Surveillance of Pneumococcal-Associated Disease among Hospitalized Children in Khanh Hoa Province, Vietnam


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Background. To understand the epidemiology of childhood bacterial diseases, including invasive pneumococcal disease, prospective surveillance was conducted among hospitalized children in Nha Trang, Vietnam.

Methods. From April 2005 through August 2006, pediatricians at the Khanh Hoa General Hospital used standardized screening criteria to identify children aged <5 years who had signs and symptoms of invasive bacterial disease. All cerebrospinal fluid (CSF) and blood specimens collected were tested by bacterial culture. Selected culture-negative specimens were tested for Streptococcus pneumoniae by antigen detection or for Haemophilus influenzae, Moraxella catarrhalis, Neisseria meningitidis, and S. pneumoniae by polymerase chain reaction (PCR).

Results. A total of 987 children were enrolled (794 with pneumonia, 76 with meningitis, and 117 with other syndromes consistent with invasive bacterial disease); 84% of children were aged 0–23 months, and 57% were male. Seven (0.71%) of 987 blood cultures and 4 (15%) of 26 CSF cultures were positive for any bacterial pathogen (including 6 for H. influenzae type b and 1 for S. pneumoniae). Pneumococcal antigen testing and PCR identified an additional 16 children with invasive pneumococcal disease (12 by antigen testing and 4 by PCR). Among children aged <5 years who lived in Nha Trang, the incidence rate of invasive pneumococcal disease was at least 48.7 cases per 100,000 children (95% confidence interval, 27.9–85.1 cases per 100,000 children).

Conclusions. S. pneumoniae and H. influenzae type b were the most common causes of laboratory-confirmed invasive bacterial disease in children. PCR and antigen testing increased the sensitivity of detection and provided a more accurate estimate of the burden of invasive bacterial disease in Vietnam.

Globally, nearly 2 million children aged <5 years die each year as a result of acute respiratory tract infections [1]. Children experience 150 million episodes of pneumonia per year, of which 11–20 million require hospitalization [2]. Recent estimates from UNICEF suggest that Streptococcus pneumoniae accounts for 50% of childhood deaths due to pneumonia each year [3, 4]. With currently available interventions, it is likely that a large proportion of these deaths could be prevented through improved access to appropriate drug therapy, as well as immunization with pneumococcal conjugate vaccines [5–7]. Financial assistance is available to Vietnam through the GAVI Alliance for the purchase of these vaccines.

There is limited information on the epidemiology and serotype distribution of invasive pneumococcal disease (IPD) in Vietnamese children. This paucity of data represents a substantial barrier to the introduction of pneumococcal conjugate vaccines into routine infant immunization programs. To help fill these gaps in information, the National Institute of Hygiene and Epidemiology initiated a pilot study to describe hospitalizations associated with invasive bacterial disease among children in Khanh Hoa Province, Vietnam, and to provide new insights into optimal methods for na-
tional surveillance of invasive bacterial disease in Vietnam.

**METHODS**

*Study population and hospital.* Before this study was initiated, the research protocol was reviewed and approved by the National Institute of Hygiene and Epidemiology and the Khanh Hoa Provincial Health Service and International Vaccine Institute Institutional Review Board. The Khanh Hoa Provincial Health Service is responsible for oversight of the Khanh Hoa General Hospital (KHGH), located in Nha Trang, the capital of Khanh Hoa Province in southeastern Vietnam (figure 1). In 2006, the Khanh Hoa Province census office reported a total population of 1,143,000 residents, with a majority living in Nha Trang [8]. The KHGH is a provincial-level referral hospital that provides primary and tertiary care medical services and a 24-h clinical laboratory service that performs routine biochemical, hematological, and microbiological tests.

*Hospital-based surveillance of invasive bacterial disease.* In prestudy workshops held at KHGH, all pediatricians, emergency physicians, infectious diseases specialists, and radiologists were provided standardized procedures for screening and evaluation of children with pneumonia, meningitis, sepsis, and other syndromes consistent with invasive bacterial disease, as well as procedures for obtaining informed consent and for collection of patient information and parent interviews. Microbiology workshops were conducted before the start of the study, to provide standardized procedures for collection and storage of clinical specimens, as well as procedures for testing for pneumococcus and other invasive bacterial pathogens with use of routine culture methods and rapid antigen tests. Hospitalized children were classified as having meningitis, pneumonia, or other severe disease on the basis of signs and symptoms noted at the time of hospital admission, as well as results of laboratory testing during their hospitalization, in accordance with criteria developed in conjunction with the Pneumococcal Vaccines Accelerated Development and Introduction Plan (PneumoADIP) (see the Appendix in this supplement).

*Patient enrollment and laboratory testing.* Children were eligible for entry into this study if they were aged <5 years and exhibited signs and symptoms of suspected bacterial disease at admission to the KHGH. After admission to the hospital, completion of informed consent forms by parents or guardians, and enrollment in the study, patients underwent collection of blood and CSF specimens appropriate to their presenting clinical syndrome. Specimens were immediately transported to the hospital clinical laboratory, and testing was initiated within 1 h after specimen collection. Microbiological testing services were available 24 h per day, 7 days per week, either as a routine or on-call service. Gram staining was performed on all CSF specimens in accordance with standard techniques. An immunochromatographic test of pneumococcal antigen (NOW S. pneumoniae Antigen Test; Binax) was performed on all collected CSF specimens and a representative subset of blood culture supernatant specimens collected from children enrolled from July 2005 through August 2006. CSF specimens were plated on blood agar (trypticase soy agar with 5% sheep blood). A second aliquot of each CSF specimen was plated on chocolate agar and was incubated according to standard bacterial culture proce-

![Map of Khanh Hoa Province, Vietnam](image_url)
dure [9]. For blood cultures, a minimum of 2 mL and a maximum of 3 mL of blood was inoculated into commercially prepared media (BACTEC PedsPlus/F; Becton Dickinson). Blood cultures were manually inspected twice daily for evidence of bacterial growth. Laboratory technicians performed routine blood subcultures at 18–24 h, 48 h, and 7 days of incubation, by transferring 2 drops of each culture specimen onto blood agar and chocolate agar plates.

Bacterial colonies grown from blood and CSF specimens underwent identification using standard biochemical test methods [10]. All bacterial isolates (stored in skim milk), blood culture supernatant specimens, and CSF specimens were shipped in labeled cryotubes at −80°C to the Molecular Biology Laboratory of the Department of Clinical Medicine, Institute of Tropical Medicine, Nagasaki University, Nagasaki, Japan, for testing by PCR. All available CSF specimens were tested by PCR, and a nonrandom sample of blood culture supernatant specimens was identified for testing with use of an algorithm that prioritized children by disease severity based on clinical signs and symptoms, total WBC count, and chest radiograph findings. Frozen CSF and blood culture broth supernatant specimens were processed for DNA extraction with use of the QIAamp DNA Mini Kit (Qiagen) in accordance with the manufacturer’s instructions, and DNA extracts were stored at −20°C before PCR testing. PCR was performed at the Molecular Bacteriology Laboratory with multiplex detection of invasive bacterial pathogens [11, 12]. Primers for detection of Haemophilus influenzae, Moraxella catarrhalis, and S. pneumoniae were used for blood culture broth specimens, and primers for detection of H. influenzae, Neisseria meningitidis, and S. pneumoniae were used for CSF specimens.

Data collection and data management. After study enrollment and collection of clinical specimens, all parents underwent a standardized interview on the day of hospital admission. A standardized case report form was used by hospital medical staff to collect information on signs and symptoms of the presenting illness, medical history, physical examination, and demographic and household characteristics. Data from the case report form were inspected for completeness and accuracy by Khanh Hoa Provincial Health Service epidemiologists before data entry. The data were double entered, and automatic range and consistency checks were performed for all data fields. The study database was uploaded by study collaborators at the International Vaccine Institute for final inspection, data analysis, and reporting to the PneumoADIP.

Quality control and statistical data analyses. To maintain data quality throughout the study period, the scientific staff of the National Institute of Hygiene and Epidemiology and the International Vaccine Institute performed weekly reviews of surveillance data and provided monthly feedback on the performance of the surveillance system to hospital investigators. Study data were analyzed in univariate and bivariate fashions, to describe clinical, epidemiological, and laboratory characteristics of children with pneumonia, meningitis, and other severe disease. Statistical comparisons for categorical variables were performed using the χ² statistic and Fisher’s exact test. Calculations of incidence rates for laboratory-confirmed IPD and H. influenzae type b (Hib) disease were limited to children living in the Nha Trang district, because this population was widely believed to access the KHGH as their sole provider for medical care for any severe disease. The 95% CIs for incidence estimates were calculated using Wilson’s score method [13].

RESULTS

Study children. From 1 April 2005 through 31 August 2006, a total of 987 children were enrolled in the study. A majority (535 [54%]) were aged <12 months, including 148 neonates (15%) aged <1 month (figure 2). An additional 298 (30%) were aged 12–23 months, and 154 (16%) were aged 24–59 months. Among the 987 study children, 559 (57%) were male, and 692 (70%) were residents of the Nha Trang district, where the study hospital (KHGH) is located. Among all participants, there were 29 deaths (case-fatality rate, 3%), including 17 (59%) neonates and 21 (72%) children hospitalized for pneumonia.

Children with pneumonia. Clinical pneumonia was the most common diagnosis among study participants (table 1). On the basis of the PneumoADIP case definitions (see the Appendix in this supplement), 794 (80%) of the 987 children had clinical pneumonia syndrome. Of these, 669 (84%) had diagnosis confirmed by chest radiograph, and 323 (41%) had severe or very severe disease.

Children with meningitis, sepsis, or other disease. Of the remaining children, 76 (8%) had meningitis, 32 (3%) had very severe disease, and 85 (9%) had other diseases. Fifteen children (22%) with suspected meningitis and 11 (33%) with disease

![Figure 2. Age distribution of enrolled patients at the Khanh Hoa General Hospital, Nha Trang, Vietnam.](image-url)
Table 1. Distribution of children enrolled in a hospital-based surveillance study, by age group and case definition, at the Khanh Hoa General Hospital, Nha Trang, Vietnam, April 2005–August 2006.

<table>
<thead>
<tr>
<th>Age group, months</th>
<th>Pneumonia</th>
<th>Meningitis</th>
<th>Other diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Probable</td>
<td>CXR confirmed, severe</td>
<td>Probable, very severe</td>
</tr>
<tr>
<td>&lt;1</td>
<td>7</td>
<td>9</td>
<td>17</td>
</tr>
<tr>
<td>1–3</td>
<td>5</td>
<td>13</td>
<td>41</td>
</tr>
<tr>
<td>4–6</td>
<td>4</td>
<td>6</td>
<td>19</td>
</tr>
<tr>
<td>7–11</td>
<td>2</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>12–23</td>
<td>15</td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>24–35</td>
<td>3</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>36–47</td>
<td>3</td>
<td>18</td>
<td>3</td>
</tr>
<tr>
<td>48–59</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>39</td>
<td>432</td>
<td>60</td>
</tr>
</tbody>
</table>

NOTE. CXR, chest radiograph.

classified as very severe had CSF specimens obtained. There were 8 deaths among children who received diagnoses other than pneumonia, including 3 of the 76 children with suspected meningitis (case-fatality rate, 4%) and 5 of the 32 children with very severe disease (case-fatality rate, 16%). Two of the 3 children with suspected meningitis who died underwent full clinical and laboratory evaluation, including lumbar puncture. No children with probable or definite meningitis died, but 2 children with meningitis-associated disabilities were identified at hospital discharge: 1 was classified as having probable bacterial meningitis and 1 as having very severe disease.

Microbiological culture testing. Of the 987 blood cultures performed, 7 (0.71%) had positive results, and 4 (15%) of the 26 CSF cultures had positive results (table 2). Six children had cultures positive for Hib, including 4 with positive CSF cultures and 2 with positive blood cultures. There was 1 child with a blood culture positive for S. pneumoniae, but no children had CSF cultures positive for S. pneumoniae. Four children had cultures positive for other pathogens (2 Staphylococcus aureus, 1 Salmonella typhi, and 1 Enterobacter cloacae). Of the 11 children with positive culture results, 10 (91%) were aged <35 months.

Pneumococcal antigen and PCR testing. Non–culture-based tests for invasive bacterial pathogens were applied in a pilot-test fashion, to better understand the potential benefits of these tests in Vietnam. Pneumococcal antigen testing was performed on a total of 11 CSF specimens (42% of the CSF specimens that were cultured) and 64 blood culture supernatant specimens (7% of the blood samples that were cultured). Because of resource constraints for laboratory testing, the use of non–culture-based diagnostic tests was necessarily limited. For this reason, PCR testing of blood supernatant specimens was prioritized on the basis of the children’s total peripheral WBC counts, measured on the day of admission and before administration of antibiotics. PCR was performed on 23 CSF specimens (89% of the CSF specimens that were cultured) that contained sufficient volume for testing, and 68 blood culture supernatants (7% of the blood samples that were cultured) from children with elevated WBC counts. Among children with culture-negative CSF or blood specimens, the pneumococcal antigen test and PCR identified an additional 16 children with IPD, including 13 (81%) with pneumonia and 3 (19%) with meningitis (table 2). Ten of the 13 children with pneumonia were classified as having chest radiograph–positive pneumonia, and an additional 3 children had chest radiograph–confirmed severe or very severe pneumonia.

Of the 16 children with cultures negative for pneumococci who were identified as having pneumococcal disease by antigen testing or PCR, 12 had positive results of pneumococcal antigen testing and 4 had positive results of PCR. Of the 4 children who had positive results of pneumococcal PCR, 1 received a diagnosis of chest radiograph–confirmed pneumonia and 3 received a diagnosis of definite meningitis. Of the 12 children who had positive results of the pneumococcal antigen test, 11 (92%) received a diagnosis of pneumonia and 1 (8%) received a diagnosis of meningitis (figure 3).

Other invasive pathogens. Because this study enrolled children with suspected bacterial meningitis, each patient’s specimens underwent routine testing for the 3 leading invasive bacterial pathogens of vaccine-preventable meningitis (H. influenzae, N. meningitidis, and S. pneumoniae). No children with meningococcal infection were identified during the study period. Four children with meningitis had CSF cultures positive for Hib, and 2 had blood cultures positive for Hib (1 child with chest radiograph–confirmed pneumonia and 1 with chest radiograph–confirmed severe pneumonia). An additional 2 children with negative cultures had PCR results positive for
Table 2. Distribution of patients by case category and laboratory test results at the Khanh Hoa General Hospital, Nha Trang, Vietnam, April 2005–August 2006.

<table>
<thead>
<tr>
<th>Case category</th>
<th>No. of patients</th>
<th>Specimens tested by culture</th>
<th>Specimens positive for any organism</th>
<th>Specimens positive for pneumococcus</th>
<th>Specimens positive for Hib</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Blood</td>
<td>CSF</td>
<td>By culture</td>
<td>By PCR or antigen test</td>
</tr>
<tr>
<td>Pneumonia (n = 794)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Probable</td>
<td>39</td>
<td>39</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CXR confirmed</td>
<td>432</td>
<td>432</td>
<td>0</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Probable, severe</td>
<td>60</td>
<td>60</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>CXR confirmed, severe</td>
<td>193</td>
<td>193</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Probable, very severe</td>
<td>26</td>
<td>26</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>CXR confirmed, very severe</td>
<td>44</td>
<td>44</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Meningitis (n = 76)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspected</td>
<td>67</td>
<td>67</td>
<td>15</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Probable bacterial</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Definite</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other diseases (n = 117)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very severe</td>
<td>32</td>
<td>32</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>85</td>
<td>85</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>987</td>
<td>987</td>
<td>26</td>
<td>11</td>
<td>18</td>
</tr>
</tbody>
</table>

NOTE. CXR, chest radiograph; Hib, Haemophilus influenzae type b.
a PCR and an immunochromatographic test of pneumococcal antigen (NOW Streptococcus pneumonia Antigen Test; Binax) were performed for only a subset of patients.

Hib, including 1 with chest radiograph–confirmed pneumonia and 1 with chest radiograph–confirmed severe pneumonia.

Estimated incidences of IPD and Hib disease. Because health care access (especially access of the Nha Trang population to KHGH) is excellent, we used demographic surveillance system data from 2006 at the Khanh Hoa Provincial Health Service to estimate minimum incidence rates for confirmed IPD (including children with positive results of culture and nonculture testing) and Hib disease (table 3). Among children aged <5 years who lived in Nha Trang, the estimated incidence rate of IPD was 48.7 cases per 100,000 children (95% CI, 27.9–85.1 cases per 100,000 children). The second highest incidence rate of invasive bacterial disease among children aged <5 years was disease caused by Hib (22.9 cases per 100,000 children [95% CI, 10.3–51.2 cases per 100,000 children]). Age group–specific incidence rates for IPD and Hib disease were highest among infants (IPD incidence, 193.4 cases per 100,000 infants [95% CI, 97.1–384.9 cases per 100,000 infants]; Hib disease incidence, 87.9 cases per 100,000 infants [95% CI, 32.3–238.9 cases per 100,000 infants]) and among children aged 2 years (IPD incidence, 49.3 cases per 100,000 children aged 2 years [95% CI, 14.0–174.0 cases per 100,000 children aged 2 years]; Hib disease incidence, 32.9 cases per 100,000 children aged 2 years [95% CI, 7.3–147.8 cases per 100,000 children aged 2 years]).

DISCUSSION

In this study of invasive bacterial disease among hospitalized children in Khanh Hoa Province, 69% of children enrolled were hospitalized for pneumonia, and 11% were hospitalized for meningitis. An additional 20% received diagnoses of very severe disease and other disease. A total of 29 children with laboratory-confirmed invasive bacterial disease were identified, including 11 with culture-confirmed disease and 18 with disease identified by antigen testing or PCR. Among the children with positive cultures, Hib and S. pneumoniae were the most common invasive bacterial isolates. Hib isolation from CSF specimens was twice as common as isolation from blood, and Hib was the only bacterial species recovered from CSF cultures. It is notable that, with limited application of non–culture-based diagnostics, 16 additional children with pneumococcal disease and 2 additional children with Hib disease were identified.

The results reported here should be interpreted in light of some study limitations. Although standardized microbiology laboratory procedures included routine subculture of all blood culture specimens at defined intervals, it is possible that growth in some cultures was not detected as quickly as may have been the case with use of automated blood culture systems. Also, in this pilot study, uniform testing of all CSF and blood culture specimens by nonculture tests (antigen detection and PCR)
could not be performed, because of limited test availability. Such limited testing may result in the underascertainment of bacterial pathogens, particularly among children who had received antibiotic treatment before admission. Additional use of these nonculture tests performed on blood samples has not been validated for diagnosis of IPD or Hib disease, so the sensitivity and specificity are unknown. Because dengue is an important disease during summer months in Khanh Hoa Province and because children with dengue may present with signs and symptoms consistent with invasive bacterial disease, it is possible that pediatricians may have misclassified cases among children during the initial clinical evaluation. In this study, vigorous efforts were made to raise awareness among pediatricians and parents about the possibility that some hospitalized children may present with febrile disease that mimics both dengue and invasive bacterial disease. Despite vigorous training and provision of standardized surveillance procedures, if suspected dengue and invasive bacterial diseases were both considered in the clinical differential diagnosis, it is possible that some pediatricians may have deferred blood or CSF collection until the probability of either disease became clearer.

Our findings in this study are consistent with those of previous invasive bacterial studies conducted in Vietnam. Using culture and antigen testing, Tran et al. [14], at Children’s Hospital Number 1 in Ho Chi Minh City, Vietnam, found that Hib accounted for 53% of bacterial meningitis cases among children aged <5 years, whereas pneumococcus was identified in 93% of bacteremic pneumonia cases. In Hanoi, Vietnam, Anh et al. [15] conducted a population-based study of childhood bacterial meningitis, in which Hib and pneumococcus were the most common causes of bacterial meningitis in hospitalized children. In the study by Anh et al. [15], nonculture testing (latex agglutination test and PCR performed on CSF specimens) also increased the yield of invasive bacterial pathogens, with a resultant increase in the estimated incidence rate of bacterial meningitis. In Vietnam, the widespread use of antibiotics represents a potential barrier to the accurate estimation of the disease epidemiology associated with invasive bacterial disease [16].

Our results suggest that the use of non–culture-based testing may increase the overall detection of IPD and Hib, compared with the use of culture methods alone. In this study, nonculture testing of CSF by PCR produced greater yields than did pneumococcal antigen testing. However, these results may underestimate the true number of CSF specimens positive for pneumococcus, because the pneumococcal antigen test was performed on fewer than half (42.3%) of the CSF specimens with sufficient volume available for testing. PCR testing for Hib performed on culture-negative CSF specimens identified an additional 2 children with invasive Hib disease. This additional PCR testing increased overall detection of laboratory-confirmed Hib disease, compared with detection by culture alone. The diagnostic yield by PCR of CSF specimens in this study is consistent with the findings of Kennedy et al. [17], who found that PCR to test for Hib and pneumococci in CSF identified additional children who did not receive a diagnosis by either culture or antigen testing.

This pilot study in Vietnam provides important lessons for conducting laboratory-based surveillance of invasive bacterial diseases among populations located in tropical or subtropical developing countries. First, implementation of standard operating procedures for microbiological diagnosis is critical for improving the detection of pathogens in routine bacterial cul-
Hib disease reported in this study is somewhat higher than the rate reported in a Hong Kong study [24–27]. The incidence of United Kingdom and Israel, but are somewhat higher than the reported incidence rates from population-based studies among childhood IPD reported in our study is within the range of burden of IPD and Hib disease. The estimated incidence rate of incidences among children aged <5 years in the Nha Trang district, Khanh Hoa Province, Vietnam.

<table>
<thead>
<tr>
<th>Age group, months</th>
<th>Nha Trang population, N</th>
<th>No. of patients</th>
<th>Incidence rate (95% CI)</th>
<th>No. of patients</th>
<th>Incidence rate (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤11</td>
<td>4015</td>
<td>11</td>
<td>193.4 (97.1–384.9)</td>
<td>5</td>
<td>87.9 (32.3–238.9)</td>
</tr>
<tr>
<td>12–23</td>
<td>4294</td>
<td>3</td>
<td>49.3 (14.0–174.0)</td>
<td>2</td>
<td>32.9 (7.3–147.8)</td>
</tr>
<tr>
<td>24–35</td>
<td>5773</td>
<td>2</td>
<td>24.5 (5.4–109.9)</td>
<td>0</td>
<td>...</td>
</tr>
<tr>
<td>36–47</td>
<td>5244</td>
<td>1</td>
<td>13.5 (1.8–98.3)</td>
<td>1</td>
<td>13.5 (1.8–98.3)</td>
</tr>
<tr>
<td>48–59</td>
<td>5315</td>
<td>0</td>
<td>...</td>
<td>0</td>
<td>...</td>
</tr>
<tr>
<td>Total</td>
<td>24,641</td>
<td>17</td>
<td>48.7 (27.9–85.1)</td>
<td>8</td>
<td>22.9 (10.3–51.2)</td>
</tr>
</tbody>
</table>

NOTE. The Khanh Hoa Province population data are from Khanh Hoa Health Service Demographic Surveillance System census update of 2006.

This study provides new insights into pneumococcal and Hib disease among children in Vietnam. On the basis of the number of cases detected only among residents of Nha Trang, this study found minimum overall pneumococcal disease and Hib disease incidences among children aged <5 years of 48.7 cases per 100,000 children and 22.9 cases per 100,000 children, respectively. Although children and families have very good access to primary health care and to care for severe disease, this study was not designed to enroll children who presented to outpatient clinics, and considering the underutilization of labor punctures, the incidence rates found in this study may underestimate the total burden of IPD and Hib disease. The estimated incidence rate of childhood IPD reported in our study is within the range of reported incidence rates from population-based studies among nonindigenous Australians, as well as studies performed in the United Kingdom and Israel, but are somewhat higher than the rate reported in a Hong Kong study [24–27]. The incidence of Hib disease reported in this study is somewhat higher than the incidence of Hib meningitis calculated using the Hib rapid disease burden assessment tool for Vietnam in 2006 (18 cases per 100,000 children aged <5 years) and is somewhat higher than the incidence reported for Hib meningitis in Hanoi (12 cases per 100,000 children aged <5 years) [15].

This is the first systematic study of invasive bacterial disease at a provincial-level hospital in Vietnam that incorporates classic bacterial culture methods and non–culture-based testing methods for detection of invasive bacterial pathogens among children presenting with major clinical syndromes, including pneumonia, meningitis, sepsis, and other severe disease. The lessons from this study are being used to develop additional prospective population-based studies of IPD in Vietnamese children, and they will be helpful for designing surveillance systems that assess the future impact of conjugate Hib vaccine after its introduction into the routine immunization schedule of Vietnam. In addition, the capacity-strengthening efforts in this study are yielding direct benefits, as national public health scientists work to establish a national Hib and pneumococcal reference laboratory at the National Institute of Hygiene and Epidemiology in Hanoi. Such national laboratory capacity will be essential to support studies that estimate the burden of IPD in other areas of Vietnam.

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References


