



Major article

Hospital respiratory protection practices in 6 U.S. states: A public health evaluation study



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Background: Lessons learned from the influenza A (H1N1) virus revealed a need to better understand hospitals' respiratory protection programmatic practice gaps. This article reports findings from a multistate assessment of hospitals' adherence to the Occupational Safety and Health Administration's respiratory protection program (RPP) requirements and the Centers for Disease Control and Prevention's infection control guidance.

Methods: Onsite surveys were conducted in 98 acute care hospitals in 6 U.S. states, including >1,500 hospital managers, unit managers, and health care workers. Descriptive statistics were used to assess hospital adherence.

Results: Most acute care hospitals adhere to requirements for initial medical evaluations, fit testing, training, and recommended respiratory protection when in close contact with patients who have suspected or confirmed seasonal influenza. Low hospital adherence was found for respiratory protection with infectious diseases requiring airborne precautions, aerosol-generating procedures with seasonal influenza, and checking of the respirator's user seal. Hospitals' adherence was also low with follow-up program evaluations, medical re-evaluations, and respirator maintenance.

Conclusion: Efforts should be made to closely examine ways of strengthening hospitals' RPPs to ensure the program's ongoing effectiveness and workers' proper selection and use of respiratory protection. Implications for improved RPPs and practice are discussed.

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Health care workers (HCWs) are exposed to many hazards and experience some of the highest rates of job-related injury and illness.¹ In 2012, registered nurses and nursing assistants were among the occupations with the highest rate of days away from

work because of work-related injuries and illnesses.² Infectious disease exposure is one of the many hazards encountered in the health care workplace. For instance, it has been reported that HCWs have a high risk of acquiring seasonal influenza and a high or very high risk of being exposed to pandemic influenza.^{3,4} To minimize the risk of infectious disease transmission, workers are expected to follow infection prevention precautions, including the appropriate use of personal protective equipment (PPE).^{5,6} However, marginal adherence to recommended precautions has been a well-documented and alarming trend.⁵ Previous studies have found HCWs' PPE usage, including respiratory protection, to be at sub-optimal levels.^{7–10} Common documented gaps in practice include improper use of respirators (eg, incorrect donning or doffing procedures) and failure to correctly use recommended types of respiratory protection.^{11–14}

During the 2009 influenza A (H1N1) pandemic, HCWs not only had an increased risk of influenza, but they were also among the most affected by the virus.^{15,16} For example, even though use of

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respiratory protection was found to have a protective effect against transmission of H1N1, 1 New York City hospital reported that for each patient with an influenza-like illness, approximately 5 unprotected HCWs were exposed during the first wave of the H1N1 pandemic.^{10,17}

Lessons learned from H1N1 yielded a mandate to better understand respiratory protection programmatic practice gaps to help inform influenza pandemic planning. In this context, the Institute of Medicine tasked the National Personal Protective Technology Laboratory (NPPTL) to conduct an evaluation of hospitals' respiratory protection programs (RPPs) and HCWs' respiratory protection practices to better understand gaps in RPPs and health care practice for targeted training and reinforcement initiatives.¹⁸ The NPPTL, which is part of the National Institute for Occupational Safety and Health (NIOSH), focuses on preventing work-related illness and death through PPE research, training, evaluation and certification.

An initial study conducted in 2010, the Respirator Use Evaluation in Acute Care California Hospitals (REACH I), focused on RPPs and practices in 16 California acute care facilities during the 2009–2010 H1N1 influenza pandemic. Findings from the REACH I study indicated that hospitals had implemented policies regarding the use of respirators and the Occupational Safety and Health Administration (OSHA) required programmatic elements related to medical evaluation, fit testing, and employee training. Nearly all interviewed HCWs stated that they would use respiratory protection when in close contact with patients suspected or confirmed with H1N1. However, there were gaps in hospitals' written RPPs, with program evaluation and designation of an RPP administrator as the most commonly missing elements. Deficiencies noted in a limited number of observations of HCWs included failure to perform a user seal check, incorrect doffing technique, and failure to perform hand hygiene after doffing the respirator.¹²

Following the REACH I study, the NPPTL collaborated with 5 independent study teams in 6 U.S. states to conduct a more comprehensive hospital evaluation called the Respirator Evaluation in Acute Care Hospitals (REACH II) study.

The purpose of the REACH II study was to expand data collection to more accurately capture how well acute care hospitals were implementing required elements of an RPP as detailed by the OSHA¹⁹ and HCWs adherence to the infection control recommendations of the Centers for Disease Control and Prevention (CDC).¹⁹ This article reports the key findings from the REACH II study and specifically answers the following questions:

1. To what extent do acute care hospitals implement the required elements of an RPP?
2. To what extent do HCWs follow usage recommendations for respiratory protection?

OSHA'S RPP REQUIREMENTS

The OSHA requires that employers establish and implement specific practices in workplaces where respirators are necessary to protect the health of employees.¹⁹ Employers are required to have a comprehensive, written RPP that documents policies and procedures related to medical evaluations, employee respirator fit testing, respirator selection, use of respirators, respirator maintenance, respirator inspection, employee training, and program evaluation. For example, employers must ensure that employees using a tight-fitting facepiece respirator pass a medical clearance, and a passage of a qualitative or quantitative fit test prior to initial use of the respirator in the workplace, at least annually thereafter and whenever a different respirator is used or there are changes to the employee's physical condition that could affect the respirator fit.

The OSHA also requires employers to provide training to employees prior to requiring the employee to use a respirator. Retraining is required annually thereafter or when there are changes in the workplace or the type of respirator that renders previous training obsolete; when there are inadequacies in the employee's knowledge or use of the respirator; or when any other situation arises in which retraining appears necessary to ensure safe respirator use.

Employers must inspect and maintain respirators and must conduct programmatic evaluations to ensure that the RPP is being properly and effectively implemented. To ensure that employees are using the respirators properly, employers must evaluate respirator fit, the respirator, respirator use, and respirator maintenance.

CDC'S RESPIRATORY PROTECTION GUIDELINES

After the 2009 H1N1 pandemic, the CDC updated its respiratory protection guidelines regarding seasonal influenza in health care settings.²⁰ The CDC recommends droplet precautions be implemented when entering the room of a patient with suspected or confirmed influenza; HCWs should don a surgical mask.

At the time of this survey, when performing aerosol-generating procedures, the CDC recommended that HCWs wear a fitted N95 filtering facepiece respirator (FFR), an equally protective respirator (eg, elastomeric half facepiece respirator [EHFR]), or a more protective respirator (eg, powered air purifying respirator [PAPR]).²⁰ An N95 FFR is an NIOSH-certified class of respiratory PPE that filters at least 95% of airborne particles, including biologic agents.

In addition to these influenza guidelines, the CDC's Healthcare Infection Control Practices Advisory Committee recommends the use of respiratory protection while in close contact with or while performing aerosol-generating procedures on a patient with suspected or confirmed infectious disease requiring airborne or droplet precautions: HCWs should use a respirator at least as protective as an N95 FFR with a patient who has a suspected or confirmed infectious disease requiring airborne precautions and use a surgical mask with a patient who has a suspected or confirmed disease requiring droplet precautions.⁵

METHODS

The REACH II study was based on data from a convenience sample of in-person surveys conducted on a staggered basis between January 2011 and June 2012 in acute care hospitals in 6 states across 5 regions of the United States: California, Illinois, Michigan, Minnesota, New York, and North Carolina. The study surveyed 3 target health care personnel (HCP) groups within each participating hospital: hospital managers (HMs), unit managers (UMs), and HCWs. In addition, structured observations were made of HCWs' respirator donning and doffing procedures. An independent research organization analyzed the survey data.

The information presented in this article is taken from a subset of the survey questions for which we were able to compare the resulting data with established respiratory protection guidance. It does not cover all the information collected in the REACH II evaluation. This research was approved by the institutional review board at each study team's state health department or university and by the NIOSH's Human Subjects Review Board.

Questionnaire design

Similar to the REACH I study, a structured questionnaire for each of the 3 target groups was used for data collection and consisted primarily of Likert-based response options. Based on field notes from the REACH I study, the study teams collaborated with the

NPPTL to refine the survey instruments and data collection methods. The 3 questionnaires included items about hospitals' implementation of the OSHA's required RPP elements, the CDC's recommended respiratory protection practices and the respondent's demographic background. The questionnaire items reported in this article are provided in [Appendices A and B](#). The criteria used to capture information from HCWs' demonstrations of respirator donning and doffing can be found in [Appendix C](#).⁶

Hospital recruitment

Each study team developed its own sampling method for hospital recruitment. Study teams randomly selected an initial list of hospitals to recruit based on factors such as hospital size (defined by the total number of beds), location (ie, rural, urban), and ownership type (ie, for-profit, nonprofit). However, this approach was later modified because of recruitment difficulties, and additional hospitals were obtained based on convenience sampling methods. Some study teams were sampled from a single city or region of the state; others were sampled from hospitals across the state. Study teams used a wide variety of methods for contacting potential hospital participants, including phone calls, mail, professional organization newsletters, and outreach at conferences. The investigators offered to share study results with the participating hospitals as an incentive.

Participant recruitment

At each participating hospital, interview participants were selected via targeted convenience sampling methods. For the HM survey, recruitment commonly focused on participants who were administratively responsible for the RPP at their hospital. For the UM and HCW survey, efforts were made to select participants that represented a range of hospital units, where respiratory protection was commonly used. One state offered participants lunch or snacks as an incentive to participate. For the observations of respirator use, HCWs were eligible to participate if they had previously been fit tested and had access to the model and size respirator for which they had been successfully fit tested and had completed the HCW survey.

Data collection procedures

Most of the interviews were conducted in person by trained study staff. Across all 3 respondent groups, interviews took approximately 20 minutes to complete and were generally conducted in a private area to protect confidentiality. Two states, however, allowed participants to complete the questionnaire and mail it back to research staff. One state conducted several of the HM interviews by phone. For the observations of respirator use, participants were asked to don and doff the respirator in the same manner in which they normally would on the job. Research staff then rated the participant's methods based on the 5 donning and 2 doffing criteria.

Data analysis

Hospital-level indicators were used to measure hospital adherence to required or recommended RPP requirements and HCWs practices. Using hospital-level analysis is an approach commonly used in public health research with aggregate units of analysis and is appropriate for answering the study questions.^{21,22}

For each participating hospital, the hospital-level adherence values are calculated on the basis of survey responses provided by

the HMs, UMs, or HCWs. These 3 HCP groups are the observation units from which data were gathered.

Hospital-level indicators were constructed for each survey question examined in the study. The indicators are binary categorical variables constructed by comparing survey responses to the relevant OSHA requirement or CDC guidance recommendation. Separate hospital-level indicators were constructed for each of the 3 surveys (ie, HM, UM, HCW). For each question and each survey, a hospital was coded as either adhering or not adhering to the required or recommended respiratory practice. Because some of the participating states have respiratory protection guidelines that exceed those of the CDC, survey responses that met or exceeded the CDC's guidelines were counted as consistent for purposes of this analysis. Response options that were considered to meet or exceed the OSHA's requirement or CDC's recommendation are documented in [Appendices A–C](#).

For each question in each survey, hospitals were coded as either adherent or not adherent based on the percentage of respondents' correct responses. The study team defined adherence using a 50% threshold for the HM and UM surveys. This threshold was thought to have face validity because hospitals were thought to often commonly assign responsibility for administering their RPPs to a single person at the hospital. The average number of HMs surveyed per hospital was 2.2; the average number of UMs surveyed per hospital was 2.5. For example, if 2 UMs at one hospital responded to the UM survey, at least 1 of those UMs must have provided a response consistent with the relevant OSHA requirement or CDC recommendation for, for example, question 1 for the hospital to be coded as adherent. This 50% threshold resulted in useful results for the HM and UM surveys.

For the HCW survey, the average number of HCWs surveyed per hospital was 11.3. Because HCWs are the frontline workers using respiratory protection and an important reference point, the study team determined that the 50% threshold was not a valid reflection of a hospital's adherence level. In addition, initial analyses using the 50% threshold for the HCW survey data resulted in almost all hospital indicators coded as adherent for almost all questions ([Appendices A and B](#)). As previously discussed, a major purpose of this study was to identify topics for future NIOSH dissemination efforts. Analyses based on a 50% threshold for the HCWs yielded results that made it difficult to prioritize areas for dissemination. Therefore, the threshold for defining adherence based on the HCW survey data was raised to 75%.

These differing thresholds help to better target health communication resources for improving HCW awareness of respiratory protection requirements and recommendations. However, although HM and UM responses and adherence rates can be compared with one another, they cannot be directly compared with the HCWs' results because of the different thresholds.

A total of 83 hospital adherence indicators were calculated. The percentages presented in [Appendices A–C](#) reflect the percentage of hospitals that adhere to an OSHA's RPP requirement or CDC's practice guidance.

Survey responses were analyzed using 1-way descriptive statistics. All analyses were generated using SAS version 9.3 (SAS Institute Inc, Cary, NC).

RESULTS

Participating hospitals and health care staff

A total of 98 acute care hospitals participated in the REACH II surveys. Overall, 33.7% of REACH II hospitals were small facilities (ie, <150 beds), 26.5% were medium-sized facilities (ie, 150–300 beds), and 39.8% were large facilities (ie, >300 beds) ([Tables 1](#)

Table 1
Survey participants by state

State	No. of hospitals	No. of HMs	No. of UMs	No. of HCWs	No. of observations
California	15	43	42	178	69
Illinois	13	46	35	177	36
Michigan	11	27	26	102	33
Minnesota	15	42	47	181	36
New York	23	40	31	127	115
North Carolina	21	17	64	340	69
Total	98	215	245	1,105	356

HCW, health care worker; HM, hospital manager; UM, unit manager.

Table 2
Size of participating hospitals by state

State	No. of beds		
	<150	150–300	≥301
California	5	6	4
Illinois	2	1	10
Michigan	6	2	3
Minnesota	7	5	3
New York	9	9	5
North Carolina	4	3	14
Total	33	26	39

and 2). HM respondents were typically upper-level managers from infection control, employee or occupational health, nursing administration, environmental health and safety, or other departments. UMs and HCWs worked in emergency departments, intensive care units, medical surgery units, and pulmonary and pediatric clinical units. HCWs were typically direct care providers with job titles that included registered nurses, nursing assistants or patient care assistants, respiratory therapists, environmental service, and housekeeping staff (Tables 3 and 4). Responses from the surveys are summarized in Appendices A–C.

HM and UM responses

RPP

Based on the HM survey, all REACH II hospitals (100.0%) adhered to the OSHA's requirement that they have a written RPP (Appendix A, item 1). The adherence rate based on the UM survey was 97.8%.

Medical evaluation and fit testing

Almost all REACH II hospitals adhered to the requirement that an initial medical evaluation and fit testing of staff prior to allowing them to wear a respirator in the workplace be conducted (adherence rates were 97.9% regarding medical evaluations and 98.9% regarding fit testing based on the HM survey; based on the UM survey they were 96.8% and 100.0%, respectively) (Appendix A, items 2 and 4). Based on the HM survey, however, only 11.0% of the hospitals conducted follow-up medical evaluations based on medical necessity, as required by the OSHA. However, most (92.3%) performed follow-up fit testing at least annually (Appendix A, items 3 and 5). For the same items, there was a similar pattern based on the UMs' responses: 4.3% of the hospitals adhered to the requirement to conduct follow-up medical evaluations based on medical necessity, and 100.0% performed follow-up fit testing at least annually.

Almost all REACH II hospitals also adhered to the requirement that only employees who have been fit tested for the specified model and size be allowed to wear the N95 respirator (the rates were 97.9% based on the HM survey and 95.7% based on the UM survey) (Appendix A, item 6). Only about two-thirds of the

Table 3
Hospital units by respondent group

Hospital unit	HMs (%)	Hospital unit	UMs (%)	HCWs (%)
Infection control	29.9	Emergency department	25.0	26.8
Employee and occupational health	25.1	Intensive care unit	20.9	22.3
Nursing administration	19.4	Medical surgery unit	18.4	25.6
Environmental health and safety	11.8	Other clinical units	35.7	25.3
Other departments	13.7			

HCW, health care worker; HM, hospital manager; UM, unit manager.

Table 4
Job titles of health care worker respondents

Job title	%
Registered nurses	61.9
Nursing assistants or patient care assistants	11.3
Respiratory therapists	6.9
Environmental service and housekeeping staff	4.5
Other	15.4

hospitals (67.0% for HMs, 68.1% for UMs) provided employees with written notification of the model and size of the respirator for which they had been fit tested (Appendix A, item 7). Based on the HM survey, 89.4% of REACH II hospitals either provided a PAPR or reassigned staff to a lower-risk job classification when they could not be successfully fit tested (Appendix A, item 8). Based on the UM survey, 88.3% followed that OSHA requirement.

Training

Almost all REACH II hospitals offered training on how and when to use respirator protection and did not permit employees to wear a respirator without training (adherence rates were 98.5%, 98.9%, and 97.9%, respectively, based on the HM survey; based on the UM survey they were 98.5%, 100.0%, and 96.8%, respectively) (Appendix A, items 9–11). Based on the HM survey, somewhat fewer hospitals (85.9%) adhered to the OSHA's requirement that employees attend annual follow-up respirator training (Appendix A, item 12). Based on the UM survey, adherence to the annual follow-up training requirement was 94.7%.

Circumstances, frequency, and location of use

Based on the HM survey, 89.4% of REACH II hospitals conducted a risk assessment to determine which employees should be included in the RPP (Appendix A, item 13). Based on the UM survey, the adherence rate on this question was somewhat lower (78.5%). Based on both surveys, workers in 97.9% of REACH II hospitals reported using respirators when they are required (Appendix A, item 14). Almost all REACH II hospitals also located respiratory protective equipment close to the point of use (the rate was 98.5% in both surveys) (Appendix A, item 15).

Program evaluation and respirator maintenance

Based on the HM survey, 93.4% of REACH II hospitals determined whether respirators were available for employees who needed them (Appendix A, item 16). Based on the UM survey, the hospital adherence rate on this question was somewhat lower (86.9%). Adherence rates regarding requirements to have a formal mechanism to evaluate the effectiveness of the RPP were 53.2% and 39.4%, based on the HM and UM surveys, respectively (Appendix A, item 17). Regarding the OSHA's requirement to formally solicit input from respirator users during the program evaluation, the rates were 56.7% and 47.5%, respectively

(Appendix A, item 18). The results varied widely between the HM and UM surveys on the question of whether the facility tracks respirator defects or problems; the adherence rate was 84.1% based on the HM survey, but only 50.0% based on the UM survey (Appendix A, item 19). Based on the HM survey, 82.0% of hospitals adhered to the requirement that the program evaluation determine whether respirators are being maintained properly. The hospital adherence rate for this item based on the UM survey was only 65.6% (Appendix A, item 20).

Selection of respiratory protective devices

Each survey presented a set of 6 scenarios involving patient contact and asked what kind of respiratory protection was required for each (Appendix B). The scenarios involved 1 of 3 kinds of suspected or confirmed patient conditions: seasonal influenza and infectious diseases requiring airborne or droplet precautions. For each patient condition, 1 scenario involved close contact with the patient and another involved aerosol-generating procedures (eg, What is the minimum level of respiratory protection employees are required to use when in close contact with patients who have suspected or confirmed seasonal influenza?). Based on the HM and UM surveys, almost all REACH II hospitals met or exceeded recommended respiratory protection for 5 of the 6 disease transmission scenarios (Appendix A, items 1–3 and 5–6). The exception concerned respiratory protection when performing aerosol-generating procedures on a patient who has seasonal influenza. Based on the HM survey, only 59.1% of REACH II hospitals recommended the use of at least an N95 FFR. Based on the UM survey, the adherence rate was 55.3% (Appendix B, item 4).

HCW responses

RPP

Based on the HCW survey and using the 75% threshold previously discussed, 78.6% of REACH II hospitals had a written RPP (Appendix A, item 1).

Medical evaluation and fit testing

Based on the HCW survey, 90.8% of REACH II hospitals provided an initial medical evaluation and fit testing of staff prior to allowing them to wear a respirator (Appendix A, item 2). Almost all hospitals (95.9%) required staff to be fit tested prior to wearing a respirator (Appendix A, item 4). Based on the HCW survey, none of the hospitals conducted follow-up medical evaluations as required by a physician based on medical necessity, 76.3% performed at least annual follow-up fit testing, and 83.7% did not allow employees who have not been fit tested for the specified model and size to wear an N95 respirator (Appendix A, items 3, 5, and 6). The HCW survey also indicated that only 28.6% of REACH II hospitals provided employees with written notification of the model and size of the respirator for which they had been fit tested; and when they could not be successfully fit tested, only 26.5% either provided a PAPR or reassigned staff to a lower-risk job classification, as required (Appendix A, items 7 and 8).

Training

Based on the HCW survey, 92.9% of REACH II hospitals provided training on how to use respiratory protection, and almost all (98.6%) provided training on when to use respiratory protection (Appendix A, items 9 and 10). However, 69.4% of the hospitals did not permit employees to wear a respirator without training, and only 54.1% provided the required annual follow-up respirator training (Appendix A, items 11 and 12).

Circumstances, frequency, and location of use

Based on the HCW survey, workers in 86.7% of REACH II hospitals used respirators when they were required (Appendix A, item 14). Almost all REACH II facilities (98.6%) located respiratory protective equipment close to the point of use (Appendix A, item 15).

Program evaluation and respirator maintenance

Based on the HCW survey, HCWs in most REACH II hospitals (96.9%) were expected to report defects or problems with respiratory equipment (Appendix A, item 23). The HCW survey indicated low rates of adherence among REACH II hospitals regarding the requirements to formally solicit input from respirator users during the program evaluation (4.1%) and to determine whether employees are donning, doffing, and disposing their respirators properly (14.3%) (Appendix A, items 18 and 22). HCWs were also asked whether respirators were being maintained properly. Based on their responses, only 21.4% of the REACH II hospitals adhered to this OSHA requirement (Appendix A, item 21).

Selection of respiratory protective devices

Adherence to the CDC's recommendations regarding appropriate selection of respiratory protective devices varied widely by scenario (Appendix B). The highest adherence rate of the 6 scenarios was for close contact with patients who have suspected or confirmed seasonal influenza (92.9%); the lowest was for performing aerosol-generating procedures on patients who have seasonal influenza (7.1%) (Appendix B, items 3 and 4). For close contact with patients with a suspected or confirmed disease requiring droplet precautions, the rate was 89.7% (Appendix B, item 5). For the comparable scenario involving aerosol-generating procedures, the rate was 78.2% (Appendix B, item 6).

For a patient with a suspected or confirmed infectious disease requiring airborne precautions, the adherence rate was 61.2% for the scenario involving close contact with patients and 56.1% for the scenario involving aerosol-generating procedures (Appendix B, items 1 and 2).

Demonstration data

Based on the demonstration data, HCWs followed manufacturers' instructions regarding correct positioning of the respirator in 84.5% of the hospitals; did not have facial hair under the face-piece seal in 84.0% of the hospitals; and correctly used nose clips (ie, adjustable nasal bars) in 83.5% of the hospitals (Appendix C, items 1 and 4). However, the adherence rates were only 15.5% for completing the user seal check procedure; 54.6% for placing the straps correctly; 43.3% for using straps to remove the respirator; and 55.3% for proper disposal of the respirator (Appendix C, items 5, 3, 6, and 7, respectively).

DISCUSSION

Our study findings identified both strengths and weaknesses in current respiratory protection practices in the acute care hospitals studied. Among the notable strengths, the current surveys indicate that most acute care hospitals have a written RPP and are adhering to many of the OSHA's requirements and CDC's recommendations regarding respiratory protection. Similarly to REACH I findings, most participating hospitals adhered to the OSHA's requirements regarding initial medical evaluations, fit testing, and training of employees prior to wearing a respirator. There was also a high level of familiarity among HM and UM with recommended respiratory protection when in close contact or performing aerosol-generating procedures on a patient with a suspected or confirmed disease requiring droplet precautions or when in close contact with a patient with suspected or confirmed seasonal influenza.

The notable gaps in respiratory protection mostly concern follow-up practices after the initial medical evaluations, fit testing, and training. This pattern exists in the HM, UM, and HCW surveys. Based on all 3 surveys, participating hospitals had lower adherence rates regarding medical re-evaluations, informing staff about which model and size of respirator they have been fit tested for, and RPP evaluation procedures. In addition, based on the UM survey, participating hospitals also had lower adherence rates regarding procedures for tracking respirator defects and maintaining respirators properly. Based on the HCW survey, participating hospitals also had low adherence rates regarding frequency of respirator follow-up training, respirator maintenance, and observing workers' proper respirator donning, doffing, and disposal techniques.

There were also low adherence rates based on all 3 surveys related to knowledge of appropriate respiratory protection when performing aerosol-generating procedures on a patient with seasonal influenza.

During the observations, HCWs had low rates of adherence for 4 out of the 7 requirements examined (ie, correct strap placement, user seal checks, proper respirator removal using straps, proper respirator disposal). The findings regarding the user seal check and doffing procedures mirror findings from previous observational studies.^{10,11,20}

Based on our findings, it appears that many HCWs are unclear about when and how to use respiratory protection and about which type of protection is needed in specific situations. As pointed out by Williams and Carnahan,²³ PPE use is a procedural skill that requires HCWs to evaluate each situation and determine the appropriate level of protection they should use. Without adequate knowledge of respiratory protection guidelines, HCWs are not equipped to make those evaluations correctly and may choose insufficient protection. They may also lack knowledge about recommended usage procedures. One recent study found that nurses who were knowledgeable about respiratory protection recommendations were 2.9 times more likely to demonstrate competency in using an N95 FFR.²⁴ Both insufficient protection and improper use can negatively impact HCWs' safety and health. The Jaeger et al study¹⁰ involving the 2009 H1N1 pandemic found that increased rates of health care–associated transmission among HCWs were correlated with irregular use of proper PPE.

A primary purpose of this study was to identify gaps in hospital respiratory protection practices that could be addressed by providing useful tools and best practice guidelines for improving the health and safety of the nation's HCWs. Based on our findings, educational resources should be developed for HMs and UMs to help them obtain a greater understanding of the OSHA's regulations and CDC's recommendations, including respiratory protection needed in the presence of patients with seasonal influenza, best practice procedures for monitoring and evaluation of hospital RPPs, and medical evaluation and fit testing requirements. There is also a need to develop educational materials that can raise HCWs' awareness of the best respiratory protection for seasonal influenza and manufacturers' recommendations for proper respirator use and RPP training and fit testing requirements. With rare exceptions, these gaps in knowledge and practice were not confined to a particular size of hospital facility; therefore, efforts to raise awareness would benefit staff in small, medium, and large facilities.

To our knowledge, this is the first study to examine adherence to respiratory protection guidance across multiple states. It is also the first cross-sectional study to measure hospital-level indicators of adherence to the OSHA's requirements and CDC's recommendations. This evaluation extends the knowledge on this topic because the literature commonly reports individual-level rather than hospital-level results, which introduces potential sampling errors unless survey weights have been appropriately applied.

Study limitations

There are several limitations to this study that should be noted. Because the samples for the study were not drawn using a randomized design, the findings cannot be generalized beyond the participating hospitals. Hospital-level inferences (eg, the derivation of adherence indicators) are based on an assumption of adequate representation through surveyed individuals. In addition, the very small sample sizes introduce sampling errors, even for the derived hospital-level indicators. The study should therefore be considered exploratory in nature; however, the use of the hospital-level indicators may have reduced the potential selection bias somewhat.

Another limitation with the study is the use of different thresholds across the 3 respondent groups. The thresholds for defining adherence were the same for the HM and UM surveys, but the threshold for the HCW survey was higher. Because of this difference, the HCW results cannot be directly compared with those of the HM or UM surveys.

As with any other self-reported data, survey responses may also have been affected by social desirability bias, especially in the context of a survey taken in the workplace regarding a subject in which workers are supposed to comply. For example, in the observational portion of the study, HCWs may have altered their typical donning and doffing procedures simply because they were being observed (ie, Hawthorne effect). Efforts were made to collect data in private whenever possible, which may have ameliorated this source of bias. However, other studies have found actual compliance rates to be lower than self-reported rates.¹² In addition, as with all surveys, some of the questions and response options may not have been fully understood by all respondents, which could have resulted in response error.

Finally, there may also be mode effects as a result of some interviews having been conducted by phone or mail in 2 of the states. In addition, the data collected in 2 of the 6 states were based on modified questionnaires that reduced the number of questions that could be compared across states and, for the common questions, reduced the number of states included in the overall assessment. It is not known if the overall adherence rates would be different for those questions if the 2 states' data had been included in the calculations.

CONCLUSIONS

Our findings indicate that the surveyed hospitals in 6 states are implementing many of the programmatic and practice recommendations regarding respiratory protection. Most hospitals are implementing most required elements of an RPP. These include the provision of initial medical evaluations, fit testing, and training of employees prior to wearing a respirator. However, we found gaps in respiratory protection knowledge and practice among HMs, UMs, and HCWs at these hospitals. Those gaps involve RPP follow-up elements, including medical re-evaluations, RPP evaluations, documentation of the model and size of respirator HCWs have been fit tested for, and respirator use and supply. Efforts should be made to closely examine ways of strengthening these program follow-up elements to ensure that the program is more than a plan on paper. Other gaps were found in HCWs' respirator donning and doffing procedures and in their knowledge about recommended respiratory protection. Efforts should be made to increase awareness among all 3 target groups; therefore, the HCWs will be better informed and hopefully better protected, particularly from aerosol-generating procedures and aerosol-transmissible diseases. Further investigation to understand why these gaps exist is also needed. Additional analyses are planned, for example, on whether adherence to the OSHA's requirements or CDC's recommendations can be

attributed to state-level policy or other factors. Analysis is also needed to better understand the impact of safety culture on HCWs' proper use of respiratory protection and on RPPs in general. Further study is also needed of hospitals' RPPs to identify the extent to which specific elements of a hospital's RPP are known by HCPs and are translated into practice and whether job title and education are correlated with recommended respiratory protection practice. Compliance with the proper use of respiratory protection is an employer and employee responsibility that needs to be better understood to best reinforce safe infection prevention practices.

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Appendix A

Percentage of hospitals that adhered to the OSHA's requirements

OSHA RPP element and REACH II questionnaire item	Hospital adherence rate (%)			
	HM	UM	HCW	
	50%	50%	50%	75%
Hospital-level adherence threshold				
Written RPP				
1. Does your facility have a written RPP? (adherent: yes)	100.0	97.8	99.0	78.6
Medical evaluation and clearance				
2. HMs/UMs: Do employees receive medical evaluation and clearance before being allowed to wear a respirator?	97.9	96.8	97.4	90.8
HCWs: Did you receive medical evaluation and clearance before wearing a respirator? (adherent: yes)				
3. HMs/UMs: How frequently are employees medically evaluated?	11.0	4.3	0.0	0.0
HCWs: How frequently are you medically evaluated? (adherent: once at hire, then as required by a physician [based on medical necessity])				
Fit testing				
4. HMs/UMs: Do employees receive fit testing before being allowed to wear a respirator?	98.9	100.0	100.0	95.9
HCWs: Did you receive fit testing before being allowed to wear an N95 respirator? (adherent: yes)				
5. HMs/UMs: How often do most employees receive fit testing after hire?	92.3*	100.0*	93.9	76.3
HCWs: How often do you receive fit testing? (adherent: once at hire and then annually)				
6. HMs/UMs: Are employees allowed to wear an N95 respirator model or size for which they have not received a fit test?	97.9	95.7	98.0	83.7
HCWs: Are you allowed to wear an N95 respirator model or size for which they have not received a fit test? (adherent: no)				
7. HMs/UMs: How do employees know which model(s) and size(s) of respirators they have been fit tested for?	67.0	68.1	53.5	28.6
HCWs: How do you know which model(s) and size(s) of respirators you have been fit tested for? (adherent: they are given a written copy of their fit test results or they are given a pocket card [or other reminder])				
8. HMs/UMs: What happens if an employee cannot be successfully fit tested?	89.4	88.3	60.6	26.5
HCWs: What happens if you cannot be successfully fit tested? (adherent: they are put into a PAPR or they are reassigned to a lower-risk job classification)				
Training				
9. HMs/UMs: Does your facility offer employees training in how to properly use respiratory protection?	98.5*	98.5*	100.0	92.9*
HCWs: Does your facility offer you training in how to properly use respiratory protection? (adherent: yes)				
10. HMs/UMs: Do employees receive training about when to wear respiratory protection? (adherent: yes)	98.9	100.0	100.0	98.6*
11. HMs/UMs: Are employees permitted to wear a respirator without training?	97.9	96.8	90.9	69.4
HCWs: Are you permitted to wear a respirator without training? (adherent: no)				
12. HMs/UMs: How often are employees required to attend respirator training?	85.9	94.7	87.9	54.1
HCWs: How often are you required to attend respirator training? (adherent: once at hire and then annually)				
Circumstances of usage				
13. HMs: Does your facility conduct a risk assessment to determine which employees should be included in the RPP?	89.4	78.5	†	†
UMs: Does your facility conduct a risk assessment to determine which employees on your unit should be included in the RPP? (adherent: yes)				
Frequency of usage				
14. Workers at my workplace use respirators when they are required (adherent: agree)	97.9	97.9	98.0	86.7
Location of usage				
15. Is respiratory protective equipment located close to the point of use (ie, rooms with suspected or confirmed seasonal influenza or patients on airborne precautions)? (adherent: yes)	98.5*	98.5	100.0	98.6*
Program evaluation and respirator maintenance				
16. HMs/UMs: During the program evaluation, do you determine whether respirators are available for employees who need them? (adherent: yes)	93.4	86.9	†	†
17. HMs/UMs: Does your facility have a formal mechanism or method to evaluate the effectiveness of the RPP? (adherent: yes)	53.2	39.4	†	†
18. HMs/UMs: Is input from respirator users formally solicited (eg, by an anonymous survey or during a meeting) during the program evaluation?	56.7	47.5	18.2	4.1
HCWs: Is your input formally solicited (eg, by an anonymous survey or during a meeting) during the program evaluation? (adherent: yes)				
19. HMs: Does your facility track respirator defects or problems?	84.1*	50.0*	†	†
UMs: As a manager, do you track respirator defects or problems? (adherent: yes)				
20. HMs/UMs: During the program evaluation, do you determine whether respirators are being maintained properly (eg, PAPRs are disinfected after use)? (adherent: yes)	82.0	65.6	†	†
21. HCWs: Are respirators being maintained properly (eg, PAPRs are disinfected after use)? (adherent: yes)	†	†	59.6	21.4*
22. HCWs: Does anyone observe you to make sure you are donning (putting on), doffing (removing), and disposing respirators properly? (adherent: yes)	†	†	44.4	14.3
23. HCWs: Are you expected to report defects or problems with respiratory equipment? (adherent: yes)	†	†	100.0	96.9

HCW, health care worker; HM, hospital manager; OSHA, Occupational Safety and Health Administration; PAPR, powered air purifying respirator; RPP, respiratory protection program; UM, unit manager.

*Comparable data were not available for Minnesota and Illinois on this question.

†This question was not asked for this respondent group.

Appendix B

Percentage of hospitals that adhered to the CDC's recommendations

Scenario (adherent response options)	Hospital adherence rate (%)			
	HM	UM	HCW	
	50%	50%	50%	75%
Hospital-level adherence threshold				
1. What is the minimum level of respiratory protection employees are required to use when in close contact with a patient who has a suspected or confirmed infectious disease requiring airborne precautions (eg, measles)? ^a (adherent: N95 FFR ¹ [exceeded: N95 EHFR or PAPR])	92.6	85.1	86.9	61.2
2. What is the minimum level of respiratory protection employees are required to use when performing aerosol-generating procedures on a patient who has a suspected or confirmed infectious disease requiring airborne precautions (eg, measles)? ¹ (adherent: N95 FFR ¹ [exceeded: N95 EHFR or PAPR])	97.8	93.6	93.9	56.1
3. What is the minimum level of respiratory protection employees are required to use when in close contact with patients who have suspected or confirmed seasonal influenza? (adherent: surgical mask [exceeded: N95 FFR, N95 EHFR, or PAPR])	97.8	97.9	100.0	92.9
4. What is the minimum level of respiratory protection employees are required to use when performing aerosol-generating procedures on a patient who has seasonal influenza? (adherent: N95 FFR [exceeded: N95 EHFR or PAPR])	59.1	55.3	33.3	7.1
5. What is the minimum level of respiratory protection employees are required to use when in close contact with a patient who has a suspected or confirmed disease requiring droplet precautions (eg, pertussis)? (adherent: surgical mask [exceeded: N95 FFR, N95 EHFR, or PAPR])	98.8	97.6	97.7	89.7
6. What is the minimum level of respiratory protection employees are required to use when performing aerosol-generating procedures on a patient who has a suspected or confirmed disease requiring droplet precautions (eg, pertussis)? (adherent: surgical mask [exceeded: N95 FFR, N95 EHFR, or PAPR])	96.4	95.2	98.9	78.2

EHFR, elastometric half facepiece respirator; FFR, filtered facepiece respirator; HCW, health care worker; HM, hospital manager; OSHA, Occupational Safety and Health Administration; PAPR, powered air purifying respirator; UM, unit manager.

^aFor these questions, 2 states substituted the term tuberculosis for the term measles as an example of an aerosol-transmissible disease.

¹California and the OSHA require the use of a respirator for any disease requiring airborne precautions, including measles, and regardless of immune status.

²In California, the Cal/OSHA requirement is for PAPR.

Appendix C

Percentage of hospitals that adhered to recommendations for donning and doffing respirators, based on observations of HCWs

Hospital-level adherence threshold	Adherence rate (%)	
	50%	75%
1. Positioned correctly on face? (adherent: yes)	99.0	84.5
2. Facial hair under seal? (adherent: no)	95.4	84.0
3. Straps correctly placed? (adherent: yes)	80.4	54.6
4. Nose clips used? (adherent: yes)	96.9	83.5
5. User seal checked? (adherent: yes)	38.1	15.5
6. Removed properly (used straps) (adherent: yes)	80.4	43.3
7. Disposed of respirator (adherent: yes)	78.7	55.3