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An outbreak investigation identified 15 pertussis cases among 5 infants and 10 healthcare professionals at 1 hospital’s neonatal intensive care unit (NICU). The cost of the outbreak to this hospital was $97 745. Heightened awareness of pertussis in NICUs is key to preventing healthcare-associated spread and minimizing outbreak-control-related costs. *Bordetella pertussis* is a highly communicable bacterial pathogen that causes a prolonged cough illness and is spread by respiratory droplet transmission. Infants aged ≤6 months are most susceptible to *B pertussis* infection and pertussis-associated complications, including pneumonia, encephalopathy, and death, and are commonly hospitalized for treatment [1]. Despite a universal pertussis vaccination program, 27 550 pertussis cases were reported in the United States during 2010 [2]. Pertussis outbreaks in healthcare settings can be challenging and costly to control [3]. On September 13, 2011 and September 15, 2011, 3 pertussis cases, including 2 confirmed by *B pertussis* isolation, among preterm infants discharged ≤30 days previously from a 71-bed NICU of a general hospital (NICU A) were reported by Hospital B, a large pediatric facility, to Maricopa County Department of Public Health. This report describes the outbreak, examines outbreak-associated costs and risk factors that might have contributed to healthcare-associated transmission, and provides guidance to prevent outbreaks in healthcare settings.

Key words. Pertussis; Disease Outbreak; Healthcare Worker-Patient Transmission; Infants; Neonates

METHODS

Case Investigation and Outbreak Response

Hospital A called the pediatricians of 40 exposed infants requesting that they inform parents of their infant’s exposure to pertussis in the neonatal intensive care unit of a general hospital (NICU A). Hospital A and the Maricopa County Department of Public Health sent a letter to these parents of exposed infants informing them of pertussis exposure, signs, and symptoms. Case-finding was performed using a standardized telephone questionnaire administered to NICU A healthcare providers (HCPs), who were furloughed from work because of cough illness, and to parents of exposed infants. A probable case was defined as cough illness for ≥14 days in a person associated with NICU A from July 28, 2011 to September 19, 2011. A confirmed case met the probable case definition and was laboratory-confirmed by (1) a positive polymerase chain reaction (PCR) result for...
Bordetella pertussis DNA, (2) isolation of B pertussis, or (3) epidemiologic linkage to a laboratory-confirmed case. We reviewed records of infants with pertussis in NICU A, assessed the infant’s age at the time of cough or apnea onset, investigated potential sources of transmission, and mapped case locations. This study underwent review by the Centers for Disease Control and Prevention’s (CDC) Scientific Education and Professional Development Program Office.

Hospital Costs
We assessed Hospital A costs (tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis [Tdap] booster vaccine, vaccine administration, postexposure prophylaxis [PEP], and laboratory and labor costs) incurred in controlling the outbreak. Cost of Tdap vaccine ($29/dose) and administration ($10/administration) for HCPs were obtained from the CDC. The hospital acquisition price for PEP ($13.16 for azithromycin; $9 for trimethoprim-sulfamethoxazole) was used. HCP furlough costs were calculated by multiplying the number of days in furlough, the number of HCPs furloughed, and a normal work shift (8 hours/day) by mean hourly earnings for full-time Arizona hospital HCPs ($35.48) [4]. Costs incurred by other institutions were not included.

RESULTS

Descriptive Epidemiology
Forty infants were hospitalized in NICU A from July 28, 2011 to September 19, 2011; parents of 35 of these infants (88%) were interviewed. Of 39 NICU A HCPs furloughed for cough illness, 35 (90%) were interviewed. We identified 15 pertussis cases including 5 infants (Table 1) and 10 NICU A HCPs. Three cases were laboratory-confirmed at HealthCare Clinical Laboratories (Stockton, CA) by PCR or isolation by culture. The remaining 12 cases were confirmed with compatible clinical findings and by epidemiologic linkage to NICU A.

Exposure and Contact Investigations
The index case occurred in a 4-week-old female who had been born at 28 weeks gestation and resided at NICU A. The index patient’s illness was confirmed after transfer to Hospital B on September 9, 2011 when a nasopharyngeal swab collected on September 14, 2011 was positive by pertussis PCR; B pertussis was isolated by culture 1 week later. The index patient received azithromycin on September 14, 2011 (32 days after cough onset, and 49 days after apnea onset). Diagnosis of Patients 2–5 were similarly delayed (Table 1). Patient 4’s sibling also had pertussis symptoms from August 4, 2011 to August 19, 2011 and visited Patient 4 in NICU A while ill. Ten HCPs at NICU A had an illness that met the pertussis case definition (age range: 32–50 years; median age 39.5 years; 6 [60%] female); all worked during cough illness.

Site Visit and Location Mapping
Two of 8 sinks in the area where the index patient and Patients 2 and 3 had been located were obstructed by carts and trash cans. Infants were routinely moved within the unit, and infant location had not been accurately recorded. Hospital policy requiring HCPs with acute respiratory illness to take personal leave had not been enforced. NICU visitors were not screened for cough illness before entry, and no signage was posted requesting ill visitors to refrain from entering NICU A.

Costs to Hospital A
Thirty-nine NICU A HCPs had been furloughed due to cough illness for 5 days ($55,349). Three hundred sixty-five HCPs and 40 infants received PEP ($5297) and underwent laboratory testing for pertussis ($7420); 330 HCPs required pertussis vaccine ($12,870). Hospital A staff worked an additional 455 hours on outbreak management ($16,809). The approximate total outbreak cost to Hospital A was $97,745, excluding the costs incurred by Hospital B and state and local health departments. HCP furloughs constituted 57% of this cost.

DISCUSSION
This healthcare-associated pertussis outbreak with 15 identified cases cost 1 hospital approximately $100,000. Forty infants hospitalized in a NICU were exposed to pertussis and required PEP. This investigation adds to prior work documenting costs incurred by hospitals responding to pertussis outbreaks and the ease with which pertussis can be transmitted within the healthcare setting [3, 5, 11]. In 2 Washington outbreaks, the hospital cost per case ranged from $30,282 to $43,893 [6], which is considerably more than the approximately $6500 per case associated with NICU A.

Multiple factors contributed to this healthcare-associated pertussis outbreak. First, delays occurred in diagnosis and isolation of cases. Delayed diagnosis of
infections has been identified as one of the most important factors in prolonged healthcare-associated outbreaks [7]. Second, infants were located in close proximity to one another and shared the same nurse when 1 infant was infectious. Third, HCPs worked during cough illness, and fourth, visitors entered the NICU when ill. Previous pertussis outbreaks have been attributed to cough illness among hospital visitors [8]; however, after outbreaks in high-risk settings (eg, nurseries), visitor screening for cough has been successfully implemented to prevent infants’ exposure. Limiting staff and visitor access to high-risk areas and discouraging parents from having contact with infants other than their own infant are additional strategies to be considered [9].

Lack of HCP pertussis vaccination documentation contributed to costs associated with this outbreak. HCP vaccination can protect against pertussis and thereby reduce spread and costs associated with pertussis outbreak management [3]. The Advisory Committee on Immunization Practices recommends the Tdap booster vaccine be administered to HCPs, and recorded, especially for HCPs working with infants aged ≤12 months, because of the increased risk for acquiring pertussis in the healthcare setting and potential for transmitting pertussis to high-risk patients [10].

One limitation of this study was an underestimation of outbreak-related costs because costs related to liability or increased duration of hospitalization were not included. First, costs incurred by state and local health departments, private and public insurance, another receiving hospital, or indirect costs borne by patients and families were not included. Second, we were unable to interview and apply the case definition to NICU A visitors because visitor information was not documented by the hospital. Third, the primary mode of healthcare-associated transmission during this outbreak could not be discerned because of poorly defined pertussis symptom onset, especially among HCPs. Transmission might have included patient-to-HCP, patient-to-patient, patient-to-visitor, and HCP-to-patient transmission. Although infants usually do not have a strong enough cough to reach other patients, the close proximity of neonates in NICU A, especially when being handled by HCPs during feeding, increases the possibility of patient-to-patient spread in this outbreak. Regardless of how the index patient became infected, our data indicate that transmission to ≥2 other infants occurred in NICU A.

This costly healthcare-associated pertussis outbreak might have been precipitated by the lack of strategies needed to prevent the spread of vaccine-preventable diseases to vulnerable populations in medical settings, including: (1) increasing pertussis awareness among providers, especially among patient populations who present with apnea (eg, infants); (2) convenient access and documenting of pertussis vaccine for HCPs; (3) allowing only HCPs with evidence of pertussis booster vaccine to provide care to infants aged ≤6 months; and (4) screening visitors for cough illness upon entry to the NICU [9, 12], and instituting a screening plan to identify suspected pertussis cases for immediate isolation.

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References


Table 1. Characteristics of Pertussis Cases in Infants Associated With NICU A, 2011a

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (weeks)</th>
<th>Comorbidities</th>
<th>Date of Pertussis Cough/Apnea Onset (age in weeks)</th>
<th>Length of NICU A Admission (days)</th>
<th>Pertussis Test Date (days post-cough/apnea onset)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28</td>
<td>LBW</td>
<td>July 28 (4)</td>
<td>77</td>
<td>September 14 (49)</td>
</tr>
<tr>
<td>2</td>
<td>28</td>
<td>LBW, trachea-esophageal fistula, PDA</td>
<td>August 24 (12)</td>
<td>91</td>
<td>September 7 (15)</td>
</tr>
<tr>
<td>3</td>
<td>39</td>
<td>Hydrocephalus</td>
<td>August 19 (15)</td>
<td>109</td>
<td>August 25 (7)</td>
</tr>
<tr>
<td>4</td>
<td>28</td>
<td>LBW</td>
<td>September 19 (4)</td>
<td>10</td>
<td>September 30 (12)</td>
</tr>
<tr>
<td>5</td>
<td>28</td>
<td>LBW</td>
<td>(4)</td>
<td>77</td>
<td>(15)</td>
</tr>
<tr>
<td>Median value</td>
<td>28</td>
<td></td>
<td>(4)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: LBW, low birth weight; NICU, neonatal intensive care unit; PDA, patent ductus arteriosus.

*All infant case-patients were female.*


