Varicella Outbreak Reporting, Response, Management, and National Surveillance

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Two national surveys were conducted to evaluate the status of varicella case-based surveillance and outbreak response. Although progress toward national surveillance has been significant, a large number of jurisdictions are still without case-based surveillance. For jurisdictions beginning case-based surveillance with limited resources, a staged approach is recommended. The national outbreak survey showed that a significant number of varicella outbreaks continue to occur. The majority of jurisdictions respond to these outbreaks, although the response varies considerably. Depending on the outbreak-response approach, costs per outbreak ranged from $3000 for a typical, or passive, response to $6000 for a more active response. As varicella surveillance and outbreak control improves, jurisdictions may benefit from more-standardized outbreak-control practices.

The recent recommendation by the Advisory Committee on Immunization Practices for a routine second dose of varicella vaccine should lead to better varicella disease control, making case-based surveillance and appropriate outbreak response even more feasible.

The varicella vaccine was introduced in 1995 to address the significant varicella disease burden, which included an annual average of 4 million varicella cases, 11,000–13,500 hospitalizations, and 100–150 deaths [1–4]. Implementation of national varicella surveillance is important for assessing the impact of the vaccination program and for monitoring changes in the epidemiology of varicella. However, national surveillance was not possible early in the varicella vaccination program because of high disease burden. In 1995, when the varicella vaccine was licensed, only 21 states were reporting varicella cases to the National Notifiable Disease Surveillance System (NNDSS), a voluntary national surveillance system [5]. In the early years of the vaccination program, data measuring the progress of the program were obtained primarily from active surveillance sites for varicella, aggregate data from 4 states that consistently reported to the Centers for Disease Control and Prevention (CDC) through the NNDSS, administrative medical data, and vital statistics.

Since vaccine licensure and incorporation of varicella vaccine in the routine childhood vaccination schedule, the incidence of varicella has decreased significantly [4, 6, 7], making reporting of individual cases more feasible. As a first step toward national varicella surveillance, the Council of State and Territorial Epidemiologists (CSTE) recommended that deaths due to varicella should be designated as nationally notifiable starting in 1999 [8]. Varicella was added to the NNDSS list of nationally notifiable diseases in 2003 [9], and the CSTE recommended that states establish case-based surveillance by 2005 [10].

Investigation of outbreaks is an important component of varicella surveillance and disease control, and
outbreak response has been a significant burden and cost to state and local health departments [11]. Although data from 1 county conducting active surveillance for varicella indicate that numbers of outbreaks have declined since introduction of the varicella vaccine [12], data are limited. In 2005, the most recent year for which national data are available, 15 outbreaks in 13 states came to the attention of the CDC. However, these outbreaks are likely to represent only a small fraction of all outbreaks.

We performed 2 national surveys to assess progress toward implementation of case-based surveillance and the status of outbreak detection and response by state and local health departments and to better define the current epidemiology of varicella. We also performed a cost analysis using data collected from an additional outbreak-cost survey that was administered to a sample of health departments with recent outbreaks in schools.

METHODS

In September 2004, a self-administered survey was distributed to immunization-program grantees (50 states, the District of Columbia [DC], and 5 cities), which are health jurisdictions that receive federal grants for immunization programs. The survey included questions about varicella reporting and surveillance practices, existing or planned legislation mandating varicella reporting, and barriers to and strategies for implementation of varicella case-based surveillance. Case-based surveillance was defined as the collection and reporting of data on individual cases of varicella. In April 2005, a second, Web-based survey was e-mailed to the grantees described above, as well as to 3 US commonwealths and territories. This survey included questions about the number of reported varicella outbreaks during 2003–2004, an estimation of the number of reported outbreaks versus the actual number of outbreaks that had occurred, varicella outbreak definitions and guidelines for outbreak control, and outbreak-response activities.

Nine sites (7 states and 2 cities) with prior experience in the investigation and surveillance of varicella outbreaks were asked to complete an additional outbreak-cost survey. This survey focused on resource utilization, costs for personnel time and materials allocated to the outbreak response, other costs accrued to public health departments, and descriptions of varicella outbreaks in schools that had occurred in 2004. Two types of outbreak response were defined: (1) a typical response included exclusion of case patients from the outbreak setting, such as work or school, and a letter to parents informing them about the outbreak, and (2) an active response included more-vigorous case finding and disease-containment efforts, in addition to the activities defined as a typical response. A range of costs for responding to outbreaks was calculated, by site, on the basis of these definitions. Average costs for responding to an outbreak were estimated in US dollars for 2004.

Using data on the number of outbreaks reported by site from the national Web-based survey and site-specific population estimates for 2004 from the US Census Bureau (http://www.census.gov), we estimated the rate of varicella outbreaks per site that involved children <18 years of age, from which we extrapolated a national estimate of the median number of varicella outbreaks for 2003 and 2004. The associated public health outbreak-response costs, by type of response, were calculated by extrapolating the estimated cost per outbreak to the estimated total number of outbreaks.

RESULTS

There was a high response rate to all surveys. Fifty-one (91%) of 56 grantees (46 states, DC, and 4 cities) responded to the surveillance survey. Fifty-five (93%) of 59 grantees (47 states, DC, 5 cities, and 2 territories and commonwealths) responded to the outbreak-response survey. Seven (78%) of 9 sites provided data for the varicella outbreak-cost survey.

Case-based surveillance survey. Twenty-three (45%) of the 51 grantees (19 states, DC, and 3 cities) that responded to the surveillance survey reported that they had established varicella case-based surveillance. Of the 19 states with case-based surveillance, 15 states had statewide reporting, 2 had sentinel-site reporting, and 2 did not respond to the question on type of case-based surveillance. Of the 3 cities with established case-based surveillance, 1 city was located in a state with case-based surveillance, and the other 2 cities were located in states with planned case-based surveillance. DC indicated that reports were received from throughout its jurisdiction. Seventeen (33%) of the 51 grantees reported that they planned to implement case-based surveillance in the future. Reporting sources for varicella cases included hospitals, emergency departments, outpatient clinics, physician offices, laboratories, elementary and high schools, colleges, health maintenance organizations, and day care facilities (figure 1).

Thirty (59%) of the 51 grantees (26 states, DC, and 3 cities) indicated that they had mandated varicella case reporting. Twenty-one (70%) of these 30 grantees had implemented case-based surveillance, whereas only 4 (20%) of the 21 grantees without mandated reporting had established case-based surveillance. Compared with grantees without mandated reporting, a larger percentage of grantees with mandated reporting stated that they were informed about varicella-related hospitalizations, laboratory-confirmed cases, and aggregate cases; the incidences of outbreaks and deaths were reported at the same rates, regardless of mandated reporting (figure 2).

The most frequently cited barrier to case-based surveillance was lack of financial and human resources. Other barriers included difficulty in obtaining support for surveillance from
Figure 1. Reporting sources among 23 immunization-program grantees that had implemented varicella case-based surveillance, case-based surveillance survey, United States, 2004. ER, emergency room; HMO, health maintenance organization.

local health-department staff and community partners, mainly because of resource gaps, absence of a varicella reporting mandate in the grantee’s jurisdiction, perception of varicella as not being an important disease, and lack of a reporting database. The most frequently cited strategy for facilitating case-based surveillance was a close partnership with the reporting community (i.e., physician offices and schools) through meetings, e-mails, and newsletters.

Outbreak survey. Forty-three (78%) and 45 (82%) of the 55 grantees that responded to the outbreak survey were notified of at least 1 varicella outbreak during 2003 and 2004, respectively. However, most grantees reported that they were probably not contacted about all outbreaks.

The majority of the grantees (39 [71%] of 55) had at least 1 definition for varicella outbreaks, although almost one-third of the grantees (16 [29%] of 55) reported not having a formal program definition for varicella outbreaks. Among health departments with an outbreak definition, there was variability in the definitions used with regard to setting, time interval, and/or number of cases. Forty-seven (85%) of 55 grantees reported that their state and/or local health departments would respond to an outbreak if notified. Among these 47 grantees, the most frequently reported outbreak-response strategies included verification of vaccination information, exclusion of case patients from the outbreak setting, and collection of certain information regarding case patients, such as age and vaccination status (table 1). Vaccination or exclusion of susceptible contacts and laboratory testing to confirm the outbreak or to assess susceptibility were reported to be used infrequently. Only 24 (44%) of 55 grantees had guidelines for varicella outbreak response. Of the 31 grantees that did not have guidelines, 23 (74%) reported that they would respond to an outbreak if notified.

Twenty-four grantees reported additional information about setting, median age of case patients, and size for 190 varicella outbreaks that had occurred in their jurisdictions in 2004. The majority of the reported outbreaks (127 [67%] of 190) had occurred in elementary schools (figure 3A). The median age of case patients in many of the outbreaks (82 [43%] of 190) was 5–9 years, although median age was not available for 40% of the outbreaks (figure 3B). The size of the outbreaks ranged from 2 to 79 cases. Outbreaks tended to be small: 64% of outbreaks (122/190) had ≤10 cases, 26% (49/190) had 11–40 cases, and 10% (19/190) had >40 cases (figure 3C).

Outbreak-cost survey. We estimated that a median of 665 and 714 varicella outbreaks occurred in US schools in 2003 and 2004, respectively. The average cost of a typical response to an outbreak in schools was $3000, whereas the average cost of an active outbreak response was $6000. Outbreaks that received a typical response had an average of 4 cases, whereas outbreaks that received an active response had an average of 49 cases. One grantee also supplied data for the response to an outbreak in a hospital, with 3 case patients and 60 persons exposed; the cost for responding to this outbreak was $7700. Most outbreak costs (88%) were related to personnel time allocated to outbreak-response activities. On the basis of these figures, we extrapolated that the estimated median cost of all active outbreak responses would have been $4 million in 2003 and $4.3 million in 2004.

DISCUSSION

These data provide an assessment of varicella surveillance practices in the United States and will serve as the baseline to which the impact of changes in varicella vaccination policy can be compared [13]. Estimates from the outbreak survey also pro-
Table 1. Components of outbreak investigation and response, reported by 47 immunization-program grantees, outbreak survey, United States, 2005.

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage (no.) of grantees, by survey response</th>
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<tbody>
<tr>
<td><strong>Outbreak investigation</strong></td>
<td></td>
</tr>
<tr>
<td>Record information provided by reporters of outbreaks</td>
<td>77 (36) 19 (9) 4 (2)</td>
</tr>
<tr>
<td>Collect epidemiological information on age of case patients</td>
<td>70 (33) 23 (11) 6 (3)</td>
</tr>
<tr>
<td>Collect epidemiological information on clinical symptoms of case patients</td>
<td>55 (26) 32 (15) 13 (6)</td>
</tr>
<tr>
<td>Varicella case finding during outbreak</td>
<td>51 (24) 32 (15) 17 (8)</td>
</tr>
<tr>
<td><strong>Outbreak response</strong></td>
<td></td>
</tr>
<tr>
<td>Exclusion of case patients</td>
<td>66 (31) 13 (6) 21 (10)</td>
</tr>
<tr>
<td>Identification of high-risk contacts to target for receipt of VZIG</td>
<td>49 (23) 26 (12) 26 (12)</td>
</tr>
<tr>
<td>Letters to parents during outbreaks in schools or child care facilities</td>
<td>45 (21) 40 (19) 15 (7)</td>
</tr>
<tr>
<td>Assistance with media inquiries</td>
<td>36 (17) 36 (17) 28 (13)</td>
</tr>
<tr>
<td>Vaccination of susceptible contacts</td>
<td>28 (13) 47 (22) 26 (12)</td>
</tr>
<tr>
<td>Notification of outbreak to health care providers, community, and/or affected population</td>
<td>15 (7) 64 (30) 21 (10)</td>
</tr>
<tr>
<td>Exclusion of unvaccinated contacts</td>
<td>15 (7) 28 (13) 57 (27)</td>
</tr>
<tr>
<td>Vaccination of all persons without screening for susceptibility</td>
<td>11 (5) 30 (14) 60 (28)</td>
</tr>
<tr>
<td><strong>Outbreak investigation and/or response</strong></td>
<td></td>
</tr>
<tr>
<td>Verification of vaccination information for case patients</td>
<td>40 (19) 40 (19) 19 (9)</td>
</tr>
<tr>
<td>Screening for varicella susceptibility for noncases</td>
<td>30 (14) 43 (20) 28 (13)</td>
</tr>
<tr>
<td>Verification of vaccination information for noncases</td>
<td>21 (10) 38 (18) 40 (19)</td>
</tr>
<tr>
<td>Analysis and presentation of collected data</td>
<td>19 (9) 49 (23) 32 (15)</td>
</tr>
<tr>
<td>Use of laboratory support for verification of diagnosis</td>
<td>9 (4) 53 (25) 38 (18)</td>
</tr>
<tr>
<td>Use of laboratory support to assess susceptibility</td>
<td>0 45 (21) 55 (26)</td>
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**NOTE.** VZIG, varicella zoster immune globulin.

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provide the only national data regarding numbers and characteristics of varicella outbreaks in the United States.

By late 2004, substantial progress toward national varicella case-based surveillance had been made, with 23 grantees having implemented case-based surveillance and 17 grantees planning implementation. Since this survey was completed, 12 additional grantees have implemented case-based surveillance, and 8 grantees are planning implementation (CDC, unpublished data). For state or local health departments without current or planned case-based surveillance, mandatory reporting laws may be an important first step toward implementation. Case-based surveillance has become more feasible because of the success of the vaccination program and the declining number of varicella cases. As varicella epidemiology changes with implementation of the vaccination program, more-detailed surveillance is needed to document the number and outcome of cases in vaccinated and unvaccinated individuals and the age of case patients, to continue to assess vaccine effectiveness, and to evaluate vaccine policy.

Lack of sufficient resources was a frequently cited barrier to implementation of case-based surveillance. The CDC has suggested that states that identified lack of resources as a barrier should begin with a staged approach, starting with the collection of data on key variables, including age and varicella vaccination history of case patients and severity of cases. Additional variables, such as source of infection of case patients, other symptoms and complications, and laboratory diagnostic information, can be incorporated at a later time. States initially may choose to use sentinel reporting sites, such as selected physician offices or schools, before moving to statewide surveillance.

Our data highlighted that many outbreaks continued to occur despite national vaccination coverage rates of 85% and 88% in 2003 and 2004, respectively [14]. Varicella outbreaks in highly vaccinated populations (>90%) are well documented [15–17], because the effectiveness of 1 dose of varicella vaccine is insufficient to interrupt endemic disease transmission. On the basis of cost estimates, the burden of responding to outbreaks was found to be substantial, with average cost ranging from $3000 to $6000. In addition to these monetary costs, responding to and investigating outbreaks can overwhelm already busy local and state health departments and can divert personnel from other crucial public health priorities.

Many grantees respond to outbreaks in some capacity and have a definition for varicella outbreaks. However, the type of response and the definitions vary by jurisdiction. As a standard of care, case patients with varicella should be excluded from the outbreak setting, a letter should be sent from the local health
Figure 3. Information from 24 immunization-program grantees regarding outbreak setting (A), estimated median age of case patients (B), and outbreak size (C) for 190 varicella outbreaks, outbreak survey, United States, 2004.

department or outbreak setting to inform parents that an outbreak is occurring, and children without evidence of immunity should be vaccinated. Standard outbreak-management guidelines should help ensure a more uniform and comprehensive response. The CDC is working with state health departments to develop and publish standard outbreak definitions and guidelines for varicella outbreak management.

There are several limitations to these surveys. The survey responses are based on grantee reports and may be subject to recall biases. We were not able to evaluate the quality of the surveillance system from the information collected in the survey. Responses collected about the number of cases may not reflect the extent of varicella disease at each reporting site, owing to possible differences in reporting practices. In addition, information about outbreaks that were not reported to the health departments usually was not captured. For the outbreak-cost survey, the cost estimates are likely to be conservative, because outbreaks may have been underreported and attributable costs underestimated. For example, costs associated with laboratory testing and time missed from work or school were not captured in the survey. In addition, although health departments were asked to include vaccine costs, the cost data reported for materials used during an outbreak response were aggregated without separation of specific costs. Furthermore, although this analysis attempted to account for differences in outbreak response, not all types of outbreak response may be represented. Finally, the cost survey did not include cost information related to implementation of the new 2-dose varicella-vaccination recommendation for outbreak control [13], because the survey was conducted prior to the recommendation's approval by the Advisory Committee on Immunization Practices (ACIP) in June 2005.

In June 2006, the ACIP recommended routine administration of 2 doses of varicella vaccine for children. A routine second-dose policy will be an effective strategy in further prevention of varicella cases and outbreaks, will alleviate the burden and costs to health departments of investigating these outbreaks, and should make case-based surveillance more feasible. With implementation of routine 2-dose vaccination, responding to outbreaks with appropriate control measures (including following the 2-dose vaccination recommendation during outbreaks) should be more manageable when outbreaks occur. Varicella surveillance and outbreak-response practices are likely to change substantially in future years as the epidemiology of varicella evolves, and periodic evaluation of the status of varicella surveillance and outbreak response will continue to be important.

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References


