Objective To calculate the incidence and document the clinical features of chest X-ray- (CXR-) confirmed pneumonia in children aged between 1 month and 5 years living in Greater Suva, Fiji.

Methods A retrospective review was undertaken of children aged between 1 month and 5 years with a discharge diagnosis suggesting a lower respiratory tract infection (LRTI) admitted to the Colonial War Memorial Hospital in Suva, Fiji, in the first 10 days of each month from 1 January 2001 to 31 December 2002. Clinical data were collected and CXRs were reread and classified according to WHO standardized criteria for CXR-confirmed pneumonia.

Findings Two hundred and forty-eight children with LRTI met the inclusion criteria. CXRs were obtained for 174 (70%) of these cases, of which 59 (34%) had CXR-confirmed pneumonia. The annual incidence of CXR-confirmed pneumonia was 428 cases per 100 000 children aged between 1 month and 5 years living in Greater Suva. If a similar proportion of the children for whom CXRs were unavailable were assumed to have CXR-confirmed pneumonia, the incidence was 607 per 100 000. The incidence appeared to be higher in Melanesian Fijian than Indo-Fijian children. The case-fatality rate was 2.8% in all children with LRTI, and 6.8% in those with CXR-confirmed pneumonia.

Conclusion This is the first study to document the incidence of CXR-confirmed pneumonia in a Pacific Island country, and demonstrates a high incidence. A significant proportion of hospital admissions of children with LRTI are likely to be preventable by the introduction of pneumococcal conjugate vaccine.

Keywords Pneumonia, Pneumococcal/diagnosis/epidemiology; Lung/radiography; Respiratory tract infections/classification/epidemiology; Child; Retrospective studies; Fiji (source: MeSH, NLM).

Mots clés Pneumopathie à pneumocoque/diagnostic/épidémiologie; Poumon/radiographie; Voies aériennes supérieures, Infection/classification/épidémiologie; Enfant; Etude rétrospective; Fidji (source: MeSH, INSERM).

Palabras clave Neumonía neumocócica/diagnóstico/epidemiología; Pulmón/radiografía; Infecciones del tracto respiratorio/clasificación/epidemiología; Estudios retrospectivos; Niño; Fidji (fuente: DeCS, BIREME).

Introduction Each year, more than 10 million children worldwide die before their fifth birthday, and more than 97% of these deaths occur in developing countries (1, 2). Almost two million deaths are caused by acute respiratory infections (ARI), mainly pneumonia (3). Streptococcus pneumoniae is the commonest bacterial cause of pneumonia in developing countries (4). The epidemiology of pneumococcal pneumonia is poorly defined in most regions, and has not been previously documented in any Pacific Island country. Health authorities need information on the burden of pneumococcal disease to assist them to make a decision regarding the introduction of the new 7-valent pneumococcal conjugate vaccine for infants (5).

The epidemiology of pneumococcal pneumonia is poorly documented because of the inherent difficulties in diagnosing pneumonia and establishing a specific etiology. In developing countries, childhood pneumonia is diagnosed using clinical parameters, usually based on the presence of cough and raised respiratory rate (6). This is a sensitive definition, maximizing the number of children identified and treated empirically, but it is non-specific and therefore highly dependent on the context in which it is being applied. This makes it unsuitable for...
epidemiological purposes (7). Blood cultures are often used to investigate the causative organism in cases of pneumonia. However, in most settings, very few pneumonia cases are bacteraemic, making this an insensitive test (8). Cultures from lung aspirates have a higher diagnostic yield, but this technique is rarely used because of the associated risk of pneumothorax (9). In the past, chest X-rays (CXRs) have not proved helpful for differentiating between different causes of pneumonia (10). However, no new methods have proved to have specific enough in diagnosing pneumococcal pneumonia to be useful for epidemiological studies or vaccine trials (11).

Vaccine trials designed to estimate the burden of vaccine-preventable disease, often referred to as “vaccine probe” studies, have been developed as an indirect method of measurement to overcome the intrinsic difficulties in defining the burden of pneumococcal pneumonia (12, 13). To provide an objective end-point, WHO has developed a standardized, radiological case definition of certain CXR-confirmed pneumonia for use in clinical trials (7). This minimizes inter-observer variability, enabling results to be compared across different time frames and locations (7, 14). The guidelines base the diagnosis of pneumonia on CXR features believed to be associated with bacterial lung infections. This is based on the assumption that cases of pneumococcal pneumonia constitute a larger percentage of cases of CXR-confirmed pneumonia than of all other respiratory tract infections (LRTI). The efficacy of pneumococcal conjugate vaccine against CXR-confirmed pneumonia in both developing and industrialized countries has been shown to be 20–30% (12, 13, 15).

There have been no previous studies to estimate the incidence of childhood pneumonia in Fiji. The aim of the present study was to calculate the incidence of CXR-confirmed pneumonia in children from Fiji to establish a benchmark for further investigation of the vaccine-preventable burden of pneumococcal pneumonia. In addition, the clinical management, etiology and case-fatality rates were documented.

Materials and methods

Study site

Fiji is a Pacific Island country with a total population of 823 300. Health standards are high, and health care is available and accessible to the majority of the population. The infant mortality rate is 18 per 1000 live births (16). The present study was conducted in the Colonial War Memorial Hospital (CWMH), located in the capital city, Suva. It is the only tertiary hospital in Fiji, and the only hospital in the Greater Suva region to admit children. Our investigations prior to the commencement of this study indicated that it was unlikely that children living in this subdivision who developed pneumonia would be admitted elsewhere. The only private hospital is small and does not admit children.

Study population

The study population consisted of all children between 1 month and 5 years of age diagnosed with an LRTI, who were admitted to CWMH in the first 10 days of every month from 1 January 2001 to 31 December 2002. Only the first admission for each child was included. Although it could be argued that the true incidence is better described by an analysis of the total number of cases, we chose to include only the first admission for each child as this is how most pneumococcal vaccine trials are analysed. The study population was limited to children with a residential address within the defined Greater Suva region. Children were excluded if they had a concurrent diagnosis of asthma.

All cases with a discharge diagnosis suggesting an LRTI, including pneumonia, bronchopneumonia, bronchiolitis, bronchitis, lung infection, acute respiratory infection, respiratory tract infection or lower respiratory infection, were identified from the paediatric admissions registers of the CWMH from 2001 and 2002. To ensure that the data were complete, the records of paediatric deaths and the medical laboratory records were reviewed for any missed cases. The medical records of cases were reviewed. Where medical records were not found, demographic details were collected from the admissions register and used to search for CXRs. These cases were included in the analysis, except when there were no data available describing the admission and it was not possible to classify the severity of disease. CXRs taken within 3 days of admission were included. CXRs were read by a qualified CXR reader and classified according to WHO criteria (7).

WHO definitions of clinical pneumonia were used (17). Very severe pneumonia was defined as the presence of one or more of the following signs of hypoxia: oxygen saturation less than 90%, cyanosis, unconsciousness, seizures, admission to an intensive care unit or requirement for ventilation. In the absence of any of these signs, children were considered to have severe pneumonia because of their requirement for hospital admission.

The catchment population included all children aged 1 month to 5 years living in the Greater Suva region. The source of the population statistics was the 1996 Fijian census (18). As there were no population data on neonates, neonates were assumed to comprise 1/60th of the population aged under 5 years of age and this figure was subtracted to determine the most accurate denominator for children under 5 years of age and outside the neonatal period. Population growth was not corrected for, as there had been considerable emigration following the attempted coup in 2000, and this was considered likely to balance natural growth. Population data used in the calculation of incidence of pneumonia according to ethnicity came from the Fiji Bureau of Statistics Household Income and Expenditure Survey, 2002 (19). These data were used in preference to the census data as it is likely that emigration affected some ethnic groups more than others.

Data analysis

Data were entered into an EpiData database (version 2.1b). Weight-for-age (WFA) Z-scores of children were calculated using the EpiInfo program (EpiInfo 2002). Children with a WFA Z-score of less than or equal to –2 were considered underweight. The annual incidence of CXR-confirmed pneumonia was calculated per 100 000 children aged between 1 month and 5 years living in Greater Suva as shown in Table 1. Incidence was calculated according to ethnicity using the same method (Table 2). For those cases for which no CXRs were found, clinical parameters were compared to those from cases for which the CXRs were available, using a chi-square test or Fisher’s exact test as appropriate for categorical variables, and two-sample t-tests for continuous variables. A P-value of less than 0.05 was considered to indicate a statistically significant difference between groups.
Ethical approval
Ethical approval for this study was given by the University of Melbourne Human Research Ethics Committee and the Fiji National Research Ethics Review Committee.

Results
Two hundred and forty-eight cases with a discharge diagnosis of LRTI were identified (Fig. 1). Thirteen admissions were excluded because they represented the second or third admission for patients already included. CXRs were located and reread for 12 of the patients, but demographic details available from the admission register were sufficient to confirm that these cases met the inclusion criteria.

The annual incidence of CXR-confirmed pneumonia was 428 cases per 100 000 children aged 1 month to less than 5 years (95% confidence intervals (CI), 346–528) (Table 1). Clinical findings were compared between LRTI cases for whom CXRs were available and the 30% of children for whom CXRs could not be found (Table 2). There were no statistically significant differences between the groups except with regard to ethnicity; more CXRs were found for the Melanesian Fijian group (P = 0.035) although there was a trend towards less severe illness in those children for whom CXRs were unavailable (Table 3). If it were assumed that the 34% positive rate found in the group for whom CXRs were available was also applicable to the group for whom CXRs could not be obtained, this would suggest that an extra 25 cases of CXR-confirmed pneumonia occurred within the study time frame, but were missed due to failure to perform an X-ray or inadequate storage of radiographs. If these cases were included in the calculations, the annual incidence becomes 607 per 100 000 children aged between 1 month and 5 years. The incidences of LRTI and CXR-confirmed pneumonia were calculated according to ethnicity and also demonstrated higher levels of disease in Melanesian Fijian children (2353 and 676 per 100 000 for LRTI and CXR-confirmed pneumonia, respectively) than in Indo-Fijian children (939 and 23 per 100 000, respectively), while children from other ethnic populations had intermediate rates of LRTI, and CXR-confirmed pneumonia (1301 and 264 per 100 000, respectively) (Table 2). The incidence ratio for Melanesian Fijian compared to Indo-Fijian children for all LRTI was 2.5 (95% CI, 1.9–3.4) and for CXR-confirmed pneumonia was 29.4 (95% CI, 9.8–143.2).

Of the 248 patients identified with LRTI, 63% were male, 61% were infants and most were Melanesian Fijian (76%). No seasonal pattern was evident in the incidence of LRTI or CXR-confirmed pneumonia. Most children admitted with LRTI had a discharge diagnosis that included pneumonia or bronchopneumonia (90%). Tachypnoea and indrawing of the lower chest wall were recorded on admission in 73% and 70% of patients, respectively. These findings are consistent with WHO guidelines that require the presence of at least one of these signs for the clinical diagnosis of pneumonia, while the indrawing of the lower chest wall indicates “severe pneumonia” requiring hospital admission (17). The diagnosis of “very severe pneumonia”, according to the WHO definition, requires the presence of at least one sign of hypoxia, which was present in 25% of the LRTI patients for whom medical records were available for review.

The most frequently administered parenteral and oral medications were penicillin (75%) and amoxicillin (40%), respectively. Other drugs commonly used were oral and parenteral fluoxacin/cloxacillin (14% and 18%, respectively), gentamycin (15%) and parenteral chloramphenicol (17%). Ceftriaxone, erythromycin, rifampicin and cotrimoxazole were rarely used. The median duration of use of antibiotics ranged from 3 to 8 days for those commonly used, suggesting good adherence to WHO recommendations (6).

Blood culture results were available for 217 (88%) of the cases with LRTI. Of these, 18 (8%) had positive isolates. The most frequently identified bacteria were S. pneumoniae (five cases) and Staphylococcus aureus (five cases). One patient was...
positive for both of these bacteria. Of the patients with CXR-confirmed pneumonia, blood cultures were performed for 55, seven (13%) of which were positive; three with S. pneumoniae and one with S. aureus. The case-fatality rate was 2.8% for all LRTI and 6.8% for CXR-confirmed pneumonia (difference not statistically significant). Of the seven children who died, four had serious underlying conditions. The median duration of hospitalization for the children who died was three days (range 1–21 days).

Discussion

The present study is the first population-based epidemiological study of the incidence of pneumonia using the radiological definition developed by WHO for use in vaccine trials. There are therefore no other published studies with which to compare this one, although it is anticipated that such studies will be published in the near future.

The annual incidence of CXR-confirmed pneumonia in Greater Suva, Fiji, was at least 428 per 100 000 children aged between 1 month and 5 years, but may be as high as 607 per 100 000. The experience from studies of the efficacy of pneumococcal conjugate vaccine against CXR-confirmed pneumonia, defined by WHO criteria, can be used to estimate the likely burden of vaccine-preventable pneumococcal pneumonia in Fiji. If this study was generalized to cover all children between 1 month and 5 years, but may be as high as 607 per 100 000. Assuming a case-fatality rate of 7% in this group, 6–9 deaths could potentially be prevented annually. Economic and health savings are likely to be appreciably higher than this figure would suggest as there will be many cases of pneumococcal disease not included because they do not conform to the WHO definition of CXR-confirmed pneumonia. Thus, reductions could also be expected in the number of non-hospitalized children and in those hospitalized but in whom there are no significant CXR findings, as well as in other manifestations of pneumococcal infection such as meningitis and bacteraemia.

Melanesian Fijian children were 2.5 times more likely than Indo-Fijian children to present to hospital with LRTI, but 29 times more likely to present with CXR-confirmed pneumonia. These results suggest that there may be a true ethnic difference in incidence of LRTI and susceptibility to more severe disease in Fiji. Ethnic differences in disease burden have been described in Alaska, Australia and Israel, and in a previous study from Fiji (20–23). Although it is possible that genetically determined differences in susceptibility to pneumococcal infection exist, it is more likely that the observed differences are related to systematic differences in important risk factors, such as housing, health-seeking behaviour, exposure to indoor air pollution and malnutrition rates. Fiji is an island country with little seasonality, so the lack of a seasonal trend was to be expected.

The generalization of these findings to the whole population of children under 5 years old in Fiji may be questioned, as this study included urban and periurban populations, with good access to health care and appropriate antibiotic treatment. Based on international experience, the incidence of disease and case-fatality rates are likely to be higher in rural or remote areas, for reasons including poorer access to basic health care, less availability of antibiotics, lower immunization coverage, less community education, greater use of traditional medicines and of solid fuel for cooking, higher unemployment levels, and different ethnic representation or different patterns of local disease outbreaks (24, 25). These factors are present in rural Fiji, but their impact is uncertain, although they would be likely to strengthen the argument in favour of introducing the vaccine.
Table 3. Demographic and clinical features of children admitted to hospital with a lower respiratory tract infection (LRTI) in 2001 and 2002, grouped according to chest X-ray (CXR) availability and result

<table>
<thead>
<tr>
<th></th>
<th>CXR-positive (n = 59)</th>
<th>CXR-negative (n = 115)</th>
<th>Total with CXR (n = 174)</th>
<th>No CXR available (n = 74)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (m/f)</td>
<td>66/34</td>
<td>62/38</td>
<td>63/37</td>
<td>63/37</td>
</tr>
<tr>
<td>Age (1 m–1yr / 1–5 yrs)</td>
<td>56/44</td>
<td>67/33</td>
<td>64/36</td>
<td>55/45</td>
</tr>
<tr>
<td>Ethnicity (Fijian/Indian/Other)</td>
<td>91/2/7</td>
<td>75/20/5(^a)</td>
<td>80/14/6</td>
<td>65/22/13(^b)</td>
</tr>
<tr>
<td>Signs/comorbidities on admission(^c)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fever(^d)</td>
<td>36</td>
<td>37</td>
<td>37</td>
<td>32</td>
</tr>
<tr>
<td>Tachypnoea(^e)</td>
<td>83</td>
<td>75</td>
<td>78</td>
<td>75</td>
</tr>
<tr>
<td>Hyoxaemia(^f)</td>
<td>38</td>
<td>18(^g)</td>
<td>25</td>
<td>16</td>
</tr>
<tr>
<td>Chest indrawing</td>
<td>76</td>
<td>71</td>
<td>73</td>
<td>77</td>
</tr>
<tr>
<td>Respiratory distress</td>
<td>33</td>
<td>32</td>
<td>33</td>
<td>34</td>
</tr>
<tr>
<td>Cyanosis</td>
<td>9</td>
<td>3</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Altered consciousness</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Seizures(^h)</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Toxic/septic appearance</td>
<td>29</td>
<td>18</td>
<td>22</td>
<td>19</td>
</tr>
<tr>
<td>Very severe LRTI(^i)</td>
<td>34</td>
<td>25</td>
<td>28</td>
<td>17</td>
</tr>
<tr>
<td>Anaemia</td>
<td>52</td>
<td>25(^j)</td>
<td>34</td>
<td>22</td>
</tr>
<tr>
<td>Malnutrition(^k)</td>
<td>19</td>
<td>15</td>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>Management</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxygen used</td>
<td>26</td>
<td>19</td>
<td>22</td>
<td>17</td>
</tr>
<tr>
<td>Admitted to ICU</td>
<td>26</td>
<td>13(^l)</td>
<td>17</td>
<td>8</td>
</tr>
<tr>
<td>Ventilated</td>
<td>10</td>
<td>3</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Deaths</td>
<td>7</td>
<td>1(^m)</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

ICU = intensive care unit.

\(^{a}\) P < 0.01 for comparison of CXR-positive and CXR-negative cases.

\(^{b}\) P < 0.05 for comparison of cases for whom CXRs were available with those for whom CXRs were unavailable.

\(^{c}\) All signs and comorbidities were considered absent if not documented in the medical records, except for fever (number with data available in order of columns: 56; 110; 172; 62), tachypnoea (58; 113; 171; 64), hyoxaemia (34; 67; 101; 31). 12 cases without medical records excluded from this section: three excluded from group for whom CXRs were available (all negative) and nine from group for whom CXRs were unavailable.

\(^{d}\) Temperature > 38 °C per axilla.

\(^{e}\) Respiratory rate > 60 breaths/min in infants 1 m – < 2 m; > 50 breaths/min in infants 2 m – 1 yr; > 40 breaths/min in children 1 yr – 5 yr (6).

\(^{f}\) Oxygen saturation < 90% in room air.

\(^{g}\) Degree tympanic temperature < 38.5 °C.

\(^{h}\) P < 0.05 for comparison of CXR-positive and CXR-negative cases.

\(^{i}\) Excluding simple febrile seizures from 1 January 2002 until 31 December 2002. Some seizures in 2001 may have been febrile seizures, but were not excluded.

\(^{j}\) Defined as weight for age < –2 calculated according to weight and age at time of admission.

Rational administration of antibiotics at CWMH was demonstrated and was consistent with WHO recommendations. Penicillin and amoxicillin or ampicillin are effective in treating the commonest bacterial causes of pneumonia; *S. pneumoniae* and *Haemophilus influenzae*. The infrequent administration of flucloxacillin plus gentamicin or ceftriaxone, or chloramphenicol suggests that these medications were appropriately reserved for patients with very severe, but less common, infections caused by *Staphylococcus aureus*, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*.

Thirty-one children (12.5%) had hyoxaemia, although this is presumably an underestimate since oximetry was documented in less than half of the cases. Oxygen use was noted in only 60% of patients with signs of hyoxaemia, and oxygen was not administered in nine cases with documented hyoxaemia on pulse oximetry. This suggests inadequate oxygen administration or failure to recognize hyoxaemia, but these findings might be misleading due to poor recording of oxygen use. The prevalence of bacteraemic pneumonia was 8% of all LRTI cases and 13% of the CXR-confirmed pneumonia cases. Pretreatment with antibiotics was common (25% and 29% of all LRTI and CXR-confirmed cases, respectively), which is likely to have reduced the yield of positive cultures. There were also some deficiencies in laboratory techniques and facilities at CWMH which probably reduced the sensitivity of culture techniques.

Case-fatality rates of 2.8% of LRTI cases and 6.8% of CXR-confirmed cases are consistent with global experience, and lower than rates seen in many developing countries (26–32). Useful comparisons between different ethnic, age and gender groups are difficult to make because of the very small numbers involved. The appropriate use of antibiotic therapy at CWMH reflects well on the quality of care provided there and may explain the low mortality, as well as helping to control the emergence of antimicrobial resistance.

The observed differences between CXR-positive and -negative cases, especially rates of hyoxaemia and admission to intensive care units.
the intensive care unit (Table 3), lend support to the objective of the WHO guidelines for CXR interpretation to identify those patients more likely to have bacterial, and therefore pneumococcal, infections.

There are important limitations to retrospective studies such as the present one. The catchment population was intended to include only children expected to present to CWMH with pneumonia, but the numbers likely to seek private, outpatient care for pneumonia could not be determined. Population data came from the 1996 census. No correction could be made for subsequent population growth or decline, and an assumption was made about the exclusion of neonates. Some cases may have been missed because of incomplete CWMH admission records or admission to other hospitals, but this is unlikely as the quality of admission records was good. The use of admission records or admission to other hospitals, but this is unlikely as the quality of admission records was good. The use of a hospital-based study design can introduce survivor bias by missing children who die without medical attention. However, health care in Greater Suva is free and easily accessible; mortality rates are low and children rarely die at home. Rereading of CXRs may have introduced bias as this was undertaken by only one examiner, who was aware that subjects had an LRTI.

The CXRs of 15 patients were suboptimal, potentially affecting their interpretation.

This study demonstrates the importance of pneumonia as a cause of childhood morbidity in a developing country with good health care and low mortality rates. The results may be applicable to other Pacific Island countries. Where health services are less adequate and/or mortality rates are higher, it can be assumed that pneumonia rates are correspondingly higher. A more accurate measure of the burden of vaccine-preventable pneumonia could be obtained by a prospective, descriptive study or by a disease burden study, undertaken in conjunction with the introduction of a pneumococcal conjugate vaccine. This may be the next step for Fiji.

Competing interests: none declared.

Acknowledgements
The authors would like to thank the staff of the Colonial War Memorial Hospital and the Fiji Ministry of Health for their assistance with this study. In particular, we thank Dr Joseph Kado, Dr Ta McCaig, Dr Paula Nankervis and Mr Singh.
The anthelmintic therapy in children with cystic echinococcosis: A case study of a 5-year-old child

We report a case of cystic echinococcosis in a 5-year-old child. The diagnosis was made based on clinical presentation and imaging studies. The patient was treated with albendazole and praziquantel. The patient's course was uneventful, and the cyst was successfully removed surgically. The child has been followed up for 2 years, and there has been no evidence of recurrence.

References
