The Cost of Containing One Case of Measles: The Economic Impact on the Public Health Infrastructure—Iowa, 2004

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ABSTRACT. *Background.* **In February 2004, students from a college in Iowa, with a high proportion of nonmedical exemptions to vaccination, traveled to India; one fourth of the students contracted measles while there. One exposed, susceptible student returned home during his infectious period, necessitating 2 months of containment efforts in Iowa.**

Objective. **The objective of this study was to measure the direct costs of measles containment from a public health system perspective.**

Methods. **We evaluated activities performed, personnel time/materials allocated, and direct costs incurred in 2004 US dollars by the Iowa public health infrastructure. The study period was defined as March 5, 2004 (when the Iowa Department of Public Health was first contacted about the case), through May 12, 2004 (when a final meeting was held on the containment effort).**

Results. **A total of 2525 hours of personnel time were expended to review flight manifests, contact exposed passengers, set up vaccination clinics, trace >1000 potentially exposed contacts, and institute and enforce quarantine orders for vaccination refusers. Two thousand twenty-five phone calls were received from the public, and 2243 miles were driven by staff. The temporal distribution of personnel time was characterized by marked peaks at the report of potential secondary cases. The total estimated cost was $ 142 452.**

Conclusions. **The direct cost to the public health infrastructure of containing 1 case of measles was far greater than the estimated cost of uncomplicated individual illness (less than $100). Economic analyses of vaccine-preventable diseases may need to go beyond the costs of individual illness to account for the costs of protecting society.** *Pediatrics* **2005;116:e1–e4. URL: www.pediatrics.org/cgi/doi/10.1542/peds.2004-2512;** ***measles, economic evaluation, measles-mumps-rubella vaccines.***

ABBREVIATION. IDPH, Iowa Department of Public Health.

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Accepted for publication Feb 2, 2005.
doi:10.1542/peds.2004-2512
No conflict of interest declared.

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Measles is a highly infectious, acute viral disease that can cause severe pneumonia, diarrhea, encephalitis, and death. An estimated 30 to 40 million cases and 750 000 measles deaths occur annually worldwide.[1] In the United States, <100 cases occurred annually during 2002–2003, 82% of which were import-associated.[2] The success of the US measles-elimination program is based on high levels of preschool vaccination coverage (>90% by the age of 3 years)[3] and the widespread requirement by states of 2 doses of measles vaccine for school entry.[4] However, exemptions for religious or philosophical reasons are permitted in most states.[5] Those who are exempt from receiving the vaccine are >22 times more likely to acquire measles than those who do receive it and create a 2- to 66-fold increased risk of measles for those who are not exempt from the vaccine mandates in the same community.[6]

In February 2004, a group of ~28 college students from a community in Iowa with a high proportion of nonmedical exemptions to vaccination traveled together to India, where ~44 000 cases of measles were reported in 2003,[7] although the true number is certainly much higher. All 6 students without receipt of at least 1 dose of measles vaccination contracted measles in India. The Iowa Department of Public Health (IDPH) recommended that students with measles stay in India during their infectious period to avoid potential spread during prolonged airline flights. Nonimmune contacts were asked to stay until the end of their potential incubation period. Despite the IDPH recommendations, 1 exposed unvaccinated student returned to Iowa earlier than requested. During his travel, involving connections in 2 busy airports, he developed a cough and conjunctivitis. Shortly after arrival in Iowa, he developed a rash and saw a physician who reported the case to the IDPH, and measles was subsequently laboratory-confirmed.[8] This was the first measles case in Iowa since 1996 and occurred in a community with a high proportion of persons with nonmedical exemptions to vaccination. In this community, only 59% of the students attending primary/secondary school were fully vaccinated, compared with the statewide average of 97%. The IDPH began an intensive measles-containment effort, at the end of which spread was limited to 2 secondary cases: 1 unvaccinated close, personal contact of the index case patient and a person who had received 2 valid doses of measles-

containing vaccine but who had sat next to the index case patient on a small airplane for 2 hours. None of the 3 people with measles were hospitalized or had known complications.

Conventional economic analyses often are confined to the costs incurred by the patient.[9,10] However, the costs incurred by the 3 Iowa patients seemed to be small (none were hospitalized or had known complications) compared with the costs incurred by the public health system in preventing spread to others. In this study, we examined the economic impact of measles-containment efforts on Iowa public health institutions.

METHODS

The study was performed from a public health system perspective and evaluated activities performed, personnel time/materials allocated, and direct costs incurred in 2004 US dollars by the Iowa public health infrastructure. Public health activities performed by the University of Iowa Hospitals and Clinics in collaboration with the Johnson County Health Department were also included in the analysis. The study period was defined as March 5, 2004 (when the IDPH was first contacted about the students returning from India) through May 12, 2004 (when a final meeting was held on the containment effort). For activities, we obtained chronological descriptions from each involved institution. Resources allocated to specific response activities were identified when available. Personnel time was based on hours allocated to containment obtained from written chronological reports and personal interviews with the personnel in the involved institutions. For costs, an instrument focusing on major containment cost categories was administered to outbreak managers from the IDPH, county health departments, and other health institutions. Personnel time was converted to costs by using the reported gross wage of each individual, plus fringe benefits when available. Overhead costs were based on the number of person-hours and each institution's accounting method. Counts and unitary costs were obtained for phone calls, vaccine, immunoglobulin, and miles traveled. Because the study evaluated containment costs, we did not attempt to measure the direct costs of disease for the 3 cases of measles.

RESULTS

Activities

Containment activities included subpoenaing flight manifests, contacting Iowa-resident passengers concerning postexposure prophylaxis, communicating with other states concerning non–Iowa-resident passengers, issuance of press releases, issuance of health advisories to alert physicians and enhance surveillance, collaboration with the Centers for Disease Control and Prevention, and establishment of special measles-vaccination clinics. A toll-free measles-information phone line registered >2000 calls.

One of the 2 secondary case patients of measles had traveled during the infectious period with 60 other children from the community's school and attending adults to a neighboring town for an academic competition with >1000 other children. Three vaccination clinics were held in different locations for these contacts and others. Seven persons refused postexposure vaccination and were placed under quarantine, and some of these persons required the intervention of law-enforcement authorities. The other secondary case patient of measles had made 4 visits to 3 clinics during the infectious period. All potentially exposed medical staff and patients were contacted to assess measles immunity by using standards of the Advisory Committee on Immunization Practices criteria (adequate vaccination with measles-containing vaccine, laboratory proof of immunity, birth before 1957, or documentation of physician-diagnosed measles).[11] Laboratory testing for immunity was performed at the Public Health Laboratory for Iowa using the Zeus Scientific enzyme-linked immunosorbent assay IgG for measles. Those lacking evidence of immunity were offered vaccination at a special vaccination clinic. Two exposed, susceptible health care workers did not receive postexposure vaccination within the recommended time period and were placed into voluntary home quarantine for 2 weeks.

Personnel Time/Materials

Approximately 2500 hours of personnel time were expended, of which ~60% was devoted to emergency response, with approximately half incurred by the IDPH (Table 1). The temporal distribution of personnel time was characterized by marked peaks when the 2 secondary cases were reported, with subsequent smaller peaks at report of other rash illnesses for which measles was subsequently ruled out (Fig 1).

Costs

The total estimated cost was $ 142 452, of which 75% was attributable to personnel costs and overhead, with the IDPH incurring 64% (Table 1).

DISCUSSION

The direct cost of an individual case of measles has been estimated to range from $70 (no complications) to $30 000 (encephalitis), with an expected cost of $704.[12] In this outbreak, the single primary patient and the 2 secondary case patients experienced no known complications; thus, the direct costs attributable to their illnesses may have been <$500. Our study suggests that the costs to the Iowa public health infrastructure of preventing the spread of disease from these cases were >$140 000. This figure is an underestimate. We did not evaluate private-sector costs (eg, physicians and hospitals increasing disease surveillance and vaccination activity), costs outside of health institutions (eg, school, police), indirect costs (eg, impact on other public health programs in Iowa by diversion of resources into measles containment), or any costs outside Iowa (eg, other states contacting exposed passengers and setting up vaccination clinics, quarantine stations, airlines providing manifests and interacting with health authorities, Centers for Disease Control and Prevention staff time).

On the other hand, containment efforts would have been easier if high rates of vaccine acceptance had been present in the local community. Additionally, Iowa does not currently have a prematriculation vaccination requirement for college attendance. States enforcing such requirements have historically had lower rates of measles outbreaks in colleges.[13] Vaccinations were administered to persons already needing vaccinations and thus may not ultimately represent incremental costs. Public-sector–containment costs cannot be translated directly into in-

TABLE 1. Estimated Costs of Personnel Time and Materials Used During the March 2004 Measles Outbreak Response in Iowa

	Institution						
	IDPH	Linn County	Jefferson County	Johnson County	University of Iowa Hospitals/Clinics	Public Health Laboratory for Iowa	Total
Personnel time per activity, h*							
Investigation	327.3	30.7	9.3	241.7	27.0	115.0	750.9
Emergency response	840.0	127.9	80.0	329.5	202.0	—	1579.5
Other	59.0	32.2	—	—	—	33.0	124.2
Total hours†	1226.3	190.8	89.5	571.3	299.0	148.0	2524.8
Materials, *n*							
Phone calls	1700.0	—	45.0	—	280.0	—	2025.0
Measles-mumps-rubella vaccine, doses‡	1550.0	33.0	33.0	32.0	—	—	1550.0
Immunoglobulin, doses‡	450.0	80.0	—	19.0	—	—	450.0
Miles	2173.0	70.0	—	—	—	—	2243.0
Estimated costs, $							
Personnel (costs, wages, and fringe benefits)§	46 185.1	6506.6	1772.7	17 646.7	8561.1	4620.0	85 292.2
Overhead costs§	15 125.0	1500.0		2738.8	—	2171.4	21 535.2
Public information‖	858.0	13.3	440.0	—	—	—	1311.3
Measles-mumps-rubella vaccine and immunoglobulin¶	28 963.5	—	—	—	—	—	28 963.5
Others	—		89.6	143.5	—	4501.0	4734.1
Miles#	595.8	20.3	—	—	—	—	616.1
Total costs, $	91 727.4	8040.2	2302.4	20 528.9	8561.1	11 292.4	142 452.4

* Activities included in "investigation": tracking of cases, case interview, contact notification, and screening of suspected cases; activities included in "emergency response": information to the public, treatment of cases, prophylaxis of contacts, enhanced surveillance, isolation/quarantine, and follow-up.
† The total number of hours includes business and nonbusiness hours (ie, during weekends or evenings) allocated by the personnel.
‡ The number of doses of measles-mumps-rubella vaccine and immunoglobulin reported by the counties used during the outbreak is taken from the total number of doses deployed by IDPH to these and other counties during the outbreak response (1550 doses of measles-mumps-rubella and 450 vials of immunoglobulins).
§ Fringe benefits and overhead costs were included when reported or calculated following the specific accounting method of each involved institution.
‖ Public-information costs include the IDPH toll-free phone line, press releases and conferences, and other communication expenses when reported.
¶ The unitary costs used are $15.99 for 1 dose of measles-mumps-rubella vaccine and $23.50 for 1 dose of immunoglobulin.
# Mile costs were calculated by multiplying $0.29 (as IDPH) by the total number of miles.

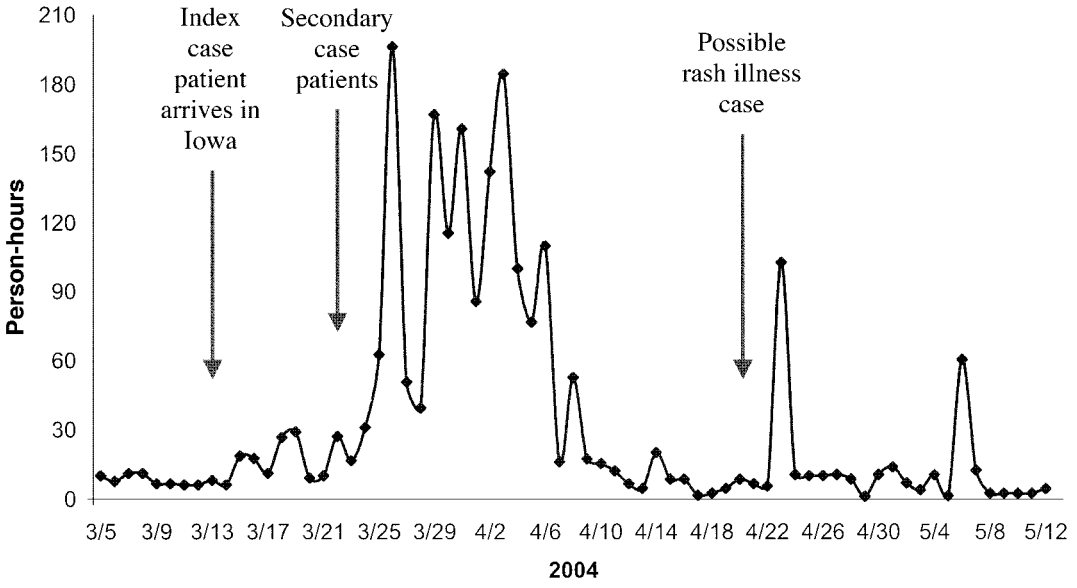

Fig 1. Person-hours per day used during March–May 2004: Iowa measles outbreak response.

creased demands on public funds, because most personnel time was salaried at a fixed level.

Large community outbreaks have been associated with low rates of measles vaccination in countries such as the United Kingdom,[14,15] Ireland,[16,17] and Italy.[18] Measles outbreaks in communities with low vaccination coverage due to exemptions have been described previously.[19,20] However, the costs of containing a community-wide outbreak can easily run into the millions of dollars even in the absence of

vaccine refusal.[21] Using an expected cost of $704 per measles case, the containment efforts would have been cost-saving if they had prevented an outbreak of ~200 measles cases. Because ~40% of the local community was unvaccinated, an outbreak of as many as 1000 cases might have occurred.

The results of our analysis also raise some health-care issues that should be considered by primary care providers in the United States: (1) the importance of knowledge of immunization rates and segments of the undervaccinated population in the community that they serve; (2) the necessity of a travel-history assessment to detect diseases that are not common in the United States; and (3) the value of early diagnosis and reporting to the public health authorities of vaccine-preventable diseases that may now be uncommon because of effective implementation of vaccination programs.

The vigorous containment efforts developed during this outbreak were probably cost-saving and may have been life-saving. The containment costs of 1 measles case in this outbreak were high. Such costs are more likely to be evident in countries that are close to measles elimination, because the direct disease costs may be minimal. However, containment costs are rarely included in economic decision analyses, in part because these costs may be difficult to assign to an individual. Our study suggests that such analyses may need to go beyond the costs of individual illness to account for the costs of protecting society, particularly when countries are close to elimination.

ACKNOWLEDGMENTS

The Iowa Measles Response Team consists of the following members. Johnson County Department of Public Health: Kathryn "Kot" Flora, Annette Scheib, Meghan Harris, and Ralph Wilmoth; Jefferson County Public Health: Vickie McKeever, Sue Robinson, Linda Sharp, Peggy Hickenbottom, and Gary Roth; Linn County Public Health: Marty Ralston, Tom Hart, John Erceg, and Vickie Smith; University of Iowa Hospitals and Clinics: Loreen A. Herwaldt, Jean Pottinger, Sherry David, Stacy Coffman, Sandy Von Behren, Stephanie Holley, Sheri Swartzendruber, Todd Wiblin, Daniel Diekema, Charles Helms, Phil Polgreen, and Melissa Ward; Iowa Department of Public Health: Dawn Hughes, Chris Taylor, Elizabeth Miller, Josh Yoakam, Judy Goddard, Mary Rexroat, Pam Deichmann, Mary Jones, Sarah Brend, Tricia Kitzman, Jim Goodrich, Don Callahan, and Teri Thornton; Iowa Attorney General's Office: Heather Adams; and University Hygienic Laboratory: Lucy DesJardin and Tom Gahan.

We thank Dr Terri Hyde for collaboration in this study.

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DOI: 10.1542/peds.2004-2512

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