SUPPLEMENT ARTICLE

Transmission of Pandemic (H1N1) 2009 Influenza to Healthcare Personnel in the United States

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After identification of pandemic 2009 influenza (pH1N1) in the United States, the Centers for Disease Control and Prevention (CDC) worked with state and local health officials to characterize infections among healthcare personnel (HCP). Detailed information, including likely routes of exposure, was reported for 70 HCP from 22 states. Thirty-five cases (50%) were classified as being infected in healthcare settings, 18 cases (26%) were considered to have been infected in community settings, and no definitive source was identified for 17 cases (24%). Of the 23 HCP infected by ill patients, only 20% reported using an N95 respirator or surgical mask during all encounters and more than half worked in outpatient clinics. In addition to community transmission, likely patient-to-HCP and HCP-to-HCP transmission were identified in healthcare settings, highlighting the need for comprehensive infection control strategies including administration of influenza vaccine, appropriate management of ill HCP, and adherence to infection control precautions.

More than 13 million people are employed in healthcare settings in the United States, representing 9% of the workforce [1], and healthcare personnel (HCP) are considered by the Occupational Safety and Health Administration to be at high risk for exposure to novel influenza viruses during a pandemic [2]. Respiratory infections, including those caused by seasonal influenza viruses, can spread rapidly in healthcare settings, leading to reported attack rates as high as 59% among HCP in local outbreaks [3–8].

Protecting HCP is critical to maintaining healthcare delivery capacity during a pandemic and is an important component of any pandemic influenza response plan. Although vaccination is the most effective means of controlling influenza transmission in healthcare settings, implementation of respiratory hygiene and cough etiquette, appropriate management of ill HCP, adherence to infection control precautions, and implementing environmental and engineering infection control measures are also components of a comprehensive infection control strategy [9].

Pandemic (H1N1) 2009 influenza virus (pH1N1) was first identified in mid-April 2009; during the spring of 2009, more than 40,000 confirmed or probable cases and more than 300 deaths were reported to the Centers for Disease Control and Prevention (CDC) [10]. Concerns about potential transmission of pH1N1 infections to HCP and uncertainty about virulence prompted the CDC to make interim infection control recommendations for the use of Standard and Contact

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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Precautions [11] plus eye protection and a fit-tested disposable N95 respirator by HCP when caring for patients with confirmed, probable, or suspected pH1N1 infection [12]. To help inform the evolving national response to this pandemic, CDC and state and local health officials monitored pH1N1 infections among HCP from 4 May to 1 June 2009 [12]. This report includes all cases of pH1N1 infection among HCP in the United States that were reported to the CDC during the early part of the outbreak, quantifies the number of these infections, identifies settings and circumstances under which infections occurred, characterizes PPE use by HCP, and describes outcomes among infected HCP.

METHODS

Data Collection and Case Definition

After identification of the first two persons infected with pH1N1 in the United States in April 2009, CDC requested that all state and local health departments implement enhanced surveillance for infections caused by unsubtypable influenza A viruses [13]. On 4 May, CDC requested that states also report pH1N1 infections occurring among HCP. For this investigation, we defined a case as a confirmed or probable pH1N1 infection diagnosed from 15 April to 1 June 2009 in a full- or part-time clinician, contractor, student, volunteer, or other employee who reported job activities involving contact with patients in an inpatient, outpatient, or long-term care setting. We defined a confirmed case of pH1N1 infection as a person with influenza-like illness (ILI) (ie, fever with cough or sore throat) with laboratory-confirmed pH1N1 infection by real-time reverse-transcription polymerase chain reaction (RT-PCR) and/or viral culture [14]. We defined a probable case of pH1N1 infection as a person with ILI who tested positive for influenza A but negative for human H1 and H3 by influenza RT-PCR [14].

We asked health departments to complete a case report form for each infected HCP. This instrument included questions on job category; facility type; contact with patients with confirmed or probable pH1N1 infection or other respiratory illness (ie, pneumonia, upper respiratory tract infections, or ILI); PPE use (ie, gloves, gowns, surgical masks, N95 respirators, and goggles or face shields); and other possible exposures to persons with pH1N1 infection or respiratory illness, including family members, close contacts, and coworkers. To minimize the burden on state and local health departments, detailed reports were actively sought only through 15 May 2009, although reports continued until 1 June 2009.

Transmission Definitions

Based on exposures reported to have occurred between 12 h and 7 days before symptom onset, we placed cases into 6 categories according to their most likely manner of pH1N1 acquisition. Cases with *probable patient-to-HCP transmission* included HCP with exposures (within 6 feet) to patients with confirmed or probable pH1N1 virus infection without report of surgical mask or N95 respirator use. *Possible patient-to-HCP transmission* included HCP with either exposure to patients with known pH1N1 infection while using a surgical mask or N95 respirator or exposure to patients with other respiratory illness (ie, pneumonia, upper respiratory tract infections, or ILI) regardless of respiratory PPE use. *Probable HCP-to-HCP transmission* was defined as exposure (within 6 feet) to a coworker with pH1N1 infection, and *possible HCP-to-HCP transmission* was defined as exposure (within 6 feet) to a coworker with other respiratory illness. *Probable community transmission* included both HCP exposed (within 6 feet) to persons with pH1N1 infection outside the healthcare setting and HCP having no contacts in healthcare settings in the week prior to symptom onset (ie, did not go to work that week). *Possible community transmission* was defined as either HCP exposure to persons with respiratory illness outside a healthcare setting or HCP travel to Mexico prior to 1 May 2009. Although PPE use affected the level of certainty assigned for patient-to-HCP transmission (probable or possible), it was not used to distinguish between acquisition attributed to community versus healthcare settings. Given the small number or cases and method of data collection, use of N95 respirators and surgical masks by HCP are generally not reported separately in this manuscript. This was done to facilitate analysis and is not meant to imply equivalence between masks and respirators in preventing influenza transmission.

Some HCP reported more than 1 potential acquisition source. When HCP reported both probable and possible sources, they were classified as having been infected through the probable source. This happened 4 times: 3 instances of both unprotected exposure to a pH1N1 patient and community exposure to someone with respiratory illness and 1 instance of both exposure to a pH1N1-infected coworker and community exposure to someone with respiratory illness. HCP reporting multiple possible sources were reported as such; no determination of the most likely possible source was made. No HCP reported multiple probable exposure sources.

Analysis

Data entry was performed using Microsoft Access 2003 (Microsoft Corp), and analysis was performed using SAS software, version 9.1.3 (SAS Institute Inc).

Ethical Review

The activities involved in this investigation constituted a public health response to an emerging problem and were not considered research; thus, they were not subject to review by a CDC institutional review board.

RESULTS

Eighty-one cases were reported to the CDC from 25 states from 4 May to 1 June 2009. Detailed exposure information was obtained for 70 cases (60 confirmed and 10 probable) from 22 states; 19 cases were reported from a single healthcare facility. Most cases were among non-Hispanic white women (47%) and the mean age of infected HCP was 38 years (Table 1). Dates of illness onset ranged from 17 April through 26 May 2009 (Figure 1). More than half of cases were registered nurses (20%), physicians (19%), or nursing assistants (13%) (Table 1). Thirty-seven cases (53%) reported working in inpatient acute care facilities, 25 (36%) in outpatient clinics, 10 (14%) in emergency departments (ED), and 6 (9%) in long-term care settings (Table 1). Forty-six cases (66%) reported working in a single healthcare setting, whereas 17 (24%) reported working in multiple healthcare settings in the week prior to symptom onset. Seven cases (10%) did not work in a healthcare setting in the week before illness onset (Table 2). Seasonal influenza vaccination coverage was 62%, and over two-thirds of cases reported ever having been fit-tested for an N95 respirator (Table 1). Two infected HCP (3%) were hospitalized for influenza illness, one of whom reported having underlying medical conditions. Neither hospitalized HCP was admitted to an intensive care unit and neither died. Cases missed a mean of 1 week of work due to their illness (range, 1-14 days).

Thirty-five cases (50%) were considered to have been infected in a healthcare setting (23 probable or possible patient-to-HCP transmission, 10 probable or possible HCP-to-HCP transmission, and 2 with multiple possible sources that were both in a healthcare setting) (Table 2). Community transmission was deemed most likely for 18 cases (26%). Three cases (4%) had both possible community and healthcare sources of acquisition and 14 (20%) had no known reported exposures (Table 2).

Occupations for the 10 instances of HCP-to-HCP transmission included 3 physicians (30%), 2 registered nurses (20%), 1 nursing assistant, 1 intake coordinator, 1 medical assistant student, 1 pharmacist, and 1 patient relations staff member; overall 3 were considered to have non-clinical care occupations. Eight HCP-to-HCP cases (80%) reported working in inpatient settings, 3 (30%) in outpatient clinics, and 2 (20%) in EDs. Three cases reported working in multiple settings in the week before illness onset.

Occupations for the 23 instances of probable and possible patient-to-HCP transmission included 7 nursing assistants or licensed practical nurses (30%), 5 physicians (22%), 3 registered nurses (13%), 3 physician assistants or nurse practitioners (13%), an echocardiography technician, a radiology technician, a medical assistant, a nurse anesthetist, and an occupational therapist; all 23 cases were considered clinical care personnel. Thirteen cases (57%) reported working in outpatient clinics, 12 (52%) in inpatient settings, 3 (13%) in EDs, and 2 (9%) in long-term care. Eight cases reported working in multiple settings the week before illness onset.

Fourteen infected HCP (20%) reported non-clinical care occupations, including a direct service employee, front office manager, guest relations employee, intake coordinator, nurse manager, nursing director, pharmacist, pharmacy technician, receptionist, and a patient transport technician (Table 1). Of these, 4 were considered infected by community sources and 3 through HCP-to-HCP transmission. One had multiple possible healthcare sources of infection (exposure to both a patient and HCP with respiratory illness) and a source could not be identified for 6.

Of the 23 cases with probable or possible patient-to-HCP acquisition, 20 provided at least some information on use of PPE when caring for the potential source patient (Table 3). None of these 20 cases reported always using all PPE components recommended in CDC's April 2009 interim infection control guidance [12]. Only 40% of cases with probable or possible patient-to-HCP acquisition reported always using gloves and few reported even occasional use of gowns and eye protection (Table 3).

Four cases with probable or possible patient-to-HCP acquisition (20%) reported always using either a surgical mask or N95 respirator during all encounters with potentially infectious patients. One physician working in an employee health clinic reported always using an N95 respirator while interacting with the presumed source patient with respiratory illness but also reported never being N95 fit-tested. Information on this physician's use of gown and eye protection use was missing. One certified registered nurse anesthetist (CRNA) reported always using gloves and a surgical mask when interacting with a presumed source patient with respiratory illness. This CRNA also reported sometimes using a gown, eye protection, and an N95 respirator and reported previously being fit-tested. One registered nurse working on an adult critical care unit cared for a patient who was on Droplet Precautions during the entire time the nurse provided care. The nurse reported always using a surgical mask and gloves when interacting with this patient but never using a gown, eye protection, or N95 respirator. The nurse was not present for any aerosol-generating procedures. An echocardiography technician in an inpatient adult ward cared for a patient with respiratory illness and reported always using either a fit-tested N95 respirator or surgical mask, as well as gloves and a gown for all patient interactions. No information was provided on the use of eye protection. Three additional cases reported wearing an N95 respirator or surgical mask during contact with patients with pH1N1 infection or respiratory illness, but also reported other possible exposure sources.

DISCUSSION

Half of reported HCP with pH1N1 infection were classified as probably or possibly having acquired infection in a healthcare

Table 1. Demographic Characteristics, Job Types, Healthcare Settings, and Occupational Health Measures of Healthcare Personnel with Confirmed or Probable pH1N1 Infection

Characteristic	Frequency
Demographic characteristics	
Sex (*n*=68)	
Female	52 (76)
Male	16 (24)
Age, years (*n*=63)	
Mean	38
Range	21–64
Race/Ethnicity (*n*=57)	
White, non-Hispanic	35 (61)
Asian/Pacific Islander	11 (19)
Hispanic	8 (14)
Black, non-Hispanic	2 (4)
Other	1 (2)
Occupational characteristics	
Job title (n=69)	
Registered nurse	14 (20)
Physician	13 (19)
Nursing assistant	9 (13)
Receptionist, intake coordinator, front office manager, or patient relations	6 (9)
Nurse manager/director	4 (6)
Physician assistant/nurse practitioner	4 (6)
Echocardiography, radiology, or clinical technician	4 (6)
Licensed practical nurse	3 (4)
Physical or occupational therapist	2 (3)
Pharmacist/pharmacy technician	2 (3)
Student	2 (3)
Other job types[a]	6 (9)
Clinical care duties (*n*=69)	
Clinical care occupation	55(80)
Non-clinical care occupation[b]	14 (20)
Work setting (*n*=70)[c]	
Acute inpatient care facility	37 (53)
Outpatient clinic	25 (36)
Emergency room	10 (14)
Long-term care facility/LTAC	6 (9)
Other healthcare setting	4 (6)
None reported in 7 days prior to onset	7 (10)
Occupational health measures	
Influenza vaccine since September 2008 (*n*=55)	
Vaccinated	34 (62)
Not Vaccinated	21 (38)
N95 respirator fit testing among HCP with clinical care duties (*n*=48)	
Ever fit tested	33 (69)
Never fit tested	15 (31)

NOTE. Data are no. (%) of participants, unless otherwise indicated.

[a] Orthodontic clinical assistant, direct service employee, emergency medical technician, medical assistant, nurse anesthetist, and transport.

[b] Non-clinical care occupations included direct service employee, front office manager, guest relations, intake coordinator, nurse manager, nursing director, pharmacist, pharmacy technician, receptionist, and transport. All others were considered clinical care occupations.

[c] HCP can report working in multiple settings in the 7 days prior to onset.

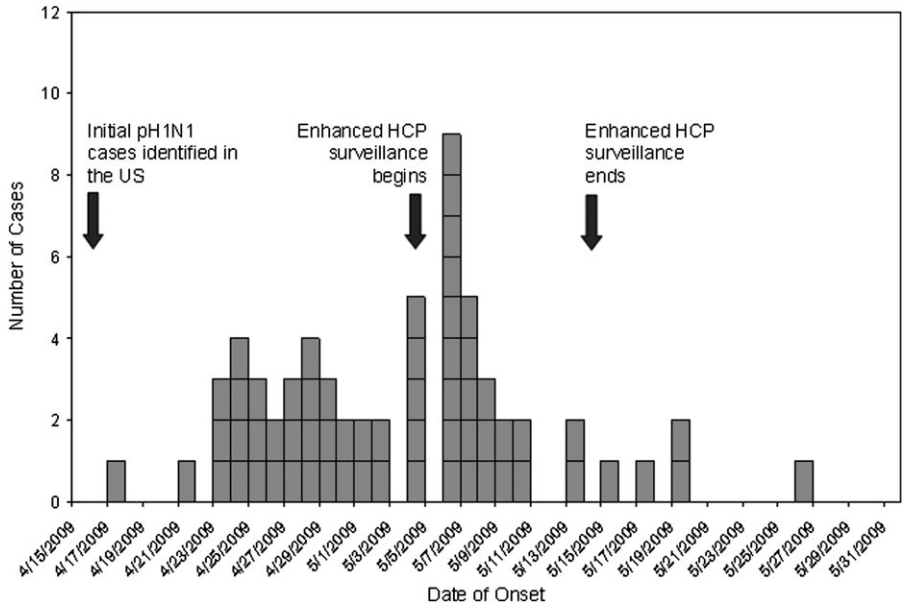

Figure 1. Probable and confirmed pH1N1 infections among healthcare personnel reported to Centers for Disease Control and Prevention (CDC) by date of symptom onset, 17 April 2009 to 26 May 2009 ($n = 63$).

setting from either ill patients or coworkers. In addition, one-quarter were likely exposed in the community and one-quarter had multiple or unknown potential sources of infection. Among HCP classified as having transmission in healthcare settings, infections were not limited to HCP working in inpatient settings.

Overall, few cases with patient-to-HCP acquisition reported always wearing an N95 respirator or surgical mask when caring for potentially infectious patients and none fully implemented CDC's April 2009 infection control guidance for care of patients with pH1N1 infection. Although no data were collected on why recommendations were not followed, low adherence has been documented among HCP for PPE recommendations for prevention of transmission of influenza as well as other infections [15–17]. Anecdotal evidence from the current study suggests that late recognition of potentially infectious patients and lack of availability of N95 respirators may have been barriers to full implementation of infection control recommendations. Although not explicitly noted in case reports, other barriers to adherence may have included a belief that these practices are unnecessary or disruptive, inadequate infection control training, and lack of a strong culture of safety in the workplace. Although some transmission described in this report occurred before CDC's interim recommendations were first issued on 24 April 2009, the CDC has had longstanding recommendations for the use of Standard plus Droplet Precautions to prevent transmission of seasonal influenza in healthcare settings; yet adherence to even these standards was low among HCP infected through patient-to-HCP transmission [18].

Although the level of PPE required for care of patients with pH1N1 has been the subject of debate, a substantial amount of transmission appears to have occurred in situations where PPE is not generally recommended and may be less feasible (eg, exposure to ill coworkers). This highlights the need for comprehensive influenza infection control strategies. CDC recommends the use of a multi-faceted approach to prevent transmission of influenza in healthcare settings, including administration of influenza vaccine, implementation of respiratory hygiene and cough etiquette, appropriate management of ill HCP, adherence to infection control precautions for all patient-care activities and aerosol-generating procedures, and implementing environmental and engineering infection control measures [9].

A higher proportion of HCP in this analysis appear to have been infected through HCP-to-HCP transmission than in an earlier report [12]. This is due largely to 8 instances of apparent HCP-to-HCP transmission reported from a single acute inpatient care facility. Nonetheless, results from a previous study showed that HCP may be reluctant to take leave when ill, leading to opportunities for influenza transmission to patients and their coworkers [19]. These results highlight the need for appropriate and nonpunitive sick leave policies and prompt identification and exclusion of ill HCP from work.

It is important that outpatient healthcare settings have mechanisms in place to minimize the risk for transmission of influenza. From May to June 2009, only 1082 hospitalizations for pH1N1 infection were reported to the CDC [20] out of an estimated 1 million persons infected during that time [10]. It is likely that many persons who interfaced with the healthcare

Table 2. Exposure Routes and Personal Protective Equipment Use among Confirmed and Probable Cases of pH1N1 Infection among Healthcare Personnel

Characteristic	Frequency
Reported exposures in the week before symptom onset (n=70)[a]	
Cared for a patient with respiratory symptoms (pH1N1 status unknown)	20 (29)
Close/family contact with respiratory symptoms (pH1N1 status unknown)	10 (14)
Cared for a patient with pH1N1 infection, did not always use mask or N95	9 (13)
Coworker with pH1N1 infection	9 (13)
Travel to Mexico prior to May 1, 2009	7 (10)
Close/family contact with pH1N1 infection	7 (10)
Did not go to work in a healthcare setting	7 (10)
Cared for a patient with pH1N1 infection, always used mask or N95	3 (4)
Coworker with respiratory symptoms (pH1N1 status unknown)	3 (4)
Postulated exposure source	
Healthcare transmission	
Probable transmission from patient-to-HCP	9 (13)
Possible transmission from patient-to-HCP	14 (20)
Probable transmission from HCP-to-HCP[b]	9 (13)
Possible transmission from HCP-to-HCP	1 (1)
Multiple possible sources, healthcare only	2 (3)
Community transmission	
Probable transmission from a community source	14 (20)
Possible transmission from a community source	4 (6)
Other/Unknown Transmission	
Multiple possible sources, healthcare and community	3 (4)
Unknown source	14 (20)

NOTE. Data are no. (%) of participants, unless otherwise indicated.

[a] HCP can report multiple exposures in the 7 days prior to onset.

[b] 8 of 9 HCP were from the same healthcare facility.

Table 3. Use of Personal Protective Equipment during Interactions with the Presumed Source Patient for Providers with Probable or Possible Acquisition of pH1N1 Infection from a Patient

Use of personal protective equipment for HCP with possible or probable patient-to-HCP transmission	Frequency
Surgical masks (n=19)	
Always	3 (16)
Most of the time	2 (11)
Sometimes	5 (26)
Never	9 (47)
N95 respirators (n=20)	
Always[a]	2 (11)
Most of the time	0 (0)
Sometimes[b]	4 (20)
Never	14 (70)
Gloves (n=20)	
Always	8 (40)
Most of the time	1 (5)
Sometimes	4 (20)
Never	7 (35)
Gown (n=19)	
Always	1 (5)
Most of the time	1 (5)
Sometimes	4 (21)
Never	13 (68)
Eye protection (n=18)	
Always	0 (0)
Most of the time	0 (0)
Sometimes	2 (11)
Never	16 (89)

NOTE. Data are no. (%) of participants, unless otherwise indicated.

[a] One fit-tested, one not fit-tested.

[b] All fit-tested.

system for their symptoms did so in outpatient settings such as clinics and doctors' offices. As such, substantial opportunity for healthcare transmission of influenza to HCP may exist in outpatient settings. In this report, over half of HCP classified with likely patient-to-HCP acquisition reported working in outpatient clinics during the week preceding symptom onset. The CDC's current infection control recommendations for both inpatient and outpatient healthcare settings can be found in "Prevention Strategies for Seasonal Influenza in Healthcare Settings"[9].

The findings in this report are subject to several limitations. First, the total number of infected HCP is likely underreported. Some HCP may not have sought care for their symptoms, some states may not have collected the occupational information necessary to identify infected HCP, and cases continued to occur among HCP after the period during which case reports were actively sought. Second, some information pertinent to pH1N1 transmission was unavailable for analysis. Case report forms were not always fully completed, and data were not collected on some infection control practices (eg, elimination of potential exposures and engineering and administrative controls). Third, HCP may have failed to recognize or recall exposure to ill persons or may have been exposed to asymptomatic infected persons in healthcare or community settings, leading to potential misclassification of the most likely source of acquisition. Fourth, no conclusions can be made about general use of PPE when caring for H1N1 patients, as this case series only included those who developed pH1N1 infection. Finally, lack of adequate denominator data on the total number of HCP at risk of acquiring pH1N1 infection in the United States prevented us from calculating incidence rates and determining the relative burden of illness among HCP compared to the general population.

These results suggest that, in addition to community settings, HCP may be at risk for occupational acquisition of pH1N1 infection. The occurrence of cases in both inpatient and outpatient settings across a variety of healthcare occupations highlights the need for comprehensive infection control strategies to prevent transmission of influenza to both HCP and patients. Institutional strategies to protect HCP from influenza infection should include promotion of influenza vaccination for HCP, excluding ill HCP from work, implementing nonpunitive sick leave policies that encourage ill HCP to stay home, providing HCP with adequate infection control training and resources, provision of appropriate PPE with adequate training and an expectation of consistent use, and properly triaging potentially infectious patients [9]. Furthermore, institutions should also conduct periodic audits of their infection control practices that include review of performance measures and corrective actions to address deficiencies.

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