Rapid Response to a Conjunctivitis Outbreak: The Use of Technology to Leverage Information

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Abstract. When an outbreak of conjunctivitis was identified at a rural New England college early in 2002, the college health center medical staff used various information management and communication systems to alert the community to the situation. They called upon the state Department of Human Services and the Centers for Disease Control and Prevention to help them understand and manage the outbreak. Technological systems already in place at the college allowed for rapid collection of data by means of a survey delivered over the Internet and a carriage study facilitated by a Web-based appointment and communication system. Within days, the data were collected and analyzed and an immediate response to contain the outbreak was launched.

Key Words: conjunctivitis, health administration, Internet communication, Web surveys

On January 24, 2002, 3 weeks after the beginning of the winter term, the Dartmouth college health service staff saw its first case of conjunctivitis in what was to evolve into a large outbreak. Three weeks later, the number of confirmed cases among students had risen to nearly 100; by the time 200 cases had been diagnosed, the Centers for Disease Control and Prevention (CDC) and the New Hampshire Department of Health and Human Services were involved in understanding and containing the outbreak.

A rapid response from a team of health professionals and researchers (from Dartmouth College, the Dartmouth Medical School, Dartmouth-Hitchcock Medical Center, the New Hampshire Department of Health and Human Services, and the Division of Bacterial and Mycotic Diseases, National Center for Infectious Diseases at the CDC) took advantage of multiple communications systems and technological innovations, identified the cause of the outbreak and risk factors for transmission among the populations, and provided the affected population with the knowledge and tools to prevent transmission. In this article, we focus on the communication systems and computerized information management tools in place at the college and describe how we used them in combination to provide an exceptionally rapid response to the outbreak.

Conjunctivitis is an inflammation of the smooth vascular mucus membrane covering the inner surfaces of the eyelids and extending onto the globe and to the border of the cornea. Objective findings with the infection include erythema and swelling of the conjunctiva with a discharge varying from purulent to watery. Etiologies include chemical irritants, allergens, autoimmune disorders, and infections. Conjunctivitis, caused by bacterial or viral infection, is common and is usually a minor disorder. However, such infections may occur in epidemics, causing significant disruptions to normal daily activities for affected individuals and institutions. Common sites of outbreaks include day-care centers, medical clinics, and college campuses.

Background

Dartmouth is a small private college in rural New Hampshire with an enrollment of approximately 4,000 undergraduate and 1,400 graduate and professional students.

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Most undergraduate students (85%) live in residential housing provided by the college, and the remainder (including most graduate students) live nearby. All students, both undergraduate and graduate, are entitled to healthcare at the student health center. Approximately 95% of the students use the nonemergency service provided at this on-campus facility. The clinic medical staff includes physicians, physician assistants, nurse practitioners, registered nurses, and pharmacists.

We identified this outbreak of conjunctivitis early in its course, primarily because of 2 factors, both related to how we monitor student health diagnoses. The first is a system by which the diagnoses of students seen during the weekend by the on-call clinician are listed on a weekend report with a 1- or 2-sentence summary that is e-mailed to all health center staff who have a need to know. In addition to informing staff of the weekend's events, the report provides an "early warning" about what cases might be seen on a Monday following a weekend. On February 4, the weekend report included the following statement: "The weekend was fairly busy and steady with a viral syndrome that consisted of conjunctivitis, sinus congestion, occasional cough. . . ." By the following Monday, February 11, "Lots of conjunctivitis" led the weekend report.

The second factor that was related to early identification of the outbreak was the health center's direct access to a clinical database. During the week of February 11, with an increasing number of students presenting with conjunctivitis, the medical-records staff initiated a data query to compare the number of cases of conjunctivitis diagnosed during the first 2½ weeks of the current winter term (January 28–February 14, 2002) with a comparable period in previous years.

This query confirmed that we were seeing a much larger number of cases than in previous years, specifically 153 in 2002 compared with 29 in 2001. These records are in a customized computer database (using FoxPro) that accommodates ad hoc queries, which are sometimes difficult to accomplish quickly with many data systems.

Initially, practitioners at the student health center treated the presenting cases as a presumed viral conjunctivitis. As the number of cases increased and the evidence mounted that the college might be facing an outbreak, we considered other possible causes for infections. We obtained ocular cultures from 12 students; *Streptococcus pneumoniae* was isolated from all 12.[1] At that point, the director of the health service got in touch with New Hampshire state health officials, who in turn called upon the CDC for assistance.

Front-page articles in the student newspaper focused on the outbreak, and "pink-eye" became the theme of the week for several cartoonists. As concern grew, the number of students visiting the student health center increased. To determine whether the outbreak was limited to our college community or other college health services were experiencing an outbreak, we asked various institutions outside the college whether they had noted increases in the number of cases of conjunctivitis. None reported such increases. Inquiries to local healthcare providers, nearby schools, daycare centers, and retirement homes yielded no information suggesting an increased number of cases, indicating that the problem seemed to be isolated to the college.

Epidemiologic Investigation

Representatives from CDC arrived on campus on February 25, and we assembled a team to investigate the outbreak. By that afternoon, the team had settled on a course of action. We needed the following additional information:

- The prevalence of conjunctivitis in the college population had to be determined.
- Behavioral patterns had to be examined to determine possible causes of transmission.
- Additional clinical examinations were necessary to further document the underlying cause of the problem.

A rapid investigation was imperative if the outbreak was to be contained because spring break was to begin in approximately 3 weeks. Dartmouth is a "wired" campus, making an annual appearance on the "Yahoo! Wired Colleges" list; in 2001, it was listed as the fifth-most-wired college in the country.[2] Each undergraduate at Dartmouth is required to have a personal computer; many incoming students purchase a laptop or desktop computer through the college. These computers come preloaded with both an e-mail package and Internet browsers. Most faculty and staff also make widespread use of e-mail. (In fact, one of the early suppositions concerning the transmission of conjunctivitis was that individuals were infecting each other through the use of public computer terminals. This hypothesis was later rejected when between 40 and 60 public terminals tested negative.) Thus, when it became necessary to reach the entire college community as quickly as possible, e-mail was a natural means to accomplish this task.

The college has also been a pioneer in the use of Web surveys to obtain data from students. The first Web survey was implemented in the spring of 1996.[3] Such surveys have been used with great success every year since, virtually replacing all mailed paper-based surveys and resulting in response rates ranging from 50% to 60%, approximately 10% higher than mailed paper surveys. Extensive experimentation over the years has shown no substantive differences in the data collected in paper and Web surveys, although one important demographic difference has been evident. Mailed paper surveys often resulted in more responses from women than from men, but with Web surveys the response rate of men was equal to that of the women. Web surveys result in a more representative sample of the specific college student population and can eliminate the necessity of weighting survey results by sex.

The student health center has also used a Web-based sign-up for influenza shots since 1996. This system allows students, faculty, and staff to use a Web interface to view available appointment times and to schedule themselves into a slot, eliminating the time-consuming process of person-to-person scheduling. This system ensures a predictable

flow of patient traffic and virtually eliminates lines. Because health center staff members can view the appointment list during the sign-up period, they can develop publicity efforts and adjust staffing levels according to the needs indicated by the sign-ups.

Thus, on many fronts, the college has a track record of successful use of technology to gather and retrieve information and schedule appointments. We drew on these strengths to create a Web-based questionnaire to gather epidemiologic data from the college population and design a "carriage study" to collect clinical data. (A carriage study examines a sample from a given population to determine if a particular organism is present in the individuals' bodies, regardless of whether or not they appear to be ill). Within 3 days of the initial strategy meetings, the process of data collection and population education began.

Web Survey

The questionnaire developed for the survey was designed to examine

- The prevalence of symptoms,
- Demographic correlates, and
- Possible modes of transmission.

We used the World Wide Web to administer 2 separate versions of the questionnaire, 1 for students and 1, less detailed, for faculty and staff. We used e-mail to notify all students, faculty, and staff about the outbreak and asked them to complete a confidential survey. The Director of the Health Service sent the e-mail after receiving approval from the offices of the president and of public affairs, as well as the Human Subjects Review Committee. E-mail on this campus is an established and effective method of communication because all members of the community are known to use their college e-mail accounts, which is not always the case at other institutions.

We conveyed the necessary information as succinctly as possible so that individuals not inclined to scroll to the bottom of the lengthy e-mail message could still receive the pertinent instructions. It was particularly important to communicate with those who did not believe they had conjunctivitis, as well as those with diagnosed conjunctivitis, to obtain a reliable estimate of prevalence. Recipients were also notified that the survey used an authentication system that included their college identification number. We assured them that all information would be kept confidential and that the identification number would be stripped from the rest of the data once it was no longer necessary for verification.

Clicking on the URL in the e-mail message took the respondent to a Web page that explained the purpose of the study and the rights of the participants. In the setting of an outbreak and intervention by CDC, the primary concern is for the benefit of the population affected by the outbreak, not to gain general knowledge. Therefore, CDC's Institutional Review Board was not required to review this investigation. Nonetheless, the team applied for and received exemption from the college's Institutional Review Board and we observed all proper human subjects protocols.

The survey HTML forms were produced using Adobe GoLive software. After participants responded, the survey data was captured on an ordinary desktop computer (a Macintosh Power Mac running Mac OS 9 and the Web application development environment Frontier). A Web page accessible to the team continually updated the number of responses for both versions of the questionnaire. We authenticated the sample by verifying replies through appropriate software, thus determining that the respondents were from the college population and that we recorded only 1 response per person. Students use the same verification system to access grades and class assignments and therefore are familiar with its requirements and confidentiality. Responses to the Web-based questionnaire were instantly submitted to a central database and were ready for analysis. Once the data were received, respondents were sent to a Web page that thanked them for participating and reminded them that survey responses were confidential. They were also told that answering the survey could not be viewed in any way as a substitute for clinical intervention and that those wishing to be seen by a healthcare provider for possible conjunctivitis should communicate with the college health service.

The life cycle of a Web survey is much shorter than that of a mailed paper survey, which may take 2 months to administer and require several reminders and additional mailings. A similar process with reminders on the Web might last only 1 week to 10 days. Most responses to a Web survey are submitted within 24 hours of a request; thus, the timing of reminders to nonrespondents can be measured in hours and days rather than weeks.

Carriage Study

To complement the survey data, we asked a random sample of approximately 2 of every 5 students who had submitted a questionnaire to participate in a clinical examination at a temporary clinic in the student center, which is more centrally located on campus than the student health center. Only undergraduate and graduate students were in the pool of participants for this component of the investigation because these were the populations of greatest concern. Students randomly selected for the carriage study received a different Web thank-you page upon submission of the questionnaire. In addition to the information on the standard thank-you page, this message included relevant information on the carriage study. To control the flow of students, we referred interested participants to a student health service Web-based appointment system that we had previously used for flu shots. This system issues automatic e-mail appointment reminders to students and provides both a hard copy and an electronic list that can be downloaded for administrative use.

Despite the logistical difficulties of an all-day clinic, we decided to complete the carriage study as rapidly as possible because the examination included a potentially uncomfortable nasopharyngeal swab. The team theorized that if

the clinic were held over a longer period, word might spread to avoid the clinic and therefore avoid such discomfort.

Response

Web Survey

Within 24 hours of the initial request to participate in the survey, we had conducted a preliminary analysis of the responses of 994 undergraduate students, an initial rate of 26%. This preliminary analysis identified potential areas of concern in fraternity and sorority residences and poor handwashing practices in all students. It also indicated a tendency for students with symptoms not to seek medical treatment.

There was some confusion about which segments of the population were expected to complete the survey. The campus-wide announcement sent by e-mail went to members of the college campus (which includes the medical school, the school of business, and the school of engineering) as well as the medical center, although the investigating team expected to survey only the college campus. Authentication for the Web site allowed access only from the main campus and refused connections from those at the hospital or other offsite locations. We could calculate a response rate based on the actual number of undergraduate and graduate students on campus and enrolled for the term. However, similar response rates for faculty were complicated by the inability of faculty and staff who were based at the medical center and other sites to gain access to the survey.

Ordinarily, only the nonrespondents would have received a reminder e-mail, but in this study, we sent 2 follow-up e-mails to the undergraduate population—1 reminder 24 hours after the initial request and another reminder 2 days later. The first reminder informed all students that we had added an additional day for the carriage study; the second reminder was sent by the student government to create a different "drawing power." Because of confidentiality issues, we did not want to provide the student government with a list of those who had actually completed the survey, and we could not limit the capacity to send e-mail to those who did not respond to the first communication. From initial survey responses, cases presenting at the health center, and the unremarkable number of conjunctivitis cases reported from other local institutions, the outbreak seemed to be contained among the Dartmouth undergraduate population. Given the difficulties of reaching graduate students and the off-campus noncollege staff, we limited reminders to the undergraduate population.

Final data on 1,812 undergraduates (48% response rate) was available approximately 5 days after the initial request to complete the survey. We focus subsequent analyses in this article on this group.

Carriage Study

At the end of the first day of the survey, 152 students had volunteered for the surveillance clinic. This participation rate (38%) was lower than we had expected because approximately 40% (400) of the students who answered the survey were randomly invited to participate. This was somewhat understandable because students were beginning final examinations on the day of the clinic. Of the 152 who made appointments, 133 presented at the carriage study, an 88% response rate of those with appointments and an overall response rate of 33%. To meet the study goal of collecting 200 specimens, we scheduled a second clinic day. For the second clinic day, 142 students scheduled appointments; 111 students were actually seen (a 78% response rate), and the overall response rate moved to 31%.

Summary of Results

Although the focus of this report is on the rapid response to the outbreak, a brief summary of the results follows. (A more complete examination of the results of the outbreak and conjunctivitis cases is available elsewhere.[1]) More thorough analyses linking the carriage study data and the questionnaire results are in progress.

Web Survey

In general, results from the preliminary analysis of the first day's data from the undergraduate Web survey were first borne out in the final data pool. On the basis of symptoms reported by respondents in the survey, we realized that twice as many students had possible cases of conjunctivitis as were presenting at the student health center. Particularly problematic segments of the population were not immediately identifiable, although some possibilities we considered were residence, academic major, athletic team participation, and fraternity and sorority membership.

Carriage Study

The carriage study confirmed that the outbreak strain was widespread on campus, even among students without eye symptoms. Thus, the importance for all students to take precautions against transmitting the infection rather than only those students with conjunctivitis was clear. Additional analysis of this data is underway, and we will report the findings separately.

Actions

Throughout the outbreak, college officials used e-mail, the student newspaper, and posters placed strategically around campus to communicate with students, faculty, and staff. Communications focused on informing students that an outbreak of conjunctivitis was occurring on campus and suggesting methods to limit transmission. These instructions included advice about the need for frequent hand washing and cautioned against sharing drinking glasses, towels, or utensils. Because hand-washing instructions were believed to have limited effectiveness,[4] the health service distributed travel-sized bottles of an alcohol-based antiseptic gel to all undergraduates' campus mailboxes with instructions for using the gel. In addition, we encouraged all members of the community who suspected symptoms of conjunctivitis to seek medical assistance.

Approximately 6 weeks after the first case, we used a national college health listserv to inform health practition-

ers at other colleges and universities about the outbreak and to solicit information concerning the prevalence of conjunctivitis on other campuses. At the time of the message posting, this listserv distributed messages to 1,557 college-health professionals. As of April 5, only 1 other institution among student health centers examining conjunctivitis activity on their campus identified a significant increase in bacterial conjunctivitis. It reported having seen 289 patients for the problem.[5] Although the connection between the 2 campus outbreaks remained unclear, the 2 schools' varsity athletic teams competed during this time period, and this interaction is suspected as one method of transmission.

College undergraduates began spring break on March 13 and returned on March 26. On March 27, a letter from the Director of the Health Service to all students provided closure on the winter term outbreak and reminded students of the continuing possibility of exposure to this strain of conjunctivitis. In the letter, he repeated the instructions to minimize transmission. This letter was also accessible on the Web from a prominent link on the college home page. In the first week after spring break, only 19 students presented at the college health center for treatment for conjunctivitis.

Comment

Early warning systems, both informal (the weekend report) and more formal (the capacity to retrieve diagnoses rapidly from medical records) contributed to prompt identification of the conjunctivitis outbreak. Rapid communication and data gathering systems (e-mail and Web surveys), as well as the ability to schedule a carriage study quickly and efficiently, allowed our investigative team to collect, analyze, and take action to quell an outbreak in a matter of days.

To be useful during this outbreak, the systems we used had to be in place. Others have demonstrated the utility of e-mail communication during a campus outbreak.[6] Both the Web survey capacity and knowledge of how to implement it successfully (based on our years of previous experience) were necessary ingredients in the success of the intervention. Such systems are established over time with the encouragement and support of the institution. The key to the application of all the methods we report in this article is that the use of the technology has met a need, not that technological innovations have been adopted merely for their own sake.

Clearly the "wired" nature of this particular campus was not only a factor in the willingness to experiment with new computer-based methods but was also helpful for our students in using these innovations. Web surveys and appointment systems might not work for all campuses although nationally, 74% of incoming first-year students report having used the Internet as high school seniors.[7] Furthermore, it is evident from our mistake in sending the initial e-mail beyond the intended audience (and the subsequent lower response rates) that lessons are still to be learned after years of practice. Whereas this college is more progressive in using technological systems than many other institutions, we believe that campuses that are "less wired" should base decisions on whether to adopt such systems on the utility of such information on their own campuses.

All campuses are becoming more interconnected through technological advances. What seems impossible today may be commonplace in the near future. Systems such as those we have outlined in this report that allow for a rapid response during normal day-to-day activities can become essential in times of crisis. In this outbreak of bacterial conjunctivitis, the ramifications of a delayed response were not terribly critical because of the relatively minor nature of the disease. A slow or delayed response could have been critical in the case of a more serious or deadly outbreak.

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NOTE

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