We analyzed varicella surveillance data in Connecticut for 2001–2005, to describe the epidemiology of varicella in a highly vaccinated population after the introduction of varicella vaccine and to determine the number of preventable cases that had occurred during school-related outbreaks. Overall, the incidence of varicella did not change during the surveillance period. Vaccination rates among reported case patients increased, and the severity of infection decreased. An annual median of 2.5 cases/outbreak was identified as being preventable, with a majority of these cases being preventable by revaccination of previously vaccinated persons. Continued surveillance is needed in order to monitor changing trends in varicella epidemiology.

Varicella vaccine was licensed in the United States in 1995. Shortly thereafter, the Advisory Committee on Immunization Practices (ACIP) recommended routine vaccination, with 1 vaccine dose, of all children 12–18 months of age and of all susceptible children 19 months to 12 years of age; vaccination with 2 doses was recommended for all susceptible persons ≥13 years of age [1]. The ACIP also recommended that, during a child’s routine physician visit at 11–12 years of age, varicella immunity status should be assessed and the vaccine given if indicated [1]. Children with a reliable history of varicella were deemed to be immune [1]. Implementation of these recommendations was followed by a marked decline in the incidence of varicella and its complications [2–5]. However, by 2001, incidence began to plateau (B. Watson, Philadelphia Department of Public Health, personal communication), and outbreaks in well-vaccinated school populations began to be noted [6, 7]. In response, in June 2005, the ACIP issued recommendations on the use of varicella vaccine, including a recommendation to use a second dose in those previously vaccinated with 1 dose, as an outbreak-control measure [8]. This recommendation was in addition to a previous recommendation to vaccinate the unvaccinated during outbreaks [9].

In 2001, Connecticut added varicella to the list of physician- and laboratory-reportable diseases and became one of the first states to conduct case-based surveillance for varicella. This act followed Connecticut legislation in 2000 that required all children entering kindergarten or seventh grade, as well as those attending child care centers, to provide proof of varicella vaccination or history of disease. This vaccination requirement applied to all school grades by the beginning of the 2006–2007 school year.

Vaccination rates among children 19–35 months of age in Connecticut are among the highest in the United States. In 2001, a total of 84.3% of children 19–35 months of age in Connecticut had been vaccinated against varicella [10]. This proportion increased to 92.7% in 2004 [11]. We analyzed the first 5 years of data from varicella surveillance in Connecticut to examine the epidemiology of varicella in a highly vaccinated population and to determine the number of potentially preventable cases during school outbreaks, by using the recent recommendations from the ACIP. This report summarizes the results of that analysis.
METHODS

Varicella surveillance in Connecticut is passive and requires reporting of clinical disease by mail, fax, or telephone within 12 h of recognition. Health care providers, child care centers, and schools are all required to report varicella cases. Any report from these sources is accepted, and laboratory confirmation of cases is not required. A 1-page data form is used to collect information, for all cases. For the purposes of this analysis, reports received each year from 2001 to 2005 were analyzed for reporting source, age and vaccination status of case patient, history of chickenpox, and severity of disease. Severity of disease was determined by the number of lesions reported (mild, <50 lesions; moderate, 50–250 lesions; and severe, >250 lesions).

To assess school-related outbreaks of varicella, a school year was considered to occur from 1 September to 30 June, for 2001–2005; therefore, we analyzed 4 school years. A school was identified as having had an outbreak (designated as an “outbreak school”) if at least 5 persons ≥12 years of age or at least 3 persons ≥13 years of age were reported to have had varicella, with each sequential infection linked by an incubation period of ≤21 days (the maximum incubation period for varicella). To estimate the number of preventable cases per school, a case was defined as potentially preventable if it occurred ≥7 days after an outbreak had been identified at a school, the vaccination status of the case patient indicated that he or she was eligible for vaccination, and the case patient did not have a history of chickenpox. Preventable cases were not required to be linked to the outbreak by an incubation period. Under the new ACIP recommendations, a patient is eligible for vaccination if he or she has been vaccinated previously; under the earlier ACIP recommendations, a patient was eligible for vaccination if he or she had never been vaccinated. Vaccinated case patients were assumed to have received 1 dose of varicella vaccine. For the analysis of potentially preventable cases in schools, case patients with missing information on vaccination status were considered to be unvaccinated, and case patients with missing information on history of chickenpox were considered to not have a history of chickenpox. Data were analyzed by use of Epi Info (version 3.3.2; Centers for Disease Control and Prevention [CDC]) and Microsoft Excel 2003. The χ² test for trend was used to test trends in proportions over the 5-year period, and the χ² test was used to test differences between proportions.

RESULTS

Since the beginning of varicella surveillance in Connecticut, schools have remained the primary source of varicella cases reported to the Connecticut Department of Public Health (CDPH), accounting for 50%–60% of reports of varicella received by the state. Physicians accounted for one-third of all reports. Since 2001, the median time between the recognition of a case and a report being received by the CDPH has been stable at 2 days.

When all reported cases were considered, the overall incidence of varicella was found to have remained stable over the 5 years from 2001 to 2005 (figure 1), averaging 51 cases/100,000 population, with 1704 cases of varicella reported in 2001 and 1722 cases reported in 2005 (range, 1584–1909 cases). Severe outcomes were rare, with no deaths reported and a small number of hospitalizations (range, 1–11 cases). Although the number of reports of varicella remained stable, the characteristics of the people who contracted varicella changed (figure 1). The percentage of patients ≥5 years of age increased from 78% in 2001 to 83% in 2005 (P<.001), and median age increased from 7 to 8 years over the same period. The percentage of cases among adults ≥18 years of age (3%) did not change. The proportion vaccinated increased from 38% in 2001 to 79% in 2005 (P<.001). During the same period, the severity of varicella cases decreased. In 2001, a total of 47% of varicella cases were reported as mild; by 2005, this proportion had increased to 68% (P<.001). There was a corresponding decrease in the percentage of cases of severe disease, from 6% to 3% (P<.001).
Table 1. No. of school outbreaks of varicella and selected outbreak characteristics, Connecticut, 2001–2005.

<table>
<thead>
<tr>
<th>Outbreak characteristic</th>
<th>School year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schools reporting ≥1 case of varicella, no.</td>
<td>384</td>
</tr>
<tr>
<td>Outbreaks, no.</td>
<td>53</td>
</tr>
<tr>
<td>Cases per outbreak, mean (range), no.</td>
<td>11 (5–62)</td>
</tr>
<tr>
<td>Vaccinated case patients, %</td>
<td>34</td>
</tr>
<tr>
<td>Age of case patients, median, years</td>
<td>7</td>
</tr>
<tr>
<td>Preventable cases, median, no.</td>
<td>Unvaccinated case patients</td>
</tr>
<tr>
<td>Vaccinated case patients</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
</tr>
</tbody>
</table>

*a P < .001 for trend of increasing percentage of outbreak-related case patients having been vaccinated. P values were determined by use of the χ² test for trends in proportions.

DISCUSSION

The varicella surveillance system in Connecticut was initiated in a highly vaccinated population after a marked reduction in varicella incidence had occurred throughout the United States following the introduction of varicella vaccine. Overall, incidence did not change during the 5-year period covered by this analysis, indicating that the limits of reduction of varicella incidence might have been reached with the current vaccination recommendations. Nonetheless, varicella vaccine continued to have an impact on the epidemiology of varicella. Specifically, as the percentage of school-aged children who had been vaccinated increased, disease occurred more often among vaccinated children but became progressively milder.

School-aged children remained the major group affected by varicella, and school-related outbreaks continued to occur, despite high vaccination rates. The majority and an increasing percentage of school-reported cases were either isolated cases or occurred in clusters of <5 cases and, thus, were not amenable to prevention by the focus on the control of outbreaks of ≥5 cases. Implementation of the 2005 ACIP recommendation to revaccinate those in outbreak settings who already had been vaccinated would increase the number of potentially preventable cases per school. However, the work to implement these recommendations might be too cumbersome for the limited overall number of potentially preventable cases and is unlikely to stop community transmission.

Given these considerations, we believe that the total burden of varicella needs to be reduced before focal outbreak control is likely to be truly effective in stopping transmission. Thus, we welcome the June 2006 ACIP recommendation to routinely vaccinate all children 4–6 years of age with a second dose of varicella vaccine, as well as the associated catch-up recom-
mendation that all older persons who have received just 1 dose of vaccine be given a second dose [12]. Implementation of these recommendations will likely result in a decrease in the total burden of disease, including the number of outbreaks, and enable a more productive effort at outbreak control.

The finding that 5%–8% of reported case patients had a history of varicella and were not vaccinated is of potential concern, since many of these case patients may never have had varicella. Monitoring and limiting the size of this group in the future is important because misdiagnosed cases and, therefore, unprotected patients contribute to the reservoir of fully susceptible persons, putting them at risk for all varicella-related complications. Changing the proof of immunity requirements from a history of clinical disease to serological evidence of previous infection might eliminate the concern about this group’s possible susceptibility.

The limitations of this analysis include the following. First, diagnosis of varicella was not confirmed and is not required for cases reported to the CDPH. Second, the definition of outbreak was based on an operational definition proposed by the National Immunization Program (CDC). More cases might have been connected to outbreaks if a more conservative definition (e.g., 3 cases) had been used. Third, the scope of school outbreaks is difficult to describe, particularly when the outbreak extends outside the school. Our estimate of preventable cases is a maximum estimate based on the cases that occurred within schools but does not take into account any cases that occurred outside schools. For the analysis of preventable cases within schools, our definition included all subsequent cases occurring >1 incubation period after the initial outbreak and assumed that all susceptible persons would accept vaccination and would be vaccinated immediately. We also assumed that vaccine given within 3 days of exposure would abort incubation of disease and that no cases occurring >7 days after vaccination were the result of exposure before the intervention. Finally, the number of outbreak-related cases not reported by schools was not ascertained, and cases resulting from sustained transmission to community contacts and across schools were not counted. Thus, we believe that the number of overall infections related to school outbreaks probably is underestimated in this analysis.

The epidemiology of varicella has continued to change, even though the limitations of a single-dose vaccination strategy may have been reached. The new ACIP recommendations for a routine second dose are likely to alter the current dynamics. Continued surveillance is needed to monitor the changing epidemiology of varicella and to evaluate the impact of the new ACIP recommendations.

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References