Hospitalisation of Indigenous children in the Northern Territory for lower respiratory illness in the first year of life

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ABSTRACT

Objective: To describe the epidemiology of acute lower respiratory infection (ALRI) and bronchiectasis in Northern Territory Indigenous infants hospitalised in the first year of life.

Design: A historical cohort study constructed from the NT Hospital Discharge Dataset and the NT Immunisation Register.

Participants and setting: All NT resident Indigenous infants, born 1 January 1999 to 31 December 2004, admitted to NT public hospitals and followed up to 12 months of age.

Main outcome measures: Incidence of ALRI and bronchiectasis (ICD-10-AM codes) and radiologically confirmed pneumonia (World Health Organization protocol).

Results: Data on 9295 infants, 8498 child-years of observation and 15 948 hospitalised episodes of care were analysed. ALRI incidence was 426.7 episodes per 1000 child-years (95% CI, 416.2–437.2). Incidence rates were two times higher (relative risk, 2.12; 95% CI, 1.98–2.27) for infants in Central Australia compared with those in the Top End. The median age at first admission for an ALRI was 4.6 months (interquartile range, 2.6–7.3). Bronchiolitis accounted for most of the disease burden, with a rate of 227 per 1000 child-years. The incidence of first diagnosis of bronchiectasis was 1.18 per 1000 child-years (95% CI, 0.60–2.16). One or more key comorbidities were present in 1445 of the 3227 (44.8%) episodes of care for ALRI.

Conclusions: Rates of ALRI and bronchiectasis in NT Indigenous infants are excessive, with early onset, frequent repeat episodes, and a high prevalence of comorbidities. These high rates of disease demand urgent attention.

MJA 2010; 192: 586–590

See also page 592

Rates of acute lower respiratory infection (ALRI) are generally considered to reflect the ongoing and substantial health disparities between Indigenous and non-Indigenous children in Australia[1] and other affluent countries such as the United States.[2] Increasingly, early respiratory illness, especially in the first 2 years of life, is recognised as an important predeterminant of adult lung disease.[3,4] Studies in Central Australia have shown an increased risk of chronic respiratory conditions, such as bronchiectasis, in Indigenous children, probably as a result of repeated respiratory infection in infancy.[5,6]

However, available data on the epidemiology of ALRI in Australian Indigenous infants are limited. Importantly, there are no comprehensive population data with standardised methods of defining pneumonia (World Health Organization [WHO] radiologically defined pneumonia) for comparison with those from other countries. There are also no data comparing ALRI rates in the Top End of the Northern Territory and in Central Australia.

The morbidity of ALRI in NT Indigenous children has recently been analysed in a large study of pneumonia applying the WHO diagnostic protocol.[7] Here, we report on a nested analysis within that study describing the epidemiology of ALRI in NT Indigenous children hospitalised in the first year of life.

METHODS

Design

We conducted a historical cohort study of hospitalised episodes of ALRI in NT Indigenous children aged less than 12 months. We included all children born 1 January 1999 to 31 December 2004. Birth cohorts were constructed from two population-based health datasets — the NT Immunisation Register and the NT Hospital Discharge Dataset.

Setting

Five public hospitals in the NT admit all NT Indigenous children requiring hospital treatment.

Every child born in the NT or receiving services at any public NT health service is allocated a unique health record number. This is used for all subsequent episodes of medical care, and is also the basis for inclusion on the NT Immunisation Register — a population-based register that vaccine providers report to routinely. Children not born in a public hospital are added to the immunisation register either through compulsory registration on the NT Midwives' Collection, or at the time of their first immunisation or first presentation for health care.

Population studied

Children were included if they were born between the specified dates and were resident in the NT at the time they were registered. Person-time under observation commenced at birth and ceased on 31 December 2004, or the date of the child's death, or the date the child turned 12 months of age, whichever occurred first.

Outcomes

All primary and secondary diagnoses within an admission were included in the analysis.

Respiratory diagnoses

A diagnosis of an ALRI was based on an ICD-10-AM code (International classification of diseases, 10th revision, Australian modification) within the range J10–J22 inclusive. Bronchiectasis was defined by ICD-10-AM code J47.

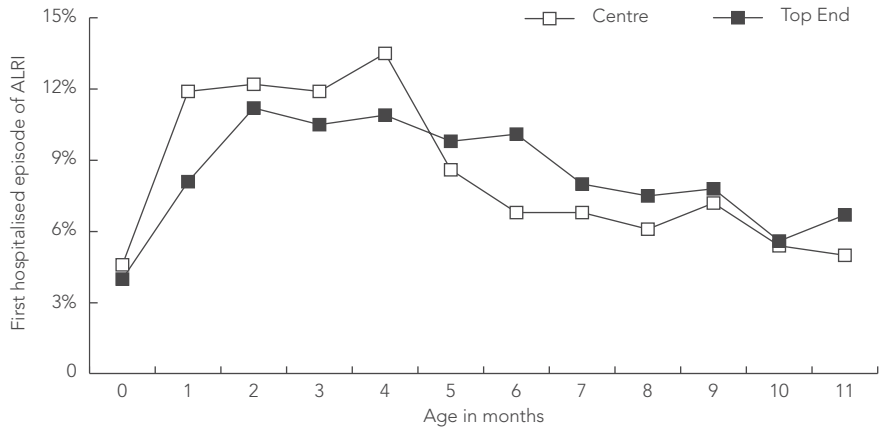
Radiologically confirmed pneumonia

All chest x-rays taken within any admission for any diagnosis were obtained from all hospital radiology departments across the NT. Films were read for WHO-defined pneumonia.[8] According to the WHO protocol, x-ray films are read independently by two paediatric or respiratory physicians blinded to all data on the demographic, clinical and vaccination history of the subject. For admissions in which more than one x-ray was taken, any film deemed positive classified the admission episode as pneumonia. A positive first x-ray taken within 3 days of admission classified the admission episode as community-acquired pneumonia.

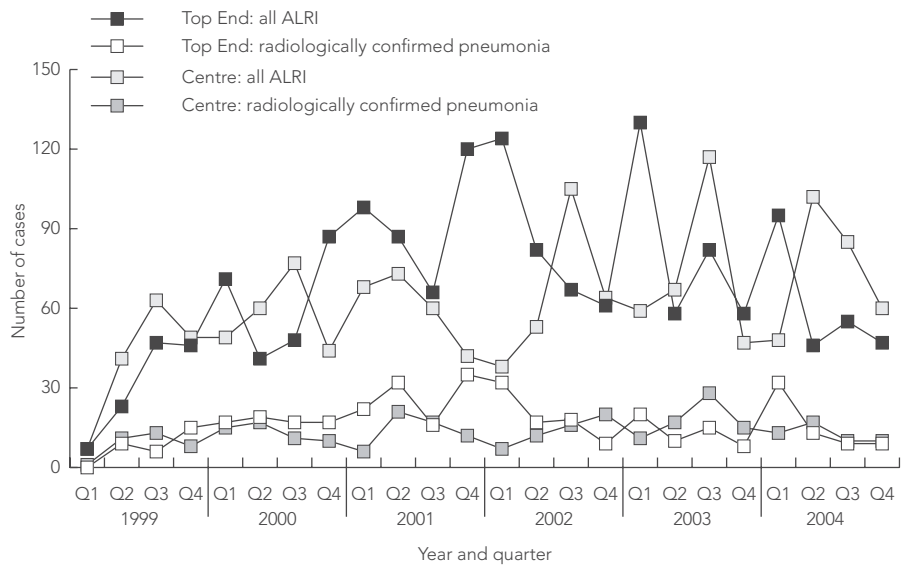
Covariates

Data on respiratory diagnoses were examined by the infant's age in months, sex, region of residence in the NT, and any key comorbidities present. Region of residence

1 Frequency distribution (%) of the first episode of acute lower respiratory infection (ALRI) requiring hospitalisation in Northern Territory Indigenous children aged < 12 months, by age in months and NT region



2 Hospitalised episodes of acute lower respiratory infection (ALRI) and radiologically confirmed pneumonia in Northern Territory Indigenous children aged < 12 months, by time period and NT region



was defined as "Top End" (Top End of the NT) or "Centre" (Central Australian region of the NT). Key comorbidities were defined as concomitant diagnoses of acute gastroenteritis, anaemia and malnutrition, classified by groupings of multiple ICD-10-AM codes for each category. Data on birthweight and other potentially important characteristics (eg, exposure to tobacco smoke) were not available in the dataset.

Statistical analyses

Incidence rates were calculated by dividing the number of cases by the person-time at risk from birth and are presented in units per 1000 child-years, with corresponding 95% confidence intervals. Relative risks and their exact 95% CIs were calculated to compare incidence rates by region and sex. The Kruskal–Wallis rank test was used to compare non-parametric distributions. Data were analysed using Stata, version 10.1 (StataCorp, College Station, Tex, USA).

Ethics approval

The study was approved by the joint institutional Human Research Ethics Committee of the NT Department of Health and Community Services and the Menzies School of Health Research (HREC ID: 05/49), and the Human Research Ethics Committee of Central Australia.

RESULTS

Overall episodes of care

There were 9295 infants, 8498 child-years of observation and 15 948 hospitalised episodes of care over the study period; 8153 episodes of care were childbirth, and 747 (8.0%) infants had no record of having been in hospital. Seventy-one per cent of infants were Top End residents, 61% were from remote areas, and 52% were boys.

There was a median of two diagnoses per hospitalisation (range 1–40; interquartile range [IQR], 1–3); 10% of episodes had five or more diagnoses. Chest x-rays were obtained in 88% of all episodes with a diagnosis of ALRI.

There were 113 deaths recorded — an overall infant mortality rate of 13.3 deaths per 1000 child-years. Ninety-four deaths (83.1%) occurred within 24 hours of birth, two at 12 and 16 days of age, and 17 between 50 and 295 days of age. In 11 of the 17 deaths after the perinatal period, the child had a respiratory diagnosis (acute bronchiolitis in four infants and pneumonia unspecified in three).

Acute lower respiratory tract infections

There were 3227 (20%) episodes of care for ALRI, and 3626 diagnoses of ALRI for 2028 infants (21.8%); 665 (7.2%) had two or more episodes, and 55 (0.6%) had five or more. The incidence was 426.7 episodes per 1000 child-years (95% CI, 416.2–437.2). Incidence rates were 23% higher in boys (relative risk [RR], 1.23; 95% CI, 1.15–1.33) and over two times higher (RR, 2.12; 95% CI, 1.98–2.27) for infants in the Central Australian region of NT.

The median age at the time of first admission for ALRI was 4.6 months (IQR, 2.6–7.3) (Box 1). For children with multiple episodes, the median intervals between first to second, second to third, and third to fourth episodes were 54, 62 and 45 days, respectively. Intervals narrowed to medians of 26–33 days for subsequent episodes.

There were clear differences in temporal trends of ALRI diagnoses by NT region (Box 2). The associated diagnoses were dominated by seasonal peaks for bronchiolitis in the first quarter of the year in the Top End and in the third quarter of the year in the Central Australian region. Influenza outbreaks accounted for peaks apparent in the fourth quarter of 2000 and third quarter of 2003 in both

3 Number (%)* of episodes of care in hospital for acute lower respiratory infection (ALRI) with one or more key comorbidities, by ALRI diagnosis and Northern Territory region: Indigenous infants aged < 12 months, 1 January 1999 to 31 December 2004

	Gastroenteritis			Anaemia			Malnutrition		
Episodes of care	Top End	Centre	NT	Top End	Centre	NT	Top End	Centre	NT
All ALRI	411 (24.0%)	421 (27.8%)	832 (25.8%)	428 (25.0%)	468 (30.9%)	896 (27.8%)	70 (4.8%)	58 (3.8%)	128 (4.0%)
Bronchiolitis	175 (17.4%)	197 (23.5%)	372 (20.0%)	211 (20.7%)	186 (22.2%)	397 (21.4%)	25 (2.5%)	27 (3.3%)	52 (2.8%)
Pneumonia	168 (30.9%)	189 (32.1%)	357 (31.5%)	182 (33.5%)	241 (40.9%)	423 (37.3%)	28 (5.2%)	29 (4.9%)	57 (5.0%)
Radiologically confirmed pneumonia	70 (28.3%)	63 (28.6%)	133 (28.5%)	82 (33.2%)	89 (40.5%)	171 (36.6%)	11 (4.5%)	14 (6.4%)	25 (5.4%)
Influenza	14 (23.3%)	5 (29.4%)	19 (24.7%)	22 (36.7%)	11 (64.7%)	33 (42.9%)	2 (3.3%)	1 (5.9%)	3 (3.9%)
Non-ALRI	962 (11.3%)	817 (19.4%)	1779 (14.0%)	447 (5.3%)	420 (10.0%)	867 (6.8%)	133 (1.6%)	85 (2.0%)	218 (1.7%)

* Percentages are of total ALRI episodes in each diagnosis category and region. ◆

regions. Seasonality was less clear for radiologically confirmed pneumonia.

One or more key comorbidities were present in 1445 (44.8%) of the 3227 episodes of care for ALRI: gastroenteritis in 832 (25.8%), anaemia in 896 (27.8%) and malnutrition in 128 (4.0%) episodes. Comorbidities were more frequent in ALRI episodes than in non-ALRI episodes and in pneumonia episodes than in bronchiolitis episodes (Box 3).

ALRI diagnostic groups

Of the ALRI diagnostic groups, bronchiolitis was the most common; rates of 352 per 1000 child-years (95% CI, 333–371) in the Central Australian region were double those of the Top End (RR, 1.99; 95% CI, 1.82–2.18). Discharge diagnoses in the 3227 episodes of care for ALRI and rates per 1000 child-years by diagnosis and NT region are presented in Box 4.

There were 428 (13.3%) episodes of care in 366 infants with radiologically confirmed pneumonia diagnosed within 3 days of admission. In a total of 457 (14.2%) episodes of care for ALRI, pneumonia was confirmed radiologically; 249 of these (54.5%) were unspecified pneumonias, and 160 (35.0%) were bronchiolitis.

Three hundred and seventeen infants had one episode and 49 had two or more episodes of radiologically confirmed pneumonia before 12 months of age. The overall incidence was 43.7 episodes per 1000 child-years (95% CI, 39.5–48.3): 38.3 (95% CI, 33.6–43.5) in infants in the Top End and 78.4 (95% CI, 68.1–89.6) in Central Australian infants. The median age at the time of the first episode was 5.7 months (IQR, 1.4–8.6 months). Of the 366 infants with one or more episodes of radiologically confirmed pneumonia, 101 (27.6%) had had at least one prior hospitalisation for ALRI before the first pneumonia episode.

Bronchiectasis

There were 13 episodes of care for 10 infants with bronchiectasis — an incidence of 1.18 per 1000 child-years (95% CI, 0.60–2.16). The incidence in Central Australian infants was 2 per 1000 child-years compared with 0.8 per 1000 child-years in Top End infants (RR, 2.4; 95% CI, 0.72–7.97); seven were boys. The median age at admission for the first diagnosis was 8.5 months (IQR, 4.1–10.2 months). All infants had multiple comorbidities at each admission; two had a concomitant diagnosis of radiologically confirmed pneumonia.

For four infants, the first episode of bronchiectasis was the first episode of care for a respiratory illness; the remaining infants had had between one and three prior hospitalised episodes with an ALRI. Three infants had had two prior episodes of radiologically confirmed pneumonia; for each child there was a 2-month interval between each episode of radiologically confirmed pneumonia and a 2-month interval until the subsequent episode for bronchiectasis.

DISCUSSION

One in five NT Indigenous infants will be hospitalised at least once before their first birthday with an ALRI; 7% will have two or more episodes and 4% will have radiologically confirmed lobar pneumonia. The first hospitalised episode occurs early in life, with 50% of cases occurring before 5 months of age; in 45% of episodes one or more comorbidities — anaemia, gastroenteritis, malnutrition — are present. At least one in every thousand NT Indigenous infants has bronchiectasis in their first year of life. The risk for most respiratory diagnoses is twice as high for infants in the Central Australian region of NT as it is for those in the Top End.

The rates of hospitalisation for ALRI (427 per 1000 child-years) among NT Indigenous infants are substantially higher than those in American Indian or Alaskan Native infants (116 per 1000 child-years),[9] or those in developing countries (290 episodes per 1000 child-years in children aged < 5 years),[10] as described in a meta-analysis of community-based studies. The incidence of WHO-defined radiologically confirmed pneumonia among children in the Central Australian region of NT (78.4 episodes per 1000 child-years; 95% CI, 68.1–89.6) is the highest incidence reported in published studies using the WHO protocol. These include studies of infants in the US,[11] The Gambia,[12] South Africa,[13] Fiji,[14] Uruguay,[15] Indonesia,[16] the Philippines,[17] and Pakistan.[18] Differences in case-ascertainment methods and access to hospital may partly explain the high rates we observed; however, they cannot entirely explain our findings.

Our study has identified a marked increase in hospital admissions for bronchiolitis (all causes) in infants. Between 1998 and 2000, the incidence in Central Australia was 190 per 1000 population aged under 12 months (88% were Aboriginal infants),[19] compared with 352 per 1000 child-years in our study. Both studies reviewed all hospitalisations and included both primary and secondary diagnoses; however, the former study included the use of ICD-9-CM diagnoses, and incidence was calculated based on 1999 population data.[19] A clear annual increase since 1999 was observed in our study, with a large epidemic in 2004. Hospitalisations for bronchiolitis have also been increasing in Western Australian Aboriginal infants,[20] as well as in the American Indian population,[9] for reasons that are not clear. The high proportion of radiologically confirmed pneumonia in bronchiolitis episodes is consistent with emerging evidence that

4 ICD-10-AM discharge diagnoses ($n = 3626$) for 3227 hospital episodes of care for acute lower respiratory infection: Northern Territory Indigenous infants aged < 12 months, by region of residence in the NT, 1 January 1999 to 31 December 2004

	Top End		Centre		NT	
	Total (%)	Rate per 1000 child-years	Total (%)	Rate per 1000 child-years	Total (%)	Rate per 1000 child-years
Bronchiolitis						
Acute bronchiolitis unspecified	809 (41.7%)	134.9	732 (43.6%)	292.8	1541 (42.6%)	181.3
Acute bronchiolitis, respiratory syncytial virus	212 (10.9%)	35.3	106 (6.3%)	42.4	318 (8.8%)	37.4
Acute bronchiolitis, other specified organism	41 (2.1%)	6.8	42 (2.5%)	16.8	83 (2.3%)	9.8
Bronchitis						
Acute bronchitis specified organism	17 (0.9%)	2.8	5 (0.3%)	2.0	22 (0.6%)	2.6
Acute bronchitis unspecified	7 (0.4%)	1.2	4 (0.2%)	1.6	11 (0.3%)	1.3
Influenza						
Influenza, virus identified	63 (3.3%)	10.5	15 (0.9%)	6.0	78 (2.2%)	9.2
Influenza, virus not identified	2 (0.1%)	0.3	6 (0.4%)	2.4	8 (0.2%)	0.9
Pneumonia						
Pneumonia unspecified	465 (24.0%)	77.5	541 (32.3%)	216.4	1006 (27.8%)	118.4
Bronchopneumonia unspecified	41 (2.1%)	6.8	32 (1.9%)	12.8	73 (2.0%)	8.6
Respiratory syncytial virus pneumonia	23 (1.2%)	3.8	21 (1.3%)	8.4	44 (1.2%)	5.2
Adenoviral pneumonia	6 (0.3%)	1.0	11 (0.7%)	4.4	17 (0.5%)	2.0
Bacterial pneumonia unspecified	16 (0.8%)	2.7	0 (0.0)	0.0	16 (0.4%)	1.9
Pneumonia due to *Haemophilus influenzae*	8 (0.4%)	1.3	6 (0.4%)	2.4	14 (0.4%)	1.6
Parainfluenza virus pneumonia	5 (0.3%)	0.8	8 (0.5%)	3.2	13 (0.4%)	1.5
Pneumonia due to *Streptococcus pneumoniae*	10 (0.5%)	1.7	3 (0.2%)	1.2	13 (0.4%)	1.5
Pneumonia due to other streptococci	10 (0.5%)	1.7	3 (0.2%)	1.2	13 (0.4%)	1.5
Viral pneumonia unspecified	2 (0.1%)	0.3	5 (0.3%)	2.0	7 (0.2%)	0.8
Other pneumonia ($n = 14$)*						
Unspecified acute lower respiratory infection	206 (10.6%)	34.3	129 (7.7%)	51.6	335 (9.3%)	39.4
Total	**1947 (100.0%)**	**323.1**	**1679 (100.0%)**	**670.7**	**3626 (100.0%)**	**426.7**

ICD-10-AM = International classification of diseases, 10th revision, Australian modification. *Lobar pneumonia unspecified (Centre, 3); pneumonia due to staphylococcus (Centre, 3); pneumonia in viral disease classed elsewhere (Centre, 2); other viral pneumonia (Centre, 2); chlamydial pneumonia (Top End, 1); pneumonia due to other specified organisms (Top End, 1); pneumonia due to *Klebsiella pneumoniae* (Top End, 1); pneumonia in bacterial disease classed elsewhere (Top End, 1). ◆

viruses play an important role in the aetiology of pneumonia, independently and as interrelated agents in bacterial infections.[21]

The high proportion of infants admitted to hospital with ALRI and a comorbidity of anaemia, gastroenteritis and/or malnutrition, known risk factors for ALRI,[22-24] is likely to be important. However, among studies using the WHO protocol, there is limited reporting of these conditions in populations without a high burden of HIV and malaria. It is unlikely that comorbidities alone are contributing to the high rates of disease in Indigenous infants. Overcrowding, young maternal age, low birthweight, and exposure to indoor and/or tobacco smoke are probable contributing factors. However, there is virtually no research specifically examining their relative importance for Indigenous children hospitalised with ALRIs. A small survey of 73 hospitalised Aboriginal children aged less than 14 years in Alice Springs found that the rate ratio for regular cough in children with household tobacco exposure was 2.77 (95% CI, 1.06–7.23).[25] The Western Australian Aboriginal Child Health Survey found that parent-reported respiratory infections were more common in low-birthweight babies and those who had not been breastfed exclusively for 6 months.[26]

The differing disease burdens in the Top End and Central Australian regions of the NT highlight the problems with reporting aggregate data across populations and regions. The difference is difficult to explain in the absence of any recent data examining the individual, social, environmental, health care and/or hospitalisation referral factors between the regions. The higher proportion of comorbidities in Central Australian children admitted with non-ALRI conditions suggests that they may have poorer overall health, but further research is needed to explain the differences reported here.

The frequency of multiple episodes of ALRI in early infancy is likely to be the key factor in the incidence of non-cystic fibrosis bronchiectasis in this population before 12 months of age. Data on the incidence in other disadvantaged populations in the same age group are scarce.

Our data provide no real clues as to the major aetiological causes of ALRI in Indigenous infants in the NT. The bulk of diagnoses are of unspecified aetiology. Our study also further highlights the limitations of using hospital discharge diagnoses alone to examine the epidemiology of disease at the population level, particularly given the suboptimal sensitivity for subcategories of ALRI.[27-29] We specifically included all diagnoses, not just primary diagnosis codes, and all chest x-rays taken in any admission for

any cause to maximise case ascertainment and to account for changes in coding practices over time. Furthermore, while there are concerns about the sensitivity and specificity of the WHO radiological definition of pneumonia,[30] in our dataset 8.4% of radiologically confirmed cases had no corresponding ALRI diagnosis. Similarly, chest x-rays were not taken in 12% of infants with an ALRI diagnosis, and milder cases may have been missed.

The high rates of ALRIs and bronchiectasis in NT Indigenous infants warrant immediate attention. The Aboriginal health debate is currently dominated by the burden of the metabolic syndrome, chronic disease and substance abuse in adults. However, the huge burden of childhood ALRI has multiple consequences for the Aboriginal population. The response must be multipronged: research must continue, and policies that change the living environment and facilitate hygiene,[31] improve educational outcomes for parents of the future, and enhance parenting skills[32] must be a priority.

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COMPETING INTERESTS

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