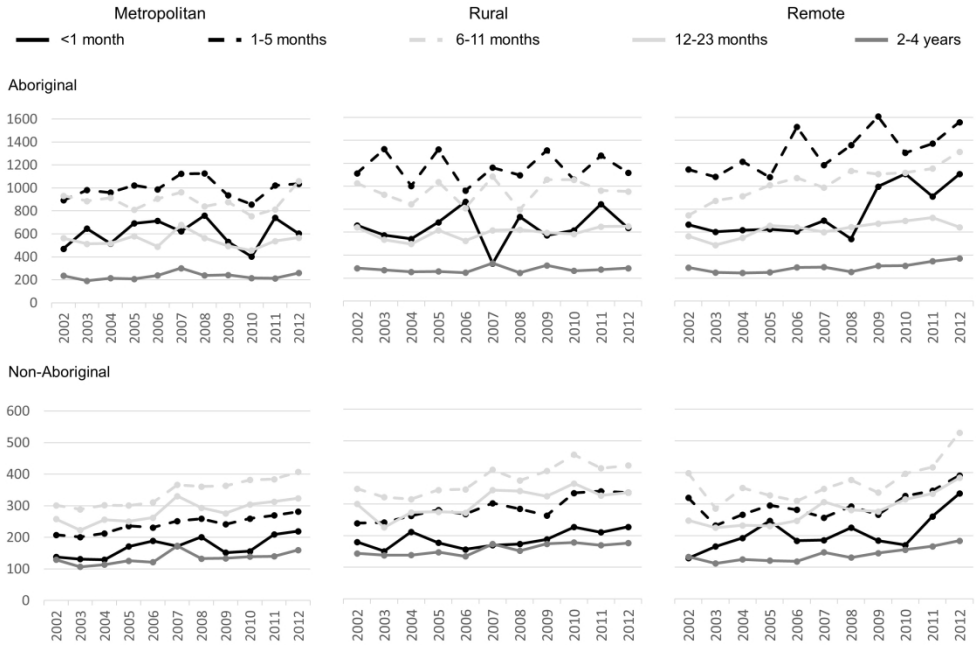

Figure 3. Annual age-specific presentation rates for acute respiratory infections in Aboriginal and non-Aboriginal children aged <5 years

275x190mm (300 x 300 DPI)

Supplementary Figure 1. Western Australian regions

Supplementary table 1. Emergency department acute respiratory infections categories and variable components

Category	N	Percentage of presentations	International Classification of Diseases or Major Diagnostic Category	Symptom code	Key words for text variables
1. Pertussis/Whooping cough	710	0.0	A37 Whooping cough	SNJ Pertussis/whooping cough	Pertussis; whooping cough; post-tussive vomiting
2. Pneumonia	10,322	0.6	J12 Viral pneumonia, not elsewhere classified J13 Pneumonia due to Streptococcus pneumoniae J14 Pneumonia due to Haemophilus influenzae J15 Bacterial pneumonia, not elsewhere classified J16 Pneumonia due to other infectious organisms, not elsewhere classified J17 Pneumonia in diseases classified elsewhere J18 Pneumonia, organism unspecified J10.0 Influenza with pneumonia, other influenza identified J11.0 Influenza with pneumonia, virus not identified	SQJ Pneumonia	Pneumonia
3. Bronchiolitis	22,446	1.4	J21 Acute bronchiolitis		Bronchiolitis
4. Influenza	1,774	0.1	J09 Influenza due to certain identified influenza virus J10.1 Influenza with other respiratory manifestations, other influenza virus identified J10.8 Influenza with other manifestations, other influenza virus identified J11.1 Influenza with other respiratory manifestations, virus not identified J11.8 Influenza with other manifestations, virus not identified	AAV Flu Like Symptoms	Influenza; flu; flu-like symptoms

Category	N	Percentage of presentations	International Classification of Diseases or Major Diagnostic Category	Symptom code	Key words for text variables
5. Unspecified ALRI (includes chest infection & LRTI)	3,780	0.2	J22 Unspecified acute lower respiratory infection	SQD Chest infection	Unspecified Acute Lower Respiratory Infection; LRTI; lower respiratory tract infection; chest infection
6. Bronchitis	1,234	0.1	J20 Acute bronchitis J40 Bronchitis, not specified as acute or chronic	SQC Bronchitis	Bronchitis
7. Croup	32,480	2.0	J05.0 Acute obstructive laryngitis [croup] R06.1 Stridor	CG Stridor	Croup; Laryngotracheobronchitis; barking cough; stridor
8. Convulsions/Febrile convulsions	9,554	0.6	R56.0 Febrile convulsions R56.8 Other and unspecified convulsions	SNG Febrile convulsion	Febrile convulsion; convulsion
9. Wheeze/cough/ crackles	10,564	0.7	R06.2 Wheezing R05 Cough	CH Wheeze CC Cough	Wheeze; wheezing; cough; crackles
10. Viral illness	72,927	4.5	B34 Viral infection of unspecified site		Viral respiratory infection; viral respiratory tract infection; rhinorrhoea; acute viral infection; viral infection; viral illness
11. Fever/Pyrexia	18,423	1.1	R50 Fever of other and unknown origin	S2B Pyrexia of unknown origin VP Pyrexia of unknown origin VD Fever PG Febrile AAU Fever	Fever; pyrexia; febrile; high temperature
12. Otitis Media	15,873	1.0	H65-H67 Otitis media		Otitis media
13. Tonsillitis	16,541	1.0	J03 Acute tonsillitis		Tonsillitis
14. Other upper respiratory diseases	61,563	3.8	J06 Acute Upper Respiratory Infections J00 Acute nasopharyngitis J01 Acute sinusitis	FE Nasal discharge	Upper respiratory tract infection; URTI; nasopharyngitis; sinusitis;

Category	N	Percentage of presentations	International Classification of Diseases or Major Diagnostic Category	Symptom code	Key words for text variables
			J02 Acute pharyngitis J04 Acute laryngitis and tracheitis J05.1 Acute epiglottitis J30-J39 Other diseases of upper respiratory tract		pharyngitis; laryngitis; tracheitis; epiglottitis; rhinitis; runny nose, nasal discharge
15. Other lower respiratory diseases	543	0.0	J41 Simple and mucopurulent chronic bronchitis J42 Unspecified chronic bronchitis J43 Emphysema J44 Other chronic obstructive pulmonary disease J47 Bronchiectasis J60-J70 Lung diseases due to external agents J80-J84 Other respiratory diseases principally affecting the interstitium J85-J86 Suppurative and necrotic conditions of lower respiratory tract J90-J94 Other diseases of pleura		Bronchiectasis; chronic bronchitis; chronic obstructive pulmonary disease; emphysema
16. Respiratory disease	118,251	7.4	MDC 4 Diseases and disorders of the respiratory system J95-J99 Other diseases of the respiratory system	C0000 Respiratory CJ Respiratory distress	Respiratory tract infection; RTI; respiratory infection; respiratory problems; respiratory distress
17. Asthma	21,770	1.4	J45 Asthma J46 Status asthmaticus	SQA Asthma & Status asthmaticus	Asthma
Total ARI	418,755	26.1			

ALRI=Acute lower respiratory infections. LRTI=Lower respiratory tract infections. ARI=Acute respiratory infections.

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort 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	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4-7, fig.1
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7, supplementary table 1
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	5-7
Bias	9	Describe any efforts to address potential sources of bias	7-8
Study size	10	Explain how the study size was arrived at	8, Fig 1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-7, supplementary table 1
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	8, fig. 1
		(*d*) If applicable, explain how loss to follow-up was addressed	NA
		(*e*) Describe any sensitivity analyses	NA
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	8, Fig 1
		(b) Give reasons for non-participation at each stage	Fig 1
		(c) Consider use of a flow diagram	Fig1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8, 18-20
		(b) Indicate number of participants with missing data for each variable of interest	9, 13, 18-20, 23
		(c) Summarise follow-up time (eg, average and total amount)	8
Outcome data	15*	Report numbers of outcome events or summary measures over time	18-20, 23
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	18-20, 23
		(*b*) Report category boundaries when continuous variables were categorized	23
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	3, 11-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	3
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	14

*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.