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Community-based estimates of incidence and risk factors for childhood pneumonia in Western Sydney

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SUMMARY

The aim was to estimate the community incidence and risk factors for all-cause pneumonia in children in Western Sydney, Australia. A cross-sectional randomized computer-assisted telephone interview was conducted in July 2000, in Western Sydney. Parents of 2020 children aged between 5 and 14 years were interviewed about their child's respiratory health since birth. No verification of reported diagnosis was available. Logistic regression analysis was used to determine risk factors for pneumonia. A lifetime diagnosis of pneumonia was reported in 137/2020 (6·8%) children, giving an estimated incidence in the study sample of 7·6/1000 person-years. Radiological confirmation was reported in 85% (117/137). Hospitalization was reported in 41% (56/137) and antibiotic therapy in 93% (127/137) of cases. Using logistic regression modelling, statistically significant associations with pneumonia were a reported history of either asthma, bronchitis or other lung problems and health problems affecting other systems. In most cases, the diagnosis of asthma preceded the diagnosis of pneumonia. The community incidence of all causes of pneumonia is not well enumerated, either in adults or in children. This study provides community-based incidence data. The incidence of hospitalization for pneumonia in this study is comparable to estimates from studies in comparable populations, suggesting that retrospective parental report for memorable events is likely to be valid. We found a relationship between pneumonia and childhood respiratory diseases such as asthma, which has implications for targeted vaccination strategies.

INTRODUCTION

The community incidence of all-cause pneumonia is not well enumerated, either in adults or in children. The estimated annual incidence will vary with diagnostic practice and the intensity of surveillance. One study described an incidence of pneumonia in adults of 2·6/1000 people [1]. In children aged 15 years or younger, other investigators found a rate of 39/1000 children, with only 9% requiring hospitalization [2]. In Finland, however, a study using active case ascertainment and radiological conformation, found an overall incidence of 11·6/1000 population, with 36/1000 in children aged 0–4 years [3]. This study described a 42% hospitalization rate and a 4% case fatality rate [3]. Rates of pneumonia as high as 74/1000 have been described in the first 3 years of life [4]. We are not aware of any community-based estimates of the incidence of pneumonia using parental recall or of any estimates from Australia.

It is estimated that 25–30% of childhood community-acquired pneumonia is caused by pneumococcus and about 20% by viruses, particularly

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respiratory syncytial virus [5]. *Chlamydia pneumoniae* and *Mycoplasma pneumoniae* are also common causes of pneumonia, particularly in older children [5].

Risk factors associated with pneumonia include asthma and day-care use [4, 6–9]. The association between asthma and pneumonia has been described several times, but the precise relationship between the two conditions is still unclear. Some studies suggest that pneumonia diagnosis precedes the onset of clinical asthma [4], but others suggest that asthma predisposes to pneumonia [6, 10]. Misdiagnosis of non-specific radiological findings in asthma (such as atelectasis) as pneumonia may be a contributing factor, but a true predisposition to pneumonia in persons with pre-existing chronic lung disease is biologically plausible.

We aimed to describe the community incidence and risk factors for all-cause pneumonia in children in Western Sydney, NSW.

METHODS

A cross-sectional randomized computer-assisted telephone interview (CATI) was conducted over a 20-day period from late June to mid July 2000, in Western Sydney, which is defined by an area health service. Parents of children aged between 5 and 14 years were interviewed about the respiratory health of one age-eligible child in their family, selected according to pre-determined criteria (see below).

Western Sydney has a population of 665 827 residents, with over a fifth (148 000) aged $\leqslant 14$ years. The area also has a large immigrant population, with 33% of its residents being born overseas, and 26% of the population originating from non-English-speaking backgrounds. The area also has a significant and relatively young aboriginal population.

Although overall socio-economic status is similar to the state average, the population is heterogeneous, with some suburbs within the highest 10% of the state, and others in the lowest 40%.

Telephone questionnaire

This study was part of a larger survey on immunization status, cough history and history of pertussis. The structured questionnaire included standard demographic information, respiratory and immunization history, and diagnos(es) of pneumonia as recalled by parents. A cross-sectional telephone survey was conducted using a telemarketing company selected by competitive tender and administered by trained marketing researchers to households with at least one child aged between 5 and 14 years. The adult with primary responsibility for the child's health was interviewed.

Households were contacted randomly by modified random digit telephone dialling. Numbers were tried up to three different times on various days until contact was established. When there was more than one eligible child, the child whose birth date was closest to the interview date was selected.

Inclusion criteria

Households within the area health service with at least one child aged between 5 and 14 years were eligible. The interviewer asked to speak to the primary health decision maker (defined as the person who took the child for immunizations or medical attention when ill). Verbal consent was obtained prior to the interview.

Exclusion criteria

Due to budgetary limitations, no households where the primary carer spoke no English were included in this survey.

Sample size and power calculations

Sample size was calculated to determine the prevalence of pertussis-like symptoms. The sample size of 2020 was chosen to adequately power the main study, of which this study was a component. The sample size required to give 95% confidence and 80% power to detect a prevalence of 5% of pneumonia in this population is 203.

Data analysis

The data were analysed using Epi-Info version 6 for univariate analysis. Because of the varying ages of children (5–14 years) and the variation in time since diagnosis of pneumonia, incidence of pneumonia was calculated using a denominator of person-years of follow up, calculated by summing the ages of all the children at the time of interview. This assumed that parental recall reflected follow up from birth to the current age at the time of interview. For the incidence of pneumonia occurring before the age of 5 years, the person-years of follow up were calculated

by multiplying the number of children (2020) by 5, the latter being the total number of years for each child to reach 5 years of age.

Egret [11] was used to model risk factors for pneumonia by logistic regression analysis. The major outcome variable was a lifetime diagnosis of pneumonia. Analyses were also conducted for the outcomes of radiologically confirmed pneumonia, and pneumonia requiring hospitalization. For this modelling, dichotomous variables were created for:

- aboriginality;
- Australian birth;
- cigarette smoke exposure in the household;
- educational institution, if any, attended by the child;
- gender;
- asthma diagnosed by a doctor during lifetime;
- bronchitis diagnosed during lifetime;
- croup diagnosed during lifetime;
- other respiratory problems;
- other health problems necessitating regular presentation to either a doctor or hospital unit;
- non-English-speaking background;
- number of
  - parents residing in the household;
  - older siblings residing in the household;
  - younger siblings residing in the household;
- socio-economic status measured by qualification for health-care card;
- lifetime diagnosis of pneumonia;
- hospitalization for pneumonia.

All the above variables were modelled using logistic regression analysis, but only variables which were significant were included in the final models.

Ethical consideration

Participation in this telephone survey was voluntary and the responding parent/guardian was informed that they did not have to answer any questions they did not feel comfortable with. No incentive was offered for participation. Ethics approval was obtained from the Ethics Committees of both the Western Sydney Area Health Service and the Children's Hospital at Westmead.

RESULTS

Of 2463 eligible households contacted, 82% (2020/2463) participated in the study. A lifetime diagnosis of pneumonia was reported in 137/2020 (6·8%) children. The estimated incidence of pneumonia in the study sample was 7·6/1000 person-years.

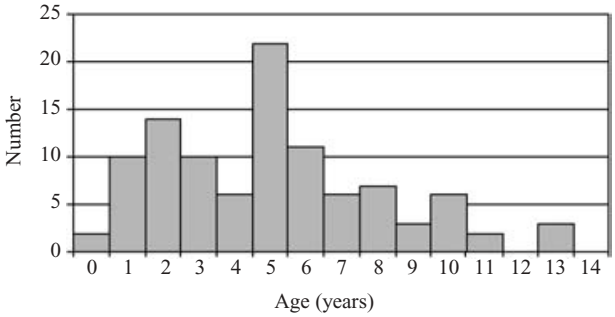

Fig. 1. Age at diagnosis of pneumonia for children aged between 5 and 14 years, Western Sydney, Australia.

Radiological confirmation of the diagnosis of pneumonia was reported by 85% of pneumonia cases (117/137). Hospitalization was required in 41% (56/137) and antibiotic therapy in 93% (127/137), giving an estimated incidence of pneumonia requiring hospitalization of 3·1/1000 person-years. More than one episode of pneumonia was reported in 20% (28/137) of children.

Only 102/137 parents recalled the age at which the child was diagnosed with pneumonia – 42/102 (41%) were diagnosed between 0 and 4 years of age. Figure 1 shows the age of diagnosis of pneumonia. The estimated incidence of pneumonia before the age of 5 (0–4 years) is 4·2/1000 person-years. In aboriginal children, the reported rate of pneumonia was 12/1000 person-years and 7·5/1000 person-years in non-aboriginal children, but this difference did not reach statistical significance (OR 1·85, 95% CI 0·55–5·63).

Table 1 shows the univariate analysis of risk factors for pneumonia. There were 69/137 (50%) children with a medical diagnosis of asthma among the pneumonia cases. Of these, 47/69 parents recalled the age of diagnosis of both asthma and pneumonia. In 28/47 (60%) cases, asthma was diagnosed prior to the onset of pneumonia, in 12/47 (25%), the episode of pneumonia occurred prior to the diagnosis of asthma, and in 7/47 (15%) cases both were diagnosed at the same time.

Using logistic regression modelling, the significant predictors of pneumonia were a history of asthma, bronchitis, other lung problems and chronic health problems affecting other systems (Table 2). Aboriginality, low socio-economic status (as determined by eligibility for a health-care card), number of children and adults in the household and smoking in the

Table 1. *Univariate analysis of risk factors for pneumonia*

Variable	*n*	OR	95% CI	*P* value
Asthma				
Pneumonia cases	68/137	2·4	1·7–3·5	<0·0001
Controls	548/1883			
Bronchitis				
Pneumonia cases	23/137	2·7	1·6–4·5	<0·0001
Controls	131/1883			
Other lung problems*				
Pneumonia cases	16/137	3·9	2·1–7·2	<0·0001
Controls	62/1883			
Other health problems†				
Pneumonia cases	31/137	2·33	1·5–3·7	<0·0001
Controls	210/1883			
Aboriginal or Torres Strait Islander				
Pneumonia cases	4/137	1·9	0·55–5·6	0·24
Controls	30/1883			
Smoking in the household				
Pneumonia cases	40/137	0·85	0·57–1·3	0·41
Controls	614/1883			
Pneumonia cases <5 years	11/42	0·74	0·34–1·55	0·39
Controls	643/1978			
Health-care card				
Pneumonia cases	50/137	1·3	0·91–1·95	0·12
Controls	568/1883			

* Other lung problems include cystic fibrosis, bronchiolitis, pneumothorax, pleurisy, tuberculosis, bronchiectasis.
† Other health problems defined as any health problem requiring ongoing medical attention. Examples in the dataset include diabetes, epilepsy, attention deficit disorder, Down Syndrome.

Table 2. *Logistic regression model for predictors of pneumonia*

Variable	OR	95% CI	*P* value
Lifetime diagnosis of asthma	2·05	1·4–2·9	<0·001
Bronchitis, ever	2·13	1·3–3·5	<0·01
Other lung problems* (ever)	3·5	1·9–6·4	<0·001
Other health problems†	1·9	1·2–3·0	<0·01

* Other lung problems include cystic fibrosis, bronchiolitis, pneumothorax, pleurisy, tuberculosis, bronchiectasis.
† Other health problems defined as any health problem requiring ongoing medical attention. Examples in the dataset include diabetes, epilepsy, attention deficit disorder, Down Syndrome.

household did not achieve statistical significance. The models which used hospitalized pneumonia and radiologically confirmed pneumonia as outcomes showed the same risk factors (asthma, bronchitis, other lung problems and chronic health problems) to be significant predictors.

DISCUSSION

The incidence of pneumonia described in this study is not directly comparable to the few other available studies which measured community incidence of pneumonia [1, 3, 4], as it was based on parental recall and used a denominator of person-years. A Finnish study found an incidence of 36/1000 children aged <5 years, but used active case finding [3]. If we used persons rather than person-years as a denominator, the rate of pneumonia in children aged <5 years would be 21/1000. However, when using cross-sectional data to estimate incidence, it is more sound methodologically to use person-years as a denominator, because this adjusts for varying periods of time since diagnosis of pneumonia. We found that 41% of reported pneumonia cases required hospitalization. This is close to the 42% estimate from Finland and lends credibility to this method of case ascertainment [3]. Our study found 85% of cases had radiological confirmation of the diagnosis. Jokinen et al. [3] reported that 97%

of their cases were radiologically confirmed, but a higher figure is expected in this study, as radiology was used as the predominant method of case ascertainment.

The risk factors we found to be associated with pneumonia were asthma, bronchitis, other lung problems and chronic illness. In most cases, we found that the diagnosis of asthma preceded the diagnosis of pneumonia, suggesting that asthma predisposes children to lower respiratory tract infection. Other studies have shown an increased risk of pneumonia in children with asthma and wheeze [4, 6, 7, 10, 12]. In a prospective study of 888 children enrolled at birth, abnormal lung function tests (suggestive of an obstructive airways disease such as asthma or bronchitis) at 2 months of age predicted an increased risk of pneumonia in later childhood [4]. Another prospective study showed that abnormal lung function in early life may predispose infants to pneumonia in the first 2 years of life [8].

The association between chronic disease and pneumonia risk has been shown in adults and children [13, 14]. Malnutrition and domestic crowding have also been shown to be risk factors [15].

Rates of pneumonia and hospitalization for pneumonia in aboriginal Australians are known to be much higher than in non-aboriginal Australians [16–18]. We were unable to demonstrate aboriginality as a significant risk factor, probably because the number of children of aboriginal or Torres Strait Islander descent was low, and therefore inadequately powered. Despite this, the point estimate showed a near doubling of risk.

Exposure to smoking in the household has been associated with risk of lower respiratory tract infections in children [19, 20], but we have been unable to demonstrate this risk. We did not quantify smoking exposure in our study – the only information we collected was whether any person residing in the same household as the child smoked inside the house.

This study is subject to certain limitations. The ascertainment of pneumonia was by parental recall, which may be subject to bias. It is unlikely that underreporting of a potentially serious illness in childhood, such as pneumonia, is a major problem, but overreporting, particularly in children with other respiratory illnesses (such as asthma), may be. There have been no specific studies of the validity of parental recall of pneumonia, but studies of parental recall of birth weight and neonatal health events show that recall is reasonable [21, 22]. Parental recall of a single diagnosis, such as in the emergency room setting, appears to be good, but is less accurate if the child has multiple diagnoses [23]. In addition, the sample size for this study was calculated for another purpose. However, this should not have a major impact on determining the incidence of pneumonia, since this is a common disease.

Another potential limitation of this study is the use of a cross-sectional approach to estimate incidence. Nevertheless, if parental recall is assumed to be a reasonable proxy for longitudinal follow up (that is, the parent has 'followed up' the child for the duration of their lifetime), this method should be valid for estimating incidence. Most studies of community-acquired pneumonia in childhood have focussed only on hospitalized cases [24–26]. Few studies have attempted to measure the community incidence of pneumonia, for logistic reasons. In the absence of expensive gold standard methods such as case registers and active case finding, a community-based telephone survey probably gives a fair estimate of the community burden of pneumonia.

In summary, we describe the community-based incidence of all-cause pneumonia in Western Sydney based on parental self-report. Our data suggest that children with pre-existing lung disease, particularly asthma and bronchitis, are at an increased risk of pneumonia. As a high percentage of pneumonia is caused by *Streptococcus pneumoniae*, potentially preventable by conjugate pneumococcal vaccine [27]. These methods could be used for population-based post-marketing surveillance of the impact of conjugate pneumococcal vaccine or other initiatives to decrease lower respiratory tract disease such as tobacco control.

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