Predictors and Outcome of Admission for Invasive *Streptococcus pneumoniae* Infections at a Canadian Children’s Hospital

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Rates of admission for invasive *Streptococcus pneumoniae* infection in children vary considerably between institutions. We performed a retrospective study to investigate factors used in the decision to admit patients with invasive *S. pneumoniae* infection to Alberta Children’s Hospital. Of 254 patients who were initially assessed in the emergency department, 38.2% were admitted to the hospital. Significant risk factors for admission as determined by a logistic regression model included murmur (odds ratio [OR], 18.98; 95% confidence interval [CI], 4.08–88.23), focal infection (OR, 11.41; 95% CI, 5.07–25.67), and older age (OR, 2.72; 95% CI, 1.03–7.17). Higher hemoglobin level (OR, 0.96; 95% CI, 0.93–0.99) and temperature of >38.5°C (OR, 0.39; 95% CI, 0.18–0.85) were associated with a lower risk of admission. Two patients died (case-fatality rate, 0.7%). Despite the low rate of admission for invasive *S. pneumoniae* infections at our hospital, the mortality rate was comparable with those at institutions with higher rates of admission, thus suggesting that the factors we identified may be useful in deciding whether to admit patients with (or who are at high risk for) invasive *S. pneumoniae* infections.

*Streptococcus pneumoniae* is the most common cause of acute otitis media and occult bacteremia in children and is a common cause of other invasive infections [1–3]. The most frequent types of invasive *S. pneumoniae* infections in children include pneumonia, bacteremia without focus, and meningitis [2, 3]. The incidence of invasive *S. pneumoniae* infection is highest in the first 2 years of life and varies with geographic location and socioeconomic status [2–4]. There are reports in the literature of an increasing incidence of invasive *S. pneumoniae* infections and resistance to penicillin [5–10]. There is a broad range of severity for childhood invasive *S. pneumoniae* infections, and the overall case-fatality rate has been reported at 1%–3%, with rates of up to 30% in the first month of life [2, 3, 11, 12].

Rates of admission for invasive *S. pneumoniae* infections vary among countries and institutions. In some countries such as Finland, all patients with invasive *S. pneumoniae* infections are admitted to the hospital, whereas in other regions, up to one-half of patients are managed as outpatients with comparable mortality rates [3, 12–14]. It is unclear how the decision for admission is made or whether it is necessary for most patients with invasive *S. pneumoniae* infections to be admitted. The main objectives of this study were (1) to identify rates of admission for invasive *S. pneumoniae* infections at Alberta Children’s Hospital (ACH; Calgary, Alberta, Canada) and investigate factors used in the decision for hospitalization and (2) to see how the outcomes of invasive *S. pneumoniae* infections at ACH differ from those in other regions. Secondary objectives included documentation of the rates of invasive *S. pneumoniae* infection and the rates of penicillin resistance in our area.

**Patients and Methods**

*Patient population.* ACH is a pediatric tertiary care center affiliated with the Faculty of Medicine, University of Calgary. This 120-bed facility serves a population of ~1.2 million children in southern Alberta and neighboring areas of British Columbia, Saskatchewan, and Montana. The study period was from January 1986 to December 1996, and all patients from whom a sterile site isolate of *S. pneumoniae* was recovered were considered for study. Charts were identified for review from the medical records department and the microbiology laboratory at ACH.

**Data collection and case definitions.** Data were collected by a retrospective chart review with use of standardized forms. Age and gender were recorded as well as data on the presence of preexisting illnesses, clinical presentation, complete blood cell count, sterile site from which *S. pneumoniae* was isolated, antimicrobial susceptibilities, and clinical diagnosis. Length of stay and need for intensive care unit (ICU) admission were recorded for inpatients. Clinical diagnoses were ascertained...
with use of predetermined criteria by one of the investigators (K.B.L.) on the basis of all the available information.

Meningitis was diagnosed by a positive CSF culture or by a positive blood culture in the setting of clinical features and pleocytosis revealed by analysis of a CSF aspirate. Pneumonia was defined as a positive sterile site (blood or bronchoalveolar lavage fluid) culture with supporting clinical and radiological evidence. Bacteremia without focus was defined as a positive blood culture with no obvious focus after clinical and laboratory investigation. Bacteremia with associated otitis media, viral illness and/or upper respiratory tract infection, or diarrhea was included in this definition [1]. All other diagnoses were based on the presence of sterile site isolates and comprehensive assessment of available clinical and investigational information. Invasive infections with nonblood isolates or with blood isolates associated with a clinical source were considered focal infections as long as the definition of bacteremia without focus was not fulfilled.

Laboratory analysis. Collection of sterile site samples and preparation of cultures were done by standard methods according to hospital protocol. S. pneumoniae was identified by gram staining and by susceptibility to optochin (Taxo P, Becton Dickinson Microbiology Systems, Cockeysville, MD) and/or a positive reaction in Pneumoslide (Becton Dickinson Microbiology Systems). Testing for susceptibility to oxacillin was performed by the disk diffusion method [15]. If the isolate was resistant, then MICs of penicillin were determined by agar dilution testing until 1993 and by the Etest (AB BIODISK, Solna, Sweden) thereafter [16]. Isolates were reported as susceptible, intermediately resistant, and resistant to penicillin if the MICs were $\leq 0.06$ µg/mL, 0.1 to 1.0 µg/mL, and $\geq 2$ µg/mL, respectively [17].

Data management and analysis. Data from standardized forms were entered manually into a spreadsheet format and analyzed by using Statistica Version 5.0 (StatSoft, Tulsa, OK). For univariate analyses, the $\chi^2$ statistic and Fisher’s exact test were used to compare categorical variables, and the Student’s $t$ test was used for comparing continuous variables. Medians were compared by means of the Mann-Whitney $U$ test. Differences in the annual rates of invasive S. pneumoniae infections were evaluated with a normal approximation for the comparison of Poisson counts [18]. A logistic regression model was developed to identify independent risk factors for admission to the hospital by using Statistica Version 5.0.

Results

Over the 11-year study period, 292 patients with sterile site infections with S. pneumoniae were identified, of whom 284 (97.3%) had sufficient documentation for assessment. Of the 284 patients whose cases were identified, 254 (89.4%) were seen initially in the emergency department, and 28 were transferred from other institutions; the location of initial assessment of two patients was unclear. Unless otherwise stated, patients initially seen in the emergency department were used for the analysis. Invasive pneumococcal infections occurred more frequently in boys than in girls (male-to-female ratio, 1.3:1), and the median age of the patients was 1.27 years (range, 76 days to 10.7 years). One hundred twenty-six (44.4%) of 292 patients and 97 (38.2%) of 254 patients assessed initially in the emergency department were admitted to the hospital.

Univariate analysis of presenting clinical features was performed to examine factors predicting admission. Significantly ($P < .05$) different presenting symptoms and signs between admitted and nonadmitted patients are shown in table 1. Although the median age of 1.39 years (range, 0.24 to 10.20 years) for admitted patients was not significantly different from the median age of 1.25 years (range, 0.21 to 10.68 years; $P = .4$) for nonadmitted patients, children treated as outpatients were more likely to be between the age of 90 days and 3 years as shown in table 1. A total of 37 comorbid medical conditions were identified in 27 patients (10.6%), most of which were cardiac, respiratory, and neurological conditions (table 1). Complete blood cell counts were available for 241 patients (94.9%); as shown in table 1, no differences in platelet or WBC counts were seen, but a significantly lower mean hemoglobin level was found for admitted patients.

A total of 270 sterile site isolates of S. pneumoniae were recovered from the 254 patients initially seen in the emergency department; of these isolates, 248 (91.9%) were from blood. All 157 isolates (100%) from nonadmitted patients were from blood alone, compared with 75 (66.4%) of 113 isolates from admitted patients ($P < .0001$). The remaining 38 isolates from the 97 admitted patients were from 22 patients for whom cultures of specimens from sites other than blood or mixed infections were positive. These patients included 15 with both CSF and blood isolates, 3 with CSF isolates alone, 2 with synovial fluid isolates only, 1 with both synovial fluid and blood isolates, and 1 with a bronchoalveolar lavage fluid isolate. The most common clinical diagnoses (which were determined by clinical and microbiological data) were bacteremia without focus, pneumonia, meningitis, and periorbital cellulitis; these conditions accounted for 94.1% of cases as shown in table 2.

A logistic regression model was developed to examine independent risk factors for admission to the hospital. Children with a murmur, focal infection, or older age were at significantly higher risk for admission as shown in table 3. A higher temperature or hemoglobin level significantly decreased the risk of admission (table 3).

The median hospital stay was 6 days (range, 0–25 days). The median hospital stay of 10 days for meningitis was significantly different than that of 3 days for pneumonia ($P < .001$) and that of 3 days for bacteremia without focus ($P < .0001$). Of the patients admitted from the emergency department, 15 (15.5%) required ICU care, and three (3.1%) were intubated. Patients with meningitis (10 [$47.6\%$] of 21) tended to be admitted to the ICU more frequently than patients with pneumonia (3 [20.0%] of 15; $P = .0875$) and were significantly more likely
Table 1. Univariate analysis of predictive factors for admission to ACH because of invasive *Streptococcus pneumoniae* infections, 1986 to 1996.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Admitted patients (n = 97)</th>
<th>Nonadmitted patients (n = 157)</th>
<th>Total (n = 254)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Younger than 90 d</td>
<td>2 (2.1)</td>
<td>1 (0.7)</td>
<td>3 (1.2)</td>
<td>.3</td>
</tr>
<tr>
<td>90 d to 3 y</td>
<td>63 (64.9)</td>
<td>124 (82.1)</td>
<td>187 (75.4)</td>
<td>.002</td>
</tr>
<tr>
<td>Older than 3 y</td>
<td>32 (33.0)</td>
<td>26 (17.2)</td>
<td>58 (23.4)</td>
<td>.004</td>
</tr>
<tr>
<td>Symptoms*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nasal discharge</td>
<td>36 (37.1)</td>
<td>87 (55.4)</td>
<td>123 (48.4)</td>
<td>&lt;.005</td>
</tr>
<tr>
<td>Difficult breathing</td>
<td>18 (18.6)</td>
<td>10 (6.4)</td>
<td>28 (11.0)</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Chest pain</td>
<td>4 (4.1)</td>
<td>0</td>
<td>4 (1.6)</td>
<td>.1</td>
</tr>
<tr>
<td>Signs*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean temperature (°C) ± SD</td>
<td>38.6 ± 1.0 (n = 93)</td>
<td>39.0 ± 1.0 (n = 153)</td>
<td>38.9 ± 1.0 (n = 246)</td>
<td>.001</td>
</tr>
<tr>
<td>Temperature, &lt;38.5°C</td>
<td>41 (44.1)</td>
<td>31 (20.3)</td>
<td>72 (29.3)</td>
<td>.0001</td>
</tr>
<tr>
<td>Temperature, 38.5°C–40.0°C</td>
<td>46 (49.5)</td>
<td>95 (62.1)</td>
<td>141 (57.3)</td>
<td>.052</td>
</tr>
<tr>
<td>Temperature, &gt;40.0°C</td>
<td>6 (6.4)</td>
<td>27 (17.6)</td>
<td>33 (13.4)</td>
<td>.013</td>
</tr>
<tr>
<td>Murmur</td>
<td>19 (19.6)</td>
<td>3 (1.9)</td>
<td>22 (8.7)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Meningismus</td>
<td>17 (17.5)</td>
<td>0</td>
<td>17 (6.7)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Bulging fontanelle</td>
<td>7 (7.2)</td>
<td>1 (0.6)</td>
<td>8 (3.1)</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Hepatomegaly</td>
<td>7 (7.2)</td>
<td>0</td>
<td>7 (2.8)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Comorbidity³</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any</td>
<td>21 (21.6)</td>
<td>6 (3.8)</td>
<td>27 (10.6)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Cardiac</td>
<td>8 (8.2)</td>
<td>4 (2.5)</td>
<td>12 (4.7)</td>
<td>.038</td>
</tr>
<tr>
<td>Respiratory</td>
<td>8 (8.2)</td>
<td>1 (0.6)</td>
<td>9 (3.5)</td>
<td>.001</td>
</tr>
<tr>
<td>Neurological</td>
<td>8 (8.2)</td>
<td>1 (0.6)</td>
<td>9 (3.5)</td>
<td>.001</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>3 (3.1)</td>
<td>2 (1.3)</td>
<td>5 (2.0)</td>
<td>.3</td>
</tr>
<tr>
<td>Renal</td>
<td>1 (1.0)</td>
<td>0</td>
<td>1 (0.4)</td>
<td></td>
</tr>
<tr>
<td>Immunocompromised</td>
<td>1 (1.0)</td>
<td>0</td>
<td>1 (0.4)</td>
<td></td>
</tr>
<tr>
<td>Blood finding</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean WBC count (×10³/L) ± SD</td>
<td>19.7 ± 8.5 (n = 94)</td>
<td>19.5 ± 6.5 (n = 153)</td>
<td>19.5 ± 7.3 (n = 247)</td>
<td>.8</td>
</tr>
<tr>
<td>Mean hemoglobin level (g/L) ± SD</td>
<td>113.5 ± 13.9 (n = 95)</td>
<td>120.4 ± 12.2 (n = 150)</td>
<td>117.8 ± 13.3 (n = 245)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Mean platelet count (×10³/L) ± SD</td>
<td>448.2 ± 170.7 (n = 91)</td>
<td>445.8 ± 145.3 (n = 150)</td>
<td>446.7 ± 155.0 (n = 241)</td>
<td>.9</td>
</tr>
</tbody>
</table>

NOTE. Unless stated otherwise, data are no. (%) of patients. Exact ages were not available for six of nonadmitted patients. ACH = Alberta Children’s Hospital (Calgary, Alberta, Canada).

* Only significant (P < .05) signs and symptoms are shown.

¹ No. of patients for whom data were available.

² Some patients had more than one comorbidity.

Table 2. Clinical diagnoses of invasive pneumococcal infections in patients at ACH, 1986 to 1996.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Admitted (n = 97)</th>
<th>Nonadmitted (n = 157)</th>
<th>Total (n = 254)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacteremia without focus</td>
<td>39 (40.2)</td>
<td>140 (89.2)</td>
<td>179 (70.5)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Focal infection</td>
<td>58 (59.8)</td>
<td>17 (10.8)</td>
<td>75 (29.5)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>15 (15.5)</td>
<td>10 (6.4)</td>
<td>25 (9.8)</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Meningitis</td>
<td>21 (21.6)</td>
<td>0</td>
<td>21 (8.3)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Periorbital cellulitis</td>
<td>7 (7.2)</td>
<td>7 (4.5)</td>
<td>14 (5.5)</td>
<td>1.0</td>
</tr>
<tr>
<td>Other</td>
<td>15* (15.4)</td>
<td>0</td>
<td>15 (5.9)</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

NOTE. ACH = Alberta Children’s Hospital (Calgary, Alberta, Canada).

* Septic arthritis or osteomyelitis (7 patients [7.2%]), gastrointestinal focus (mesenteric adenitis, peritonitis, and bowel obstruction, respectively; 3 [3.1%]), endocarditis (2 [2.1%]), parotitis (1 [1.0%]), oral abscess (1 [1.0%]), and infected cystic hygroma (1 [1.0%]).
Table 3. Independent risk factors for admission to ACH because of invasive *Streptococcus pneumoniae* infections, 1986 to 1996.

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>OR (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Murmur</td>
<td>18.98 (4.08–88.23)</td>
<td>.0002</td>
</tr>
<tr>
<td>Focal infection</td>
<td>11.41 (5.07–25.67)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Age²</td>
<td>2.72 (1.03–7.17)</td>
<td>.042</td>
</tr>
<tr>
<td>Hemoglobin level</td>
<td>0.96 (0.93–0.99)</td>
<td>.008</td>
</tr>
<tr>
<td>Temperature of &gt;38.5°C</td>
<td>0.39 (0.18–0.85)</td>
<td>.018</td>
</tr>
</tbody>
</table>

NOTE. ACH = Alberta Children’s Hospital (Calgary, Alberta, Canada).

Despite the low rates of admission of patients with invasive *S. pneumoniae* infections at our hospital, mortality rates were not higher than those at institutions with high rates of admission. This finding suggests that physicians at our hospital use implicit criteria for the selection of patients for outpatient treatment or hospitalization safely, and these criteria are reflected by the factors identified in our logistic regression model (table 3). Our overall admission rate of 44.4% is in the lower end of the range reported in studies by Eskola et al. [3], Mirzanejad et al. [12], Barry et al. [14], and Breiman et al. [13] in which 100%, 69%, 50%, and 46% of patients, respectively, were admitted. Variability in rates of admission may reflect many factors, including differences in study case identification, the health care system, socioeconomic and geographic factors, and variation in physician practice. For instance, in Finland, patients are admitted routinely if blood specimens for cultures are obtained, whereas in other countries such as Canada, the decision whether to admit is often a function of clinical impression, hospital policies, and physician and patient comfort [3]. A recent study by Ros et al. [19] suggested a marked variation in physician management of occult bacteremia in children in emergency departments. Criteria have been proposed for some age groups and clinical diagnoses to help guide whether to admit patients at risk for serious bacterial infection to the hospital.

Discussion

A total of 307 sterile site isolates were recovered from the 284 patients with invasive *S. pneumoniae* infections. There was a significant variability in the number of cases seen per year, with a peak of 3.5 cases per 1,000 discharges in 1990 (P = .027) as shown in figure 1. Fourteen isolates (4.6%) from 13 patients (two isolates were from one patient) demonstrated reduced susceptibility to penicillin. Nine isolates (3.0%) were immediately resistant, and five (1.6%) were highly resistant. One-half of the isolates with reduced susceptibility to penicillin (including all highly resistant organisms) were identified in the last 2 years of the study. All intermittently resistant isolates remained susceptible to third-generation cephalosporins. Of the penicillin-resistant strains, 1 was susceptible, 2 were intermittently resistant, and 2 were resistant to third-generation cephalosporins.

Figure 1. Admission for invasive pneumococcal infections to Alberta Children’s Hospital (Calgary, Alberta, Canada). The distribution of 126 cases in patients admitted to the hospital because of invasive *Streptococcus pneumoniae* infection is shown by year of presentation from 1986 through 1996. No. of cases = the number of cases per 1,000 discharges.
tal, but there is no clear consensus or reliable test to direct this
decision [20, 21]; factors identified at our hospital may be of
use in guiding the decision to admit patients with, or who
are at increased risk for, invasive S. pneumoniae infection to
institutions with high rates of hospitalization, and prospective
evaluation is warranted.

Independent risk factors for admission identified in our study
included focal infection, murmur, age, hemoglobin level, and
temperature. Focal infection and age younger than 3 months
and older than 3 years have been well documented as risks for
serious infection, and guidelines for the outpatient management
of febrile children are usually directed toward children aged 3
months to 3 years who do not have a clinical focus [20, 21].
The presence of a murmur significantly increased the risk of
admission, which was at least in part related to the presence
of a comorbidity. In the logistic regression model, if murmur
is removed, both comorbidity (OR, 5.07; 95% CI, 1.45–17.82)
and difficult breathing (OR, 3.70; 95% CI, 1.27–10.78) become
significant predictors for admission. If both murmur and dif-
cult breathing are removed from the model, then the predictive
power of comorbidity is increased further (OR, 5.93; 95% CI,
1.72–20.40). This finding suggests that the presence of comor-
bidity is an important predictor for admission and that they
are measured at least in part by the observations of difficult
breathing and murmurs. Comorbid illnesses likely increase the
risk of admission because of raised concern for serious illness
or complications related to the coexistent condition.

Numerous studies [3, 4, 11, 22–25] have suggested the im-
portance of underlying medical conditions in children with
invasive pneumococcal infections; underlying medical condi-
tions were documented in up to 37% of cases in these studies.
Although it was not surprising that patients with lower hemo-
globin levels were more likely to be admitted, it was unex-
pected that higher temperatures decreased the risk of hospital-
ization (table 3). Sicker children may have been more likely
to receive antipyretics; however, this is only speculation, and
the observation is unexplained.

The outcomes of invasive S. pneumoniae infections in our
study were comparable with those previously reported. Our
most common diagnoses of bacteremia without focus, pneumo-
nia, and meningitis were similar to those found in other studies,
although there is considerable variation [2–4, 11, 12, 22]. De-
spite our lower rates of admission, the severity of illness seen
in our study, as measured by length of stay (median, 6 days),
was comparable with that observed in other reports such as
those from Winnipeg, Manitoba, Canada (5 and 9 days in two
hospitals, respectively), and Israel (6 days) [2, 12]. The case-
fatality rate of 1.6% for all admitted patients is in the lower
end of the range (1%–7%) reported at other centers [3, 12, 22].

In contrast with previously reported findings, our observa-
tions do not support an increasing incidence of invasive
S. pneumoniae infections in children (figure 1) [5–9]. Although
our study was hospital-based, our hospital is the major center
for pediatric admissions in our region and traditionally has
accounted for most (≥85%) outpatient pediatric visits. Because
of recent bed closures in our region, our hospital now accounts
for ~95% of all pediatric admissions. Therefore, we are un-
likely to be missing cases being referred elsewhere, and rates
at our hospital likely reflect incidence rates in our region.
Prospective surveillance is required to determine this conclusively.

Most (95.4%) of the S. pneumoniae isolates in this study
were susceptible to penicillin. This finding is consistent with
previous reports of low rates of resistance in Canada, Finland,
Australia, and New Zealand [3, 12, 22, 26] and is in contrast
to reports of high rates of resistance in the United States, Spain,
Hungary, the Middle East, and South Africa [10, 27–29]. Of
concern, however, is that although a low overall rate of resis-
tance was observed, 50% of the strains with reduced suscepti-
bility to penicillin (including all highly resistant strains) were
isolated in the last 2 years of the study. This result cannot be
explained by the change in the method of susceptibility testing
used at our hospital, as this change occurred in 1993 (2 years
before the noted increase in penicillin-resistant isolates). Our
observation of increasing resistance to penicillin is consistent
with recently reported Canadian data that demonstrated penicill-
in resistance in 11.7% of S. pneumoniae isolates [30], which
is likely heralding the onset of higher frequencies of penicillin
resistance in Canada. As a result, clinicians will need to closely
follow empirically treated patients, and vigilant surveillance of
resistance will likely be essential to avoid treatment failure and
the resulting morbidity and mortality due to invasive
S. pneumoniae infections.

Although most patients with invasive S. pneumoniae infec-
tions who present to ACH are treated as outpatients, our low
overall mortality rate is similar to those at institutions with
higher rates of admission. This finding suggests that this prac-
tice is safe and that the factors we identified as being associated
with the likelihood of admission for invasive S. pneumoniae
infection may be used to guide admission of patients with
highly suspected or proven invasive S. pneumoniae infections;
however, prospective evaluation involving a different cohort
of children is required first. Finally, although our observations
suggest that the incidence of invasive S. pneumoniae infection
is not rising in our region, the recent emergence of penicillin-
resistant S. pneumoniae is of great concern.

Acknowledgments

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crobiology laboratory at Alberta Children’s Hospital for their assis-
tance and patience with case identification and record searching.

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