Pneumococcal Vaccination

Analysis of Opportunities in an Inner-city Hospital

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Background: Adult pneumococcal vaccination rates for persons at risk of developing pneumococcal disease remain below desired levels. Various sites within the hospital (inpatient medicine wards [IMWs], general medicine clinics [GMCs], and emergency departments [EDs]) have been suggested as venues for administering vaccination. The cost-effectiveness of such sites for delivery of pneumococcal vaccination is not known.

Objective: To compare the potential coverage of at-risk patients and cost of pneumococcal vaccination delivered in an ED, GMC, and IMWs.

Methods: We studied a retrospective cohort of 300 patients with pneumococcal bacteremia who had been hospitalized at Cook County Hospital, an inner-city Chicago public teaching hospital, from January 1994 through December 1998. We measured the presence of risk factors, as defined by the Centers for Disease Control and Prevention, for developing pneumococcal disease prior to index admission for bacteremia; patient use of ED, GMC, and IMWs from 4 weeks to 5 years before index admission; size of target population for vaccination in each site; and cost benefit of a pneumococcal vaccination strategy at each site.

Results: In the 4 weeks to 5 years before index admission, risk factors were present in 209 patients; 182 (87.1%) of the 209 had been in the ED, 104 (49.7%) in an IMW, and 64 (30.6%) in a GMC. The ED showed the greatest potential vaccine coverage, at a cost savings in a best-case scenario; the IMWs showed the best cost-benefit ratio but would provide access to fewer at-risk patients; and a program in the GMC would reach the fewest at-risk patients, with a cost-benefit ratio similar to that of the ED.

Conclusions: The ED in an inner-city hospital has the potential to vaccinate more patients at risk of pneumococcal bacteremia than a GMC or IMWs, and may do so at a cost savings. A prospective evaluation of such a strategy is warranted.


Pneumococcal bacteremia is a major cause of morbidity and mortality in the United States, with a yearly incidence estimated to be 15 to 30 cases per 100,000 population. This vaccine-preventable disease kills more Americans than all other vaccine-preventable diseases combined, in large part because of inadequate rates of vaccination among populations at risk.

Fedson and Baldwin and Fedson and Chiarello reported that 36% to 70% of patients hospitalized for pneumococcal bacteremia had been inpatients at the same hospital during the previous 5 years. This suggested that vaccination at the time of hospital discharge for patients with risk factors for pneumococcal bacteremia might prevent subsequent morbidity and mortality. A significant percentage of patients hospitalized with pneumococcal bacteremia also had been seen previously in the hospital’s outpatient clinic, suggesting a role for vaccination programs in this setting as well. More recently, Stack et al demonstrated that 55% of patients hospitalized in a university hospital had visited that hospital’s emergency department (ED) during the previous 5 years, and Slobodkin et al demonstrated that immunizing patients against pneumococcal disease during visits to a public hospital ED was feasible.

Considering the large number of patient visits in our public hospital ED, we hypothesized that an ED-based vaccination program could capture a majority of at-risk patients in a cost-effective manner. We tested this hypothesis by doing a retrospective review of patients with pneumococcal bacteremia and by comparing vaccination
opportunities and costs in our ED, general medicine clinic (GMC), and inpatient medicine wards (IMWs).

METHODS

This study was conducted at Cook County Hospital, a large inner-city public hospital in Chicago, Ill. We reviewed microbiology laboratory records from January 1, 1994, to December 31, 1998, to identify all adult patients with blood cultures positive for *Streptococcus pneumoniae*. The laboratory routinely serotypes pneumococcal isolates using diagnostic antisera of the Statens Serum Institut (Copenhagen, Denmark). Serotypes were recorded for each positive culture. Patient records and computerized discharge summaries were reviewed to determine demographic information, pneumococcal vaccination status, and presence of risk factors for the development of pneumococcal disease and indications for pneumococcal vaccination. The reviews included each prior contact with the institution’s GMCs, ED, and/or IMWs during the period from 4 weeks to 5 years before the onset of each bacteremic episode. Contacts within this time frame were defined as opportunities to immunize.

We report the costs in 1998 dollars. Annual hospital admissions and ED and clinic visit data represent the 1998 hospital census. We used our hospital's annual expenditure report to estimate the local cost of a pneumococcal vaccination program and the potential cost savings in this patient population. The cost of purchasing and administering pneumococcal vaccine in our hospital was $15 per dose. The average cost of 1 day of hospitalization was $1178, with a one-time administrative admission cost of $689 (unpublished data, 1998). The percentage of at-risk patients in the ED was adapted from prior studies. The percentage of at-risk patients in the GMC was derived from surveys of clinic patients. Our IMW analyses are limited to the medicine service because only 10 patients with bacteremia had prior admissions to other services. The percentage of patients with risk factors for pneumococcal disease on the IMWs was determined by a prospective survey of 382 consecutive admissions. The cost of a vaccination program at each site was calculated by multiplying the cost of vaccination per patient by the number of at-risk patients at that site.

The number of patients with potential benefit from pneumococcal vaccination was calculated by multiplying the number of patients with bacteremia and risk factors that warranted vaccination by the percentage infected with strain types in the pneumococcal vaccine by the efficacy (0.45-0.85) of the current pneumococcal vaccine. The cost of care of patients with potential benefit from vaccination was estimated by multiplying the number of these patients by the average length of hospital stay for our patients with bacteremia (11.83 days) by the cost of hospitalization per day. A cost-benefit ratio was obtained by dividing the cost of vaccination for the total at-risk patient population by the cost of index hospitalization for those patients with bacteremia who had potential benefit from vaccination.

Data were analyzed using SPSS version 8.0 (SPSS Inc, Chicago, Ill.). The χ² statistic was used to determine the significance of nominal variables. All reported P values are 2-tailed.

We identified 325 bacteremic episodes in patients older than 16 years. The source patient could not be identified for 10 of these episodes owing to incomplete or corrupted identifiers. The remaining 315 bacteremic episodes occurred in 300 unique patients; 287 patients had a single episode, 11 patients had 2 episodes each, and 2 patients had 3 episodes each. For patients with more than 1 bacteremic episode, only the initial episode was analyzed.

Most (69.6%) of our patients (n = 209) had risk factors for the development of pneumococcal disease at the time of a prior hospital contact (Table 1); 154 (74%) of the 209 patients had at least 2 risk factors (Table 2). Only 17 (22%) of the 77 patients with human immunodeficiency virus (HIV) had this as their only risk factor. Among the 37 patients 65 years or older, the most common additional risk factors were diabetes (n = 17; 46%), heart failure (n = 12; 32%), and chronic renal failure (n = 10; 27%). In the 172 patients younger than 65 years who had risk factors, HIV/acquired immunodeficiency syndrome (AIDS), alcohol abuse, and chronic renal failure constituted 67% of risk factors.

Overall mortality in our cohort of patients with bacteremia was 8% (Table 2). The mortality rate was 3 times higher in patients with any risk factors than it was in those with no risk factors (10.0% vs 3.2%; P = .05). Lengths of stay for patients with and without risk factors were similar (12.4 and 11.8 days, respectively), although this is confounded by the difference in mortality rates.

Capsular types included in the commercially available 23-valent pneumococcal vaccines (Merck Pneumovax 23 and Lederle Labs Pnu-Imune 23) caused 93% of bacteremias. The most prevalent capsular types in our patients with bacteremia, in descending order of frequency, were 9, 4, 19, and 14. There were no differences in the frequency of serotypes by different sites of prior hospital contact (ie, ED, GMC, or IMWs). Only 4 of 100 patients with risk factors for whom complete vaccination records were available were documented to have pneumococcal vaccination, 2 prior to the index admission (1 patient’s subsequent infection was with a strain type represented in the 23-valent vaccine) and 2 at discharge from the index admission.

Almost all (n = 198; 95%) of the 209 patients with risk factors had contact with Cook County Hospital 4 weeks to 5 years before their index admission for pneu-

| Table 1. Frequency of Risk Factors in 300 Patients With Pneumococcal Bacteremia* |
|-------------------|------------------|---------------------|
| Risk Factor†       | < 65 (n = 263)    | ≥ 65 (n = 37)        |
| HIV/AIDS§          | 77 (29)          | 0                   |
| Alcohol abuse      | 71 (27)          | 5 (14)              |
| Chronic renal failure | 29 (11)       | 10 (27)             |
| Diabetes mellitus  | 22 (8)           | 17 (46)             |
| Congestive heart failure | 23 (9)       | 12 (32)             |
| COPD               | 22 (8)           | 5 (14)              |
| Other§             | 50 (19)          | 5 (14)              |
| None               | 91 (35)          | 0                   |

*All data are number (percentage) of patients. HIV indicates human immunodeficiency virus; AIDS, acquired immunodeficiency syndrome; and COPD, chronic obstructive pulmonary disease.
†Risk factors are not mutually exclusive.
§Only 17 patients had AIDS.
Data were analyzed using SPSS version 8.0 (SPSS Inc, Chicago, Ill.). The χ² statistic was used to determine the significance of nominal variables. All reported P values are 2-tailed.

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Pneumococcal bacteremia (Table 3). These prior contacts included a median of 2 ED visits, 5 GMC visits, and 1.5 IMW admissions. If all at-risk patients would have received pneumococcal vaccination at a prior contact, the patients in 182 of the 209 bacteremic episodes would have been immunized by a program in the ED; 104 would have been immunized by a vaccination program that focused on hospital discharge; and 64 would have been immunized by a program in the GMC (Table 3). Conversely, vaccination efforts conducted solely in the inpatient setting would have failed to vaccinate 105 of our 209 patients with risk factors for pneumococcal bacteremia, and a program in the GMC would have missed 145 patients, while an ED-based program would have missed only 27 patients.

Table 4 outlines projected benefits and direct costs based on vaccination programs at different administrative sites in the hospital: 15 to 28 bacteremic episodes per year might have been prevented by a vaccination program in the ED, 5 to 10 by a program in the GMC, and 9 to 17 by a program based at hospital discharge. These results assume 100% vaccination of the large at-risk target populations seen at each of these sites. The inpatient discharge vaccination strategy seems most cost-effective (Table 4) but would reach fewer at-risk patients than would an ED-based program; moreover, all but 1 patient admitted to the hospital had prior contact with the ED or GMC. In a best-case scenario, an ED-based program could show direct cost savings of $87174 per year ($447174 minus $360000).

Table 3. Summary of Prior Hospital Admissions, Clinic Visits, or Emergency Department Visits From 4 Weeks to 5 Years Before the Index Admission for Pneumococcal Bacteremia in 209 Patients With 1 or More Risk Factors for Pneumococcal Disease

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Emergency Department</th>
<th>Medical Clinics*</th>
<th>Admission (Medicine Wards)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. (%) of patients</td>
<td>182 (87.1)</td>
<td>147 (70.3)</td>
<td>104 (49.7)</td>
<td>198 (95)</td>
</tr>
<tr>
<td>Total No. of contacts</td>
<td>1021 (2.0)</td>
<td>3313 (5.0)</td>
<td>314 (1.5)</td>
<td>4468 (3.0)</td>
</tr>
<tr>
<td>Patients’ only prior contact</td>
<td>35 11 1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Includes all medical clinics, general and subspecialty; 64 patients had been in a general medical clinic. Ellipses indicate not applicable.

lar to those noted by Stack and colleagues. As in that study, our economic calculations are based on a hospital perspective; we had additional details available for our cost-benefit analysis. We compared 3 different venues within the hospital: the ED, the GMC, and IMWs. We studied a public hospital where episodic care in the ED, for a very large number of at-risk patients, is common. Our analysis includes a range of vaccine efficacy rates and the percentage of vaccine capsular types in patients with pneumococcal bacteremia in our institution.

For several reasons, an ED-based pneumococcal vaccination study may be particularly warranted. There were more than 100.4 million ED visits in the United States in 1998.11 The ill, the elderly, the poor, and members of ethnic minorities are overrepresented in that group.12,13 These patients are at higher risk of respiratory disease and of undervaccination. Although significant progress has been made in the last 10 years in immunizing Medicare patients overall, vaccination rates among black and Hispanic Medicare patients lag significantly behind those of the general Medicare population.10,14 Also, estimates of vaccination rates among chronically ill patients younger than 65 years show that this group has benefited little. Known ethnic discrepancies in access to medical insurance and medical care15,16 suggest that chronically ill minority patients younger than 65 years may have the lowest vaccination rates of any group.
The existence of disparities in pneumococcal vaccination rates points out the need to intensify vaccination efforts in settings with high proportions of minority underinsured or uninsured patients. Emergency departments are frequently visited by such patients, including America’s 41 million uninsured, who have little or no access to other medical practitioners. However, successful ED-based pneumococcal vaccination programs seem to be rare. Critics of such programs cite the variable efficacy of this vaccine, the perceived indifference of patients and ED physicians to participate in such programs, and cost and time constraints as barriers to an effective ED vaccination program. Nevertheless, surveys of ED patients and physicians suggest that at least half of those queried would accept and participate in such a program. A pilot study in our ED showed that the median extra time for screening and pneumococcal vaccination was only 4 minutes per patient (range, 2-10 minutes) without deployment of additional personnel and that 76% of high-risk patients who were screened accepted and received pneumococcal vaccination.

The other major arena for pneumococcal vaccination, which has been suggested but largely ignored, is the inpatient setting. Fedson and Baldwin and Fedson and Chiarello have shown that more than two thirds of patients with pneumococcal bacteremia had previous hospital admission, but the percentage of hospitalized patients who have risk factors that would make them vaccine recipients and the hospital discharge vaccination rates remain largely unknown. Our study shows the relatively low cost associated with immunizing at-risk individuals at discharge from IMWs. The use of a standing-order program, as recommended recently by the Advisory Committee on Immunization Practice, is a strategy that could be applied effectively in this setting.

There are certain limitations of our study that warrant consideration. Our reviews were retrospective, and the charts may not have had complete information regarding risk factors and vaccination status. The percentage of bacteremias in our patients due to strain types present in the 23-valent pneumococcal vaccine is slightly higher than the 86% reported recently, but this would not affect the comparison of venues for vaccination. All cost analyses were from a hospital perspective; however, our findings are comparable to an analysis from a Medicare perspective (data not shown). The cost of hospitalization in our public hospital may be less than at other institutions, and our ratio of fixed and variable costs may be different, which would tend to underestimate the cost savings of a vaccination program. Also, the setting of this study in a public hospital, where uninsured are overrepresented, might not completely represent the situation in community or private hospitals, where sites such as clinics or private offices may have a larger role in a vaccination program and where indirect societal benefits of vaccination (eg, a healthier workforce) might be greater.

We did not include the cost of developing the vaccination program in our calculations, but we believe that such costs would be similar in each of the venues; the cost-benefit ratios (Table 4) are directly proportional to changes in costs of vaccine and its administration. We did not evaluate the effects of patients’ repeated ED, GMC, or IMW visits, which would tend to lessen costs and increase the likelihood of vaccinating at-risk individuals. Repeated visits also carry the potential for inadvertent repeated vaccination. Although the risks posed by revaccination are small, the movement to electronic medical records could alleviate this problem. In the meantime, ED records can be adapted to readily retrieve vaccination status. Finally, the high percentage of patients with HIV/AIDS in our case series might affect our cost-benefit calculations, although most of our HIV-infected patients had other indications for vaccination, and only a small proportion had full-blown AIDS. While questions have been raised about the efficacy of pneumococcal vaccine in patients with HIV/AIDS, the Centers for Disease Control and Prevention recommends that all patients with HIV be vaccinated, and in the era of highly

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### Table 4. Comparison of Projected Yearly Direct Cost and Benefit in 3 Venues of Pneumococcal Vaccination Programs, Cook County Hospital, 1994 Through 1998

<table>
<thead>
<tr>
<th>Site of Program (Mean Number/Year, 1994-1998)</th>
<th>Emergency Department</th>
<th>General Medicine Clinic</th>
<th>Inpatient Medicine Wards</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients with pneumococcal bacteremia who had been seen previously at each site</td>
<td>51</td>
<td>17</td>
<td>25</td>
</tr>
<tr>
<td>No. of patients with bacteremia and immunization indications (ie, risk factors)*</td>
<td>36</td>
<td>13</td>
<td>21</td>
</tr>
<tr>
<td>No. of patients with potential benefit from vaccination†</td>
<td>15-28</td>
<td>5-10</td>
<td>9-17</td>
</tr>
<tr>
<td>Cost of care at index admission for patients with potential benefit from vaccination, $‡</td>
<td>239 557-447 174</td>
<td>79 852-159 705</td>
<td>143 734-271 498</td>
</tr>
<tr>
<td>Size of total at-risk population in care at each site§</td>
<td>24 000</td>
<td>9000</td>
<td>7500</td>
</tr>
<tr>
<td>Cost of vaccinating total at-risk population, $¶</td>
<td>360 000</td>
<td>135 000</td>
<td>112 500</td>
</tr>
<tr>
<td>Cost-benefit ratio¶¶</td>
<td>0.8-1.5</td>
<td>0.9-1.7</td>
<td>0.4-0.7</td>
</tr>
</tbody>
</table>

*Derived from Table 3.
†Total number of patients with pneumococcal bacteremia and risk factors (prior row) × fraction with a vaccine strain (0.93) × efficacy of vaccine (0.45-0.85).
‡Number of patients (prior row) × average length of stay for these patients (11.83 days) × cost of hospitalization per day from hospital perspective.
§Number of patients with risk factors warranting pneumococcal vaccination, seen at each site.
¶Cost of pneumococcal vaccination including administration cost ($15) × number of patients with risk factors at each site (prior row).
¶¶Cost of vaccination to total at-risk population (prior row)/cost of care at index admission for bacteremic patients with potential benefit from vaccination (row 4).
active antiretroviral therapy, the improved immunologic status of patients with HIV may make pneumococcal vaccine more efficacious.

In conclusion, our findings suggest that an ED-based pneumococcal vaccination program in an inner-city hospital can reach a larger number of underserved patients at risk of pneumococcal bacteremia than the other venues evaluated. The relative importance of such a program compared with other possible ED health promotion initiatives — screening for asymptomatic sexually transmitted diseases and HIV, smoking cessation counseling, domestic violence evaluation — depends on analysis of local disease morbidity, program feasibility, likelihood of program benefit, and the possibility of bundling such value-added services for high-risk patients. Nevertheless, with increasing rates of antibiotic resistance in pneumococci, a prospective evaluation of the impact of an ED pneumococcal vaccination program seems warranted.

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REFERENCES