Pediatricians’ Self-reported Clinical Practices and Adherence to National Immunization Guidelines After the Introduction of Pneumococcal Conjugate Vaccine

Karen C. Lee, MD; Jonathan A. Finkelstein, MD, MPH; Irina L. Miroshnik, MS; Donna Rusinak, BS; Jeanne M. Santoli, MD, MPH; Susan M. Lett, MD, MPH; Tracy A. Lieu, MD, MPH

Background: Little is known about whether pneumococcal conjugate vaccine (PCV) has altered pediatricians’ practices regarding well-child and acute care.

Objectives: To (1) describe whether PCV caused pediatricians to move other routine infant vaccines and/or add routine visits; (2) characterize adherence to national immunization recommendations; and (3) determine whether PCV altered pediatricians’ planned clinical approach to well-appearing febrile infants.

Design and Methods: One year after PCV was added to the pediatric immunization schedule, we mailed a 23-item survey to 691 randomly selected pediatricians in Massachusetts. The adjusted response rate was 77%.

Results: After PCV introduction, 39% of pediatricians moved other routine infant vaccines to different visits and 15% added routine visits to the infant schedule. The self-reported immunization schedules of 36% were nonadherent to national immunization guidelines for at least 1 vaccine. Nonadherence rates were significantly higher among pediatricians who had been in practice longer, moved another vaccine because of PCV introduction, and/or offered to give shots later when multiple injections were due. For a hypothetical febrile 8-month-old girl who had received 3 doses of PCV, pediatricians reported they were significantly less likely to (1) perform both blood and urine testing and (2) prescribe antibiotics than in the pre-PCV era.

Conclusions: The introduction of PCV may have had unintended effects on pediatric primary care, including decreased adherence to national recommendations for the timing of immunizations and decreased urine testing for well-appearing febrile infants. Special efforts may be warranted to ensure that pediatricians remain current with changing recommendations.

Arch Pediatr Adolesc Med. 2004;158:695-701

In 2000, the Centers for Disease Control and Prevention Advisory Committee on Immunization Practices, Atlanta, Ga, recommended pneumococcal conjugate vaccine (PCV) for routine use in children younger than 2 years and for high-risk groups aged 2 to 5 years. The addition of PCV to the pediatric immunization schedule increased by at least 25% the number of injections required by 24 months of age. The introduction of new routine childhood immunizations such as PCV may affect several areas of pediatric practice, including the delivery of other immunizations and clinical decision making. The increasing complexity of the infant immunization schedule has increased concerns about the logistical challenges of delivering multiple injections and the resultant effects on adherence. Studies of previously introduced vaccines have examined parental and pediatrician compliance by determining whether children are up-to-date with their immunizations. However, to our knowledge, no previous studies have attempted to determine whether pediatricians’ self-reported practices are themselves adherent to national immunization recommendations.

In addition to its effects on preventive care, the widespread use of PCV may also affect pediatricians’ decision making during sick visits. The documented efficacy of PCV in preventing invasive pneumococcal infection has raised questions about the necessity of screening blood testing (eg, complete blood cell count with differential, blood culture) and antibiotic treatment of well-appearing febrile infants, though some maintain that more data are needed before changing clinical practice guidelines. However, little is known about how PCV has affected pediatricians’ planned clinical approach to febrile infants.

To address these questions, we sought to (1) determine the effect of PCV on pe-
METHODS

OVERVIEW

During the summer of 2001, 1 year after the addition of PCV to the pediatric immunization schedule, we mailed a 23-item survey assessing pediatrician beliefs, practice settings, and self-reported immunization practices to 691 randomly selected subjects. The study period followed universal purchase by the state of Massachusetts and preceded the nationwide shortage that started later that year. In Massachusetts and other states with universal vaccine purchase, the state health department provides all vaccines (including PCV) that are used by both public and private providers of primary care and/or immunizations to children, including physicians, nurse practitioners, and nurses. The combined Haemophilus influenzae B (Hib)—hepatitis B (HBV) vaccine is not available through Massachusetts’ universal purchase program. Almost all vaccine providers in Massachusetts use this program and can be identified through state licensing records.

STUDY POPULATION AND DATA COLLECTION

The survey was mailed to 691 pediatric providers, including (1) a random sample of pediatricians from the Massachusetts state licensing board and (2) all pediatricians and nurse practitioners with Harvard Vanguard Medical Associates, a large multispecialty provider group in eastern Massachusetts. The original 23-item survey, accompanied by a pen as a token of appreciation, was mailed in 2 waves to 187 providers. Both surveys are available on request. All available data were analyzed, resulting in an increased number of responses to questions included in both the original and abbreviated surveys.

Respondents were eligible for study inclusion if they provided more than 8 hours per week of routine well-child care. The study protocol was approved by the institutional review boards of Harvard Pilgrim Health Care, Boston, Mass, and the Centers for Disease Control and Prevention, Atlanta, Ga.

SURVEY QUESTIONS

Nonadherence to National Immunization Recommendations

The survey included several questions about pediatricians’ current immunization practices. One question presented a grid in which respondents were asked to indicate when they regularly administer all of the immunizations routinely given during the first 2 years of life (ie, HBV, diphtheria and tetanus toxoids with acellular pertussis vaccine [DTaP], Hib, inactivated poliovirus vaccine [IPV], measles, mumps, and rubella virus vaccine [MMR], varicella-zoster vaccine [VZV], and PCV). The following age categories were provided in this grid: birth and 1, 2, 4, 6, 9, 12, 15, and 18 months. The Recommended Child and Adolescent Immunization Schedule (approved by the Advisory Committee on Immunization Practices; the American Academy of Pediatrics, Elk Grove Village, Ill; and the American Academy of Family Physicians, Leawood, Kan)20 was not included in survey mailings. Respondents were not given explicit instructions about whether to consult the recommended schedule when completing the survey.

Respondents were considered nonadherent to national immunization recommendations if they (1) reported giving an inappropriate number of doses of a given vaccine and/or (2) reported giving doses at ages or intervals not consistent with the recommendations. For example, according to the 2001 national immunization recommendations, the first 3 doses of PCV should be given at 2, 4, and 6 months; the fourth dose may be given at 12 to 15 months. Thus, a respondent who reported giving PCV at 2, 4, 6, and 9 months was considered nonadherent.

Pediatricians were classified as nonadherent to overall immunization recommendations if their reported immunization schedules were at all inconsistent with any immunization recommendation. Because many respondents were nonadherent to PCV recommendations, we also classified pediatricians whose reported immunization schedules were inconsistent with 1 or more immunization recommendations (excluding PCV) as nonadherent to non-PCV recommendations.

We considered the possibility that some reported nonadherent patterns may be less likely to result in potential clinical consequences. We developed a hierarchical framework that classifies reasons for nonadherence according to their likelihood of association with potential clinical consequences: (1) too few primary doses; (2) primary doses at ages not recommended—potential clinical consequences; (3) booster dose not reported; (4) booster dose at ages not recommended; (5) primary doses at ages not recommended—unlikely clinical consequences. We agreed that the following nonadherent patterns would least likely result in potential clinical consequences for US children: (1) 3-dose HBV patterns with mistiming of the second and/or third dose(s), not including patterns in which all 3 doses were given within a 2-month timeframe20-22 and (2) 3-dose IPV patterns in which the first dose was not given before 2 months.

Febrile Infant

The survey also included several questions about a hypothetical well-appearing 8-month-old girl with a 2-day history of fever and a temperature of 102.5°F. Pediatricians were asked to select which laboratory tests and treatment strategies they would recommend in 2 different scenarios: (1) before PCV was widely used and if the child had not received PCV at all (pre-PCV) and (2) if the child had received 3 doses of PCV (post-PCV).

STATISTICAL METHODS

Several factors were tested in bivariate analysis for possible associations with nonadherence to immunization recommendations and changes in planned clinical approach to the febrile infant. Bivariate analyses included the t test for continuous variables, the χ² test for binary variables, and the calculation of 95% confidence intervals for changes in proportions.

Organizational and demographic factors associated with nonadherence in bivariate analyses were entered into a multivariate logistic regression model for each type of nonadherence (overall and non-PCV). To preserve sample size in multivariate analyses, we included subjects with missing data for independent covariates under the category “missing.”

STUDY POPULATION AND PCV ADOPTION

Of the 691 pediatricians to whom we mailed the survey, 393 completed the original survey and 33 completed the
abbreviated version. An additional 84 pediatricians responded but were ineligible, and two respondents were eligible but refused. Of unknown eligibility were (1) 33 pediatricians whose surveys were returned because of incorrect address information and (2) 146 pediatricians who did not respond. Given the eligibility rate of 70.5% among respondents, we estimated that 126 of these 179 pediatricians would have been eligible. The adjusted response rate was 77% (426 completed long and short surveys out of an estimated 554 eligible providers). There were no statistically significant differences in date of medical school graduation or sex between the 426 participants and 265 nonparticipants. Approximately half of the respondents were in pediatric group settings, and two thirds were seeing fewer than 25% Medicaid patients in their practices (Table 1). At the time of the survey, almost all respondents (385/388) were using PCV routinely for infants.

EFFECTS ON OTHER VACCINES
One hundred sixty-four (30%) of 419 pediatricians reported that adding PCV caused them to move other routine infant vaccines to different visits. With the exception of MMR, vaccines were generally moved to later visits. The most frequently moved vaccine was HBV (moved by 306 pediatricians [73%] who moved vaccines), followed by IPV (134 [32%]) and VZV (54 [13%]); less than 5% of pediatricians moved Hib, DTaP, or MMR. Sixty-four (15%) of 422 pediatricians reported that the introduction of PCV caused them to add at least 1 routine visit (either a vaccine-only or well-child visit) to the infant schedule.

VARIATION IN IMMUNIZATION PRACTICES
The 381 respondents who described their immunization practices reported 209 different schedules for giving all of the recommended childhood vaccines. The most commonly reported adherent pattern for administering all vaccines was followed by 34 respondents (9%). Of the 381 respondents, 138 (36%) reported patterns that were nonadherent to national recommendations for at least 1 vaccine series. The most common reasons for nonadherence were giving too few primary doses, giving primary doses at ages not recommended, not giving booster doses, and giving booster doses at ages not recommended (Table 2). The numbers and proportions of physicians nonadherent to recommendations for specific vaccine series were: 78 (21%) for PCV; 42 (11%) for HBV; 41 (11%) for Hib; 18 (5%) for DTaP; and 18 (5%) for IPV. Nineteen pediatricians (24%) were nonadherent to recommendations for at least 1 non-PCV series. Six pediatricians reported giving the first doses of DTaP, Hib, and PCV to infants at 1 month. The following tables are available on request: (1) a summary of the most common adherent patterns for administering all vaccines and (2) a complete listing of the actual reported nonadherent patterns for administering specific vaccines.

Of the pediatricians who were nonadherent with recommendations for DTaP, Hib, or PCV, about three quarters were giving the first 3 doses at appropriate ages. About half of these pediatricians omitted reporting the fourth dose altogether; the others reported giving it at times not recommended (usually at a later age). We considered the possibility that respondents who did not report giving booster doses were actually doing so in clinical practice but had simply neglected to complete the grid accordingly. If we ignored nonadherence to booster doses and considered respondents adherent to DTaP, Hib, or PCV recommendations as long as they reported giving the first 3 doses at 2, 4, and 6 months, this lowered the estimated rate of overall nonadherence to 27%.

We determined the frequency of nonadherent patterns more likely to be associated with potential clinical consequences. Based on our definitions, 15 of the 41 nonadherent HBV patterns and 16 of the 18 nonadherent IPV patterns would be more likely to result in potential clinical consequences. Therefore, 116 pediatricians (30%; 84% of those nonadherent) reported at least 1 nonadherent immunization pattern with potential clinical consequences.

FACTORS ASSOCIATED WITH NONADHERENCE TO THE IMMUNIZATION SCHEDULE
Pediatricians who reported that the addition of PCV had caused them to move vaccines were significantly more likely to be nonadherent to non-PCV recommendations than those who had not moved any vaccine (P = .01). Examination of nonadherent patterns suggested that pediatricians’ decisions to move vaccines earlier or later may have resulted in their nonadherence. Of the pediatricians who reported nonadherent HBV patterns and had moved HBV, the reported schedules of 22 of 27 pedia-

Table 1. Characteristics of Survey Respondents

<table>
<thead>
<tr>
<th>Practice setting (n = 420)†</th>
<th>Practice reimbursement for well-child care (n = 375)‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solo</td>
<td>Capitation</td>
</tr>
<tr>
<td></td>
<td>42 (10)</td>
</tr>
<tr>
<td>Pediatric group</td>
<td>217 (52)</td>
</tr>
<tr>
<td>Multispecialty group</td>
<td>80 (19)</td>
</tr>
<tr>
<td>Staff/group model HMO</td>
<td>17 (4)</td>
</tr>
<tr>
<td>Academic/hospital-based</td>
<td>29 (7)</td>
</tr>
<tr>
<td>Community health center</td>
<td>31 (7)</td>
</tr>
<tr>
<td>Proportion Medicaid patients (n = 418)</td>
<td></td>
</tr>
<tr>
<td>&lt;5%</td>
<td>73 (17)</td>
</tr>
<tr>
<td>5%-25%</td>
<td>205 (49)</td>
</tr>
<tr>
<td>25%-50%</td>
<td>91 (22)</td>
</tr>
<tr>
<td>&gt;50%</td>
<td>49 (12)</td>
</tr>
<tr>
<td>Years since medical or nursing school graduation (n = 426)</td>
<td></td>
</tr>
<tr>
<td>0-9</td>
<td>90 (21)</td>
</tr>
<tr>
<td>10-19</td>
<td>135 (32)</td>
</tr>
<tr>
<td>20-29</td>
<td>117 (27)</td>
</tr>
<tr>
<td>30-57</td>
<td>84 (20)</td>
</tr>
<tr>
<td>Practice reimbursement for fee for service (n = 425)</td>
<td></td>
</tr>
<tr>
<td>Medical</td>
<td>397 (93.4)</td>
</tr>
<tr>
<td>Nurse practitioner</td>
<td>21 (5.0)</td>
</tr>
<tr>
<td>Osteopathic</td>
<td>6 (1.4)</td>
</tr>
<tr>
<td>Physician assistant</td>
<td>1 (0.2)</td>
</tr>
</tbody>
</table>

Abbreviation: HMO, health maintenance organization.
*Values are expressed as number (percentage) of respondents.
†Four respondents (1%) indicated “other.”
‡Forty respondents (11%) indicated “did not know”; 19 (5%) indicated “other.”

Years since medical or nursing school graduation (n = 426):
0-9: 90 (21)
10-19: 135 (32)
20-29: 117 (27)
30-57: 84 (20)
Practice reimbursement for fee for service (n = 425):
Medical: 397 (93.4)
Nurse practitioner: 21 (5.0)
Osteopathic: 6 (1.4)
Physician assistant: 1 (0.2)

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Table 2. Primary Reasons for Nonadherence to 2001 National Immunization Recommendations

<table>
<thead>
<tr>
<th>Reasons for Nonadherence</th>
<th>HBV (n = 377)</th>
<th>DTaP (n = 380)</th>
<th>Hib (n = 380)</th>
<th>IPV (n = 378)</th>
<th>PCV (n = 376)</th>
<th>Total†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Too few primary doses‡</td>
<td>11 (27)</td>
<td>2 (10)</td>
<td>0</td>
<td>12 (67)</td>
<td>9 (12)§</td>
<td>33</td>
</tr>
<tr>
<td>Primary dose(s) at age(s) not recommended, likely clinical significance</td>
<td>4 (10)</td>
<td>6 (30)</td>
<td>8 (20)</td>
<td>4 (22)</td>
<td>8 (10)</td>
<td>31</td>
</tr>
<tr>
<td>Booster dose not reported¶</td>
<td>NA</td>
<td>12 (60)</td>
<td>17 (42.5)</td>
<td>NA</td>
<td>31 (40)</td>
<td>60</td>
</tr>
<tr>
<td>Booster dose at age not recommended#</td>
<td>NA</td>
<td>0</td>
<td>15 (37.5)</td>
<td>NA</td>
<td>30 (38)</td>
<td>45</td>
</tr>
<tr>
<td>Primary dose(s) at age(s) not recommended; unlikely clinical significance**</td>
<td>26 (63)</td>
<td>NA</td>
<td>NA</td>
<td>2 (11)</td>
<td>NA</td>
<td>28</td>
</tr>
<tr>
<td>Total No. of nonadherent responses</td>
<td>41</td>
<td>20</td>
<td>40</td>
<td>18</td>
<td>78</td>
<td>197††</td>
</tr>
<tr>
<td>Percentage of nonadherent responses for each vaccine</td>
<td>11</td>
<td>5</td>
<td>11</td>
<td>5</td>
<td>21</td>
<td>NA</td>
</tr>
</tbody>
</table>

Abbreviations: DTaP, diphtheria and tetanus toxoids with acellular pertussis vaccine; HBV, hepatitis B vaccine; Hib, Haemophilus influenzae B vaccine; IPV, inactivated poliovirus vaccine; MMR, measles, mumps, and rubella virus vaccine; NA, not applicable; PCV, pneumococcal conjugate vaccine; VZV, varicella-zoster vaccine.

*Values are expressed as number (percentage) of nonadherent patterns for each vaccine unless otherwise indicated. Nonadherent patterns were evaluated according to hierarchical, mutually exclusive reasons for nonadherence. For each vaccine, the cells in the table report the number of nonadherent responses for each category—provided that each pattern did not fall into preceding categories of nonadherence. For example, only patterns reporting the correct number of primary doses could be evaluated for whether these doses were given at correct ages. The few individual patterns that revealed multiple reasons for nonadherence (i.e., separate identifiable problems with primary and booster doses) are noted in subsequent footnotes.

†Totals generated by adding frequencies across HBV, DTaP, Hib, IPV, and PCV columns.

‡Fewer than 3 doses of HBV and IPV; fewer than 3 total doses of DTaP, Hib, and PCV. Includes 1 pediatrician who reported giving 4 doses of DTaP by age 6 months. These patterns were not evaluated for other reasons for nonadherence.

§The number of pediatricians reporting 4, 3, 2, and 1 dose(s) of PCV were 35, 37, 4, and 2, respectively.

¶Fourth (booster) dose not reported for DTaP, Hib, or PCV. Not applicable to HBV or IPV.

#For DTaP, fourth (booster) dose reported before 15 to 18 months. For Hib and PCV, fourth booster dose reported at ages other than 12 or 15 months.

**For HBV patterns with 3 doses, first dose given at recommended age but second and third dose reported at age(s) not recommended. The HBV patterns reporting all 3 doses at birth and 1 and 2 months are not included in this category. For IPV patterns with 3 doses, the first and second doses were reported late (at ages 4 and 6 months).

††The total number of nonadherent responses (197) exceeds the number of pediatricians who were nonadherent to at least 1 national immunization recommendation (138, as reported in the text).

Table 3 shows the results of a multivariate logistic regression model that includes the factors that were significantly associated with overall or non-PCV nonadherence in bivariate analyses. Moving other vaccines because of PCV introduction, many reported HBV schedules in which at least 1 dose was given earlier than recommended. The same was true for the few pediatricians with nonadherent DTaP, Hib, or IPV patterns who reported they had moved these vaccines.

PRACTICES FOR FEBRILE INFANTS

In the hypothetical scenario describing a well-appearing 8-month-old girl with a temperature of 102.5°F for 2 days and no obvious source of infection, pediatricians were significantly less likely to say they would order a white blood cell count, blood culture, urine culture, urinalysis/urine dip, and antibiotic treatment for an infant who had received 3 doses of PCV than for an infant in the pre-PCV era (Table 4). Sixty-seven (17%) of 393 pediatricians said they would order at least 1 test for the pre-PCV infant that they would not have ordered for the post-PCV infant.

We evaluated whether the pediatrician’s practice setting (eg, pediatric group or community health center) was associated with changes in testing practices using the χ² test. Physicians in pediatric group practices were significantly less likely to order urine testing for the post-PCV than for the pre-PCV infant; 9 (8%) of those ordering urine tests for the pre-PCV infant said they would not perform at least 1 of these urine tests for the post-PCV infant (95% confidence interval, −13% to −3%). However, the magnitude of change in urine testing was the greatest for pediatricians in health maintenance organizations (−21%) and academic or hospital-based practice settings (−19%). There were no significant differences among practice settings in the proportions of pediatricians who reported changes in approach to overall testing, blood testing, and antibiotic use between pre-PCV and post-PCV scenarios.

Sixty-seven (17%) of 389 pediatricians reported that the widespread use of PCV had changed their treatment approach in cases in which they were uncertain of the diagnosis of otitis media. Of those who reported their practices had changed, 55 (82%) were more likely to observe without antibiotics, and 9 (13%) would administer antibiotics for less than 10 days.
This study shows that the addition of PCV may have had unintended effects on pediatricians’ practices for other immunizations and well-appearing febrile infants. One year after the introduction of PCV, many pediatricians had moved other vaccines and/or were nonadherent to national immunization recommendations. It is not surprising that pediatricians were significantly less likely to report that they would obtain a white blood cell count or blood culture for hypothetical well-appearing febrile infants who had received 3 doses of PCV than for infants in the pre-PCV era. However, the significant decrease in urine testing for similar infants is concerning.

ADHERENCE TO NATIONAL IMMUNIZATION GUIDELINES

Our study is unique in that we evaluated nonadherence to the national immunization recommendations by asking pediatricians to give detailed reports of the ages at which they routinely administer all routine immunizations. Most previous studies of pediatrician and parental compliance with immunization recommendations have focused on whether children are up-to-date with their immunizations at certain ages.5,8-10 Other studies have examined pediatrician attitudes or adoption of particular new vaccines or immunization recommendations.2,23-26 To our knowledge, no previously published studies have sought to determine whether pediatricians’ self-reported schedules for all routine immunizations are actually adherent to national recommendations.

We found wide variation in immunization practices, with 381 pediatricians following 209 schedules for administering all vaccines. Even the most commonly reported pattern for administering all vaccines was followed by only 34 respondents (9%). Perhaps this may not come as a surprise, given that there are 10,368 possible different adherent combinations for administering all vaccines. However, even with this many adherent variations, 138 pediatricians (36%) in our study reported patterns that were nonadherent to national recommendations for at least 1 vaccine.

Table 3. Factors Significantly Associated With Nonadherence to Immunization Guidelines in Multivariate Analysis (N = 381)*

<table>
<thead>
<tr>
<th>Factors</th>
<th>Overall Nonadherence</th>
<th>Non-PCV Nonadherence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Added routine visits</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Offered shots later†</td>
<td>2.05</td>
<td>1.24 to 3.38</td>
</tr>
<tr>
<td>Each additional decade since</td>
<td>1.57</td>
<td>1.28 to 1.91</td>
</tr>
<tr>
<td>medical school graduation</td>
<td></td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Abbreviations: NA, not applicable; PCV, pneumococcal conjugate vaccine.

*In both bivariate and multivariate analyses, proportion of Medicaid patients was significantly associated with both overall and non-PCV nonadherence. However, this covariate’s effects are not shown in this table because there was not a clinically meaningful, monotonic linear trend in the effect estimates on nonadherence.

†Usually offer the option of giving some vaccines at later visits when multiple injections are due (274 respondents [72%]).

Table 4. Change in Pediatrician-Reported Approach to the Well-Appearing Febrile Infant After Pneumococcal Conjugate Vaccine (PCV) Immunization*

<table>
<thead>
<tr>
<th>Approach</th>
<th>Pre-PCV</th>
<th>Post-PCV</th>
<th>Percentage Change, %†</th>
<th>95% Confidence Interval for Percentage Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory testing</td>
<td>388</td>
<td>386</td>
<td>17</td>
<td>11 to 24</td>
</tr>
<tr>
<td>No tests</td>
<td>122 (32)</td>
<td>143 (37)</td>
<td>−23</td>
<td>−30 to −17</td>
</tr>
<tr>
<td>WBC</td>
<td>212 (54)</td>
<td>162 (42)</td>
<td>−31</td>
<td>−39 to −23</td>
</tr>
<tr>
<td>Blood culture</td>
<td>178 (46)</td>
<td>124 (32)</td>
<td>−9</td>
<td>−13 to −4</td>
</tr>
<tr>
<td>Urine culture</td>
<td>200 (51)</td>
<td>183 (47)</td>
<td>−9</td>
<td>−13 to −4</td>
</tr>
<tr>
<td>Urinaryysis or dipstick</td>
<td>185 (48)</td>
<td>169 (44)</td>
<td>−9</td>
<td>−13 to −4</td>
</tr>
<tr>
<td>Urine Gram stain</td>
<td>14 (4)</td>
<td>11 (3)</td>
<td>−23</td>
<td>−48 to 2</td>
</tr>
<tr>
<td>CSF cell count/culture</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0</td>
<td>NA</td>
</tr>
<tr>
<td>Treatment‡</td>
<td>382</td>
<td>372</td>
<td>18</td>
<td>13 to 24</td>
</tr>
<tr>
<td>No antibiotics</td>
<td>191 (50)</td>
<td>226 (58)</td>
<td>18</td>
<td>13 to 24</td>
</tr>
<tr>
<td>Oral antibiotics if high WBC</td>
<td>36 (9)</td>
<td>28 (7)</td>
<td>−39</td>
<td>−57 to −20</td>
</tr>
<tr>
<td>Parenteral antibiotics if high WBC</td>
<td>152 (40)</td>
<td>116 (31)</td>
<td>−25</td>
<td>−33 to −17</td>
</tr>
</tbody>
</table>

Abbreviations: CSF, cerebrospinal fluid; NA, not applicable; WBC, white blood cell count.

*Values are expressed as number (percentage) of pediatricians unless otherwise indicated.
†Percentage ordering test/treatment pre-PCV who did not order test/treatment post-PCV.
‡Fewer than 1% of pediatricians would have ordered oral or parenteral antibiotics regardless of WBC.
tiveness may differ even among adherent patterns.\textsuperscript{27} In most cases, data are insufficient to determine the effect of nonadherence on actual disease risk. Nevertheless, 114 pediatricians (30\%) in our study reported nonadherent patterns that might have potential clinical consequences after we excluded the patterns least likely to have clinical effect. Some methods of coping with the increasingly complex immunization schedule (eg, moving vaccines to later visits) were associated with decreased adherence, which could result in reduced immunization rates and might affect protection against vaccine-preventable disease. Interventions to maintain adherence to changing immunization recommendations (eg, electronic reminder systems) may be warranted, especially when new vaccines are introduced. Our study suggests that these efforts should be focused on pediatricians who have been in practice longer.

A recent study by Schaffer et al\textsuperscript{2} found that PCV caused many pediatricians to give other immunizations at later visits. The current study confirms this finding but offers a more complete picture of the effect of PCV on pediatric immunization practices. For example, the Schaffer et al study asked whether pediatricians were more likely to postpone HBV, IPV, or VZV vaccinations; schedule extra visits; or give more Hib-HBV vaccine as a result of giving 4 or more vaccinations simultaneously. In comparison, our survey offered more response options by asking about the addition of visits and movement of all vaccines either earlier or later.

EFFECTS ON PRACTICES FOR FEBRILE INFANTS

When asked how they would manage a hypothetical well-appearing febrile infant, a substantial fraction of respondents said they were less likely to perform blood testing and prescribe antibiotics if the infant had received PCV than for the pre-PCV infant. These findings parallel a growing body of literature that questions the clinical necessity and cost-effectiveness of empirical blood testing and antibiotic use for febrile infants who have received PCV.\textsuperscript{13-15} However, this change in blood testing may affect disease surveillance, which complicates the use of disease incidence as a marker of vaccine effectiveness (ie, decreased blood testing may underestimate actual disease incidence).

Another unintended effect of PCV introduction on pediatricians’ acute care practices is the significant decrease in pediatrician-reported urine testing. This was an unexpected finding and suggests an unintended decrease in quality of care for an unrelated condition. Efforts to promote urine testing of febrile infants are clearly warranted, and empirical studies of actual practice are needed to monitor the long-term effects of PCV.

LIMITATIONS

Previous research has shown that self-reported behavior may not match actual clinical practice.\textsuperscript{28} Respondents’ tendency to give socially acceptable answers would bias against variability in reported practices, possibly resulting in an underestimation of nonadherence. Conversely, this study may have overestimated nonadherence if the 6 pediatricians who reported giving the first doses of non-HBV vaccines at the 1-month visit were actually giving these vaccines at 6 weeks of age (an accepted practice) but were unable to indicate this on our grid with predetermined age categories. More importantly, it is possible that a substantial number of pediatricians, facing competing time demands, simply did not complete the survey as carefully as they would provide medical care. We cannot determine whether reported deviations from the recommended schedule were due to conscious decisions not to follow guidelines, misinformation, missing data due to careless survey completion, and/or poor recall. However, the high prevalence of nonadherent patterns with potential clinical consequences illustrates the need for continued efforts to ensure that physicians’ knowledge and practices remain current with changing recommendations.

To our knowledge, this is the first study to evaluate pediatricians’ adherence to all immunization recommendations, but we did not study participants’ immunization practices prior to PCV introduction. While we have measured pediatrician adherence to national immunization recommendations after PCV introduction, we have made educated inferences about the actual effect of PCV on adherence to recommendations.

Some of our study’s findings may not generalize to all pediatricians nationwide because Hib-HBV vaccine is not available through Massachusetts’ universal purchase program. Pediatricians in our study may have been more likely to add visits or move vaccines than those in other states where this combination vaccine is used. On the other hand, since there is only 1 vaccine formulary in Massachusetts, there may be even greater variation in immunization practices among pediatricians in other states.

CONCLUSIONS

The addition of PCV has already reduced the incidence of pneumococcal infection in children.\textsuperscript{29} However, it may also have had some unintended effects on the delivery of existing immunizations and management of well-
appearing febrile infants. Such potential changes in practice should be taken into account when future vaccines are introduced. Given the wide variations in self-reported immunization practices and clinical decision making, special efforts may be warranted to ensure that pediatricians’ knowledge and practices remain current with changing recommendations. The actual effect of PCV on immunization coverage rates, clinical decision making, and disease incidence warrants further investigation.

Accepted for publication March 18, 2004.

From the Harvard Pediatric Health Services Research Fellowship, Boston, Mass (Drs Lee, Finkelstein, and Lieu); the Center for Child and Adolescent Health Policy, Massachusetts General Hospital, Boston (Dr Lee); the Center for Child Health Care Studies, Department of Ambulatory Care and Prevention, Harvard Pilgrim Health Care and Harvard Medical School, Boston, (Drs Finkelstein, Miroshnik, and Lieu, Ms Rusnak); the Division of General Pediatrics, Children’s Hospital Boston, Boston (Drs Finkelstein and Lieu); the National Immunization Program, Centers for Disease Control and Prevention, Atlanta, Ga (Dr Santoli); and the Division of Epidemiology and Immunization, Massachusetts Department of Public Health, Boston (Dr Lett). Dr Lee is now with the Epidemiology Branch, Division of Viral Hepatitis, National Centers for Infectious Diseases, Centers for Disease Control and Prevention, Atlanta.

This study was funded by the National Immunization Program at the Centers for Disease Control and Prevention, Atlanta, which provided assistance in the study design, interpretation of findings, and review/approval of the manuscript.

Portions of this study were presented at the 2003 Annual Meetings of the Pediatric Academic Societies; May 3 and May 5, 2003; Seattle, Wash; the NRSA Trainees Research Conference; June 26, 2003; Nashville, Tenn; and the Advisory Committee on Immunization Practices; October 16, 2003; Atlanta.

Correspondence: Tracy A. Lieu, MD, MPH, Department of Ambulatory Care and Prevention, Harvard Pilgrim Health Care and Harvard Medical School, 133 Brookline Ave, Sixth Floor, Boston, MA 02215 (tracy_lieu@harvardpilgrim.org).

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