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Major article

Outpatient healthcare personnel knowledge and attitudes towards infection prevention measures for protection from respiratory infections

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Background: Healthcare personnel (HCP) knowledge and attitudes toward infection control measures are important determinants of practices that can protect them from transmission of infectious diseases.
Methods: Healthcare personnel were recruited from Emergency Departments and outpatient clinics at seven sites. They completed knowledge surveys at the beginning and attitude surveys at the beginning and end of each season of participation. Attitudes toward infection prevention and control measures, especially medical masks and N95 respirators, were compared. The proportion of participants who correctly identified all components of an infection control bundle for seven clinical scenarios was calculated.
Results: The proportion of participants in the medical mask group who reported at least one reason to avoid using medical masks fell from 88.5% on the pre-season survey to 39.6% on the post-season survey (odds ratio [OR] for preseason vs. postseason 0.11, 95% CI 0.10-0.14). Among those wearing N95 respirators, the proportion fell from 87.9% to 53.6% (OR 0.24, 95% CI 0.21-0.28). Participants correctly identified all components of the infection control bundle for 4.9% to 38.5% of scenarios.

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Conclusions: Attitudes toward medical masks and N95 respirators improved significantly between the beginning and end of each season. The proportion of HCP who correctly identified the infection control precautions needed for clinical scenarios was low, but it improved over successive years of participation in the study.

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INTRODUCTION

Medical masks and N95 respirators are integral components of infection prevention and control measures that protect healthcare personnel (HCP) from transmission of respiratory infections from patients.[1] Effectiveness of N95 respirators and medical masks (commonly referred to as surgical masks) for prevention of transmission depends on the characteristics of the pathogen, host susceptibility, environmental conditions, the facial fit of the protective device, the filtration efficiency of the protective device,[2] and adherence of the device wearers to consistent and proper device use throughout the period of exposure.[3-7]

Laboratory studies have demonstrated superior filtration efficiency for N95 respirators compared to medical masks[2]; however, clinical trials have not confirmed superiority for N95 in practice.[8-11] The Respiratory Protection Effectiveness Clinical Trial, (ResPECT), was a pragmatic, cluster randomized clinical trial, designed to compare the effectiveness of N95 respirators and medical masks worn by HCP for prevention of transmission of influenza and other viral respiratory infections.[12] Participants in ResPECT completed surveys of their knowledge, attitudes and beliefs regarding infection control measures designed to prevent transmission of respiratory pathogens from patients to HCP. We report herein the results of those surveys.

HCP adherence to guidance, regulation and healthcare institutional policies about wearing medical masks and N95 respirators has been shown to be incomplete, ranging widely from 10% to 84%.[13-16] Strategies employed to improve adherence include education, training, making masks readily available, and observation of and feedback to HCP about workplace behaviors. Improving HCP adherence with all types of personal protective equipment (PPE) and other protective measures has been a major goal for infection prevention programs.

A better understanding of HCP knowledge of and attitudes toward infection prevention and control practices, including the use of medical masks and N95 respirators, can inform efforts to diminish unnecessary exposures. Previous studies have assessed HCP knowledge and attitudes at a single time point, showing that HCP are less adherent to guidance, regulations, and policies if they believe that it interferes with performance of their job functions.[17, 18] When HCP were asked to wear medical mask and/or N95 respirator ensembles for an eight-hour work period, the probability of tolerating the ensembles ranged from 0.30 to 0.55, despite doffing breaks approximately every two hours. Their intolerance was due, at least in part, to discomfort and interference with communication[19, 20] and possibly familiarity with routine respirator wear. Attitudes toward shorter periods of medical mask or N95 respirator use, and changes in attitudes over a respiratory virus season, have not been previously described.

Education of HCP is a foundational strategy in infection control. There are few studies of interventions to improve HCP attitudes toward medical masks and N95 respirators. We sought to broaden our understanding of HCP knowledge and attitudes about medical masks and respirators by conducting surveys at the beginning and end of each respiratory virus season in the ResPECT study.[12] We hypothesized that participation in a study of medical masks and N95 respirators would familiarize HCP with the devices, and ultimately improve attitudes through experiential learning. Recent trends in education theory support experiential learning in medicine and nursing. [21, 22] At one site, we supplemented this experiential learning with an educational campaign encouraging adherence. We compared adherence at this site to a similar control site without an educational campaign.

METHODS

Study design

ResPECT was a multicenter, multi-season cluster randomized clinical trial designed to compare the effectiveness of medical masks and N95 respirators for preventing acute respiratory illnesses and infections in HCP working in outpatient clinical settings.[12] Participants assigned to the medical mask group were instructed to follow CDC guidance to wear a medical mask whenever they were in contact with a patient with acute respiratory infection during influenza season; participants in the N95 group were instructed to wear an N95 respirator in such circumstances. This study was approved by the Human Subjects Research Board at The National Institute for Occupational Safety and Health (#10-NPPTL-O5XP) and the institutional review boards (IRBs) at the seven study sites, as previously described,[12] and approved or exempted by IRBs at affiliate sites. Participants were recruited from outpatient settings at seven sites in five geographic regions (Children's Hospital Colorado metropolitan Denver, CO; Denver Health Medical Center, Johns Hopkins Health System in Baltimore, MD; and the Department of Veterans Affairs sites in Denver, CO; Houston, TX; New York, NY; and Washington, DC).

Participants were enrolled during each of four consecutive influenza seasons, between 2011 and 2015. HCP could participate in more than one season. During each influenza season, participants were instructed to wear their assigned device (medical mask or N95 respirator) whenever positioned within six feet of patients with known or suspected acute respiratory infection (ARI), throughout a 12 week period of high influenza activity as predicted by the ALERT algorithm.[23] The definition of eligible healthcare personnel for the purposes of the study was any person who was a full-time employee (average of ≥ 24 hours/week of patient contact time), at least 18 years old, working at the study site and interacting with patients. Interaction in this context meant the provision of clinical care, positioning oneself within six feet of patients, or entering into a small enclosed space shared with patients, such as a typical patient treatment room.

Data collection

Each season, prior to randomization, all participants were asked to complete the pre-study survey that included questions regarding attitudes and behaviors toward infection prevention and control measures, including medical masks and N95 respirators. An identical post-study survey of attitudes and behaviors was administered at the end of each study season. Responses that applied to the randomly assigned mask type for each participant, i.e. medical mask or N95 respirator, were analyzed. A survey of infection control knowledge was administered at the beginning of each season (Supplementary Fig S1), to assess participants' knowledge of recommended infection control practices. Participants were asked to select all infection prevention and control measures (i.e., hand hygiene; gown; gloves; eye protection and/or face shield; medical mask; N95 respirator) they would use when caring for patients with specific respiratory, gastrointestinal, or dermatologic signs or symptoms.

Upon enrollment each season, and prior to randomization, information was gathered in a baseline survey on each participant's occupation or role in their outpatient clinical setting. Positions were grouped as follows: nursing group (included registered nurses, licensed practical nurses, certified nursing assistants, occupational therapists, physical therapists, respiratory therapists, and dental hygienists); provider group (included physicians, physician assistants, nurse practitioners, and dentists); clinical technical/support staff; and administrative, clerical, social work, pastoral care, and environmental services. Study data were collected and managed using REDCap electronic data capture tools.

Educational Campaign

A nested sub-study of the impact of an educational campaign on adherence to medical masks or N95 respirators was conducted at the Denver VA and Houston VA sites during the 2013 to 2014 influenza season. At the Denver VA site, an educational campaign was conducted, consisting of notices on electronic announcement boards and placement of posters at vital sign stations, triage areas, nurse stations, elevator lobbies, and staff offices reminding staff to wear medical masks or N95 respirators. The educational materials reiterated the CDC mask wearing guidelines for HCP in close contact with patients presenting with signs and symptoms of respiratory infection.[3] The intent of this campaign was to maximize medical mask and N95 respirator wearing adherence among study participants and other staff to reduce exposures. The Houston VA, with no educational campaign, served as the control site.

Statistical analysis

Data from all study sites were analyzed to assess knowledge, attitudes and behaviors. For the nested sub-study of the educational campaign, analysis was limited to the Denver VA and Houston VA sites. Person-seasons of participation were compared between groups. Because clusters were randomized annually, a participant could be assigned different interventions each year. Analysis was limited to participants who completed both the pre-study and the post-study survey for a season. A participant who completed both surveys for multiple seasons was defined as a survey respondent and survey responses were analyzed for each season. The characteristics data for participants are presented as N (percentage) for categorical values. Chi-square was used for analyses of unpaired and paired categorical variables. All tests were two-sided. All continuous variables are expressed using the statistical mean and, when appropriate, standard deviation. Linear regression was used to analyze continuous variables.

Logistic regression was used to explore associations between responses to surveys and individual attributes (age, occupation) and study attributes (study arm, pre or post, study year, severity of flu season). Study year was defined for each individual participant as the sequential year that each respondent had participated in the study (i.e. Year 1, Year 2, etc.). Questions about medical masks and N95 respirators were analyzed separately. Each respondent answered questions about the acceptability of each mask regardless of study arm assignment, to maintain blinding of study personnel. Data on attitudes were analyzed for the assigned mask type for that study year. Knowledge data included both mask types. We hypothesized that participation in the study may have changed participants' perceptions of the PPE and so we analyzed each year's data from each participant separately. We also analyzed all survey responses together adjusting for the impact of study year and arm.

To examine whether longitudinal correlation of an individual's responses affected the inferences of the effect of each covariate, we used random effects logistic regression to account for possible correlation. A random effect was used to account for an individual's participation across multiple seasons. We also included terms to adjust for correlation of responses within clusters.

RESULTS

Among 5,180 participant-seasons, a pre-study and post-study survey pair was available for 4,560 (88.1%), of which 3,913 (85.7%) were female. Nursing group was the most commonly reported occupational category, followed by the provider group. There were no significant differences in demographic variables or occupation assignment between participants among respondents and non-respondents for each participant season (Table 1).

Attitudes toward medical masks and N95 respirators improved significantly between the beginning and end of each season (Table 2). The proportion of participants assigned to medical masks who reported a reason to avoid wearing a medical mask fell from 88.5% in the pre-study survey to 39.6% in the post-study survey (OR 0.11, 95% CI 0.10-0.14). The proportion of participants assigned to N95 respirators who reported a reason to avoid N95 respirators fell from 87.9% in the pre-study survey to 53.6% in the post-study survey (OR 0.24, 95% CI 0.21-0.28). There were also significant decreases between preseason and post-season surveys in the proportion of participants in both groups that reported discomfort or difficulty communicating effectively while wearing medical masks or N95 respirators. In surveys at both time points, participants were more likely to report discomfort or difficulty breathing while wearing an N95 respirator than a medical mask (Table 2).

Participants assigned to medical masks reported adherence in 57.1% of applicable patient contacts, versus 55.2% of participants assigned to N95 respirators (P = .67). Participants who reported that

Table 1
Characteristics of survey respondents versus all study participants

	Survey Respondentsn = 4566	All Participant-Seasonsn = 5180	*P*
Mean Age at Study Entry (SD)	42.6	42.6	
Gender			
Female	3913 (85.7%)	4382 (84.6%)	.13
Male	653 (14.3%)	798 (15.4%)	
Race			
American Indian or Alaska Native	23 (0.5%)	27 (0.6%)	1.00
Asian	367 (8.0%)	405 (8.9%)	
Black or African American	1317 (28.8%)	1502 (32.9%)	
Native Hawaiian or Other Pacific Islander	12 (0.3%)	13 (0.3%)	
White	2312 (50.6%)	2616 (57.3%)	
Other	418 (9.2%)	484 (10.6%)	
No race reported	117 (2.6%)	133 (2.9%)	
Ethnicity			
Hispanic	728 (15.9%)	824 (15.9%)	
Job role			1.00
Nursing group	1876 (41.1%)	2128 (41.1%)	
Physician group	497 (10.9%)	552 (10.7%)	
Clinical Technician Support Staff	743 (16.3)	839 (16.2)	
Administrative Clerical Registration Reception Social Work Pastoral Care Environmental Services	896 (19.6%)	1026 (19.8%)	
Other	554 (12.1%)	635 (12.3%)	

Participants who submitted both a pre-study and post-study survey were considered survey respondents for all analyses for that season.

Table 2
Attitudes to medical masks and N95 respirators

Questions	Medical Masks			N-95 Respirators				
	Pre-study	Post-study	Pre-study vs. Post-study Odds Ratio (95% CI)[REF= Post]	Pre-study	Post-study	-Pre-study vs. Post-study Odds Ratio (95% CI) [REF= Post]	N95 Respirators vs. Medical MasksPre-study Odds Ratio (95% CI) [REF= MM]	N95 Respirators vs. Medical Masks Post-study Odds Ratio (95% CI) [REF= MM]
N	2373	2373		2193	2193			
Reasons to not wear medical masks or N95 respirators								
Uncomfortable/Difficulty breathing	1049 (44.2%)	438 (18.5%)	5.1 (4.3-6.1)	1142 (52.0%)	872 (39.8%)	2.3 (2.0- 2.6)	1.3 (1.1-1.4)	3.4 (2.7-4.3)
Interferes with communication	795 (33.5%)	290 (11.6%)	5.2 (4.3-6.3)	649 (29.6%)	440 (20.1%)	1.9 (1.6- 2.3)	0.80 (0.68-0.93)	4.0 (2.9-5.6)
Unavailable	696 (29.3%)	232 (9.78%)	5.1 (4.2-6.1)	599 (27.3%)	240 (10.9%)	4.0 (3.3- 4.8)	0.89 (0.76-1.0)	1.4 (0.96-2.0)
Don't protect from infections	90 (3.79%)	25 (1.05%)	26.0 (11.5- 58.6)	45 (2.05%)	25 (1.14%)	4.7 (2.0-11.0)	0.22 (0.22-0.22)	0.74 (0.73-0.74)
Other	727 (30.6%)	453 (19.1%)	1.6 (1.4-1.9)	798 (36.4%)	631 (28.8%)	1.1 (0.95-1.3)	1.2 (1.1-1.4)	1.8 (1.5-2.1)
All False	273 (11.5%)	1433 (60.4%)	0.11 (0.10-0.14)	266 (12.1%)	1017 (46.4%)	0.24 (0.21- 0.28)	1.1 (0.91-1.3)	0.47 (0.41-0.55)

Table 3
Comparison of attitudes toward medical mask and N95 respirator use at a hospital with an educational campaign, and a control hospital without an educational campaign

	Educational Campaign Hospital (n = 266)	Control Hospita l (n = 274)	*P*
	n (%)	n (%)	
Future plans for medical mask use			0.31
I will wear a mask more often than before	76 (29)	75 (27)	
I will wear a mask as often as before	48 (18)	42 (16)	
I will wear a mask less often than before	1 (0.4)	5 (1.8)	
Don't know	5 (1.9)	10 (3.6)	
No response	136 (51.1)	142 (52)	
Future plans for N95 respirator use			0.24
I will wear a respirator more often than before	48 (18)	53 (19)	
I will wear a respirator as often as before	51 (19)	36 (13)	
I will wear a respirator less often than before	1 (0.4)	4 (1.5)	
Don't know	10 (3.8)	14 (5.1)	
No response	156 (58.6)	167 (61)	

they would be deterred from using medical masks due to discomfort or difficulty breathing were significantly less likely to report complete adherence than those who did not report discomfort or difficulty breathing (OR 0.75, 95% CI 0.57-0.97). For participants assigned to N95 respirators, the difference in adherence among those who reported discomfort did not reach statistical significance (OR 0.78, 95% CI 0.59-1.0).

There was no difference in attitudes between the site that conducted an educational campaign and the comparator site (Table 3). Observed adherence with medical masks and N95 respirators was higher at the site with an educational program than the comparator site during all study years (OR 1.56, 95% CI 1.29-1.89). During 2013 to 2014, the year of the educational campaign, adherence did not change significantly during the season at the site with the campaign (OR 1.23, 95% CI 0.87-1.74, REF= 2012-2013).

In the baseline knowledge survey, administered at the beginning of each study year, participants correctly identified all components of the infection control bundle for 4.9% to 38.5% of the clinical scenarios presented (Table 4).

Participants were least likely to correctly identify the need for gowns, while masks were most often correctly identified as necessary (Table 5).

The proportion of correct bundle identification was higher among the providers than among other occupational groups ($P < .001$). Bundle knowledge improved over successive years of participation by most categories of staff (Table 6).

DISCUSSION

In this multicenter clinical trial conducted over four influenza seasons, HCP attitudes toward medical masks and N95 respirators improved significantly between the beginning and the end of each season. When comparing the end-of-season survey to the preseason survey, the proportion of participants reporting each objection to medical masks or N95 respirators decreased significantly, and the proportion who reported no objections increased significantly. These data from a large trial conducted at sites across the US suggest that when HCP participated in a study of medical masks and N95 respirators, they learned by their experience that wearing these devices generally does not interfere with their occupational functions in the magnitude that was initially anticipated.

End of season surveys showed that the proportion of participants reporting objections to wearing medical masks or N95 respirators was higher in the N95 group than in the medical mask group. This

Table 4
Pre-season HCP knowledge survey of prevention bundles

Scenario	Proportion Correct All Years Combined	Proportion Correct Years Participated =1	Proportion Correct Years Participated =2	Proportion Correct Years Participated =3	Proportion Correct Years Participated =4	*P* value for trend
Fever, cough, sore throat (indicative of influenza)	10.7 (9.8 - 11.6)	10.2 (9.1 - 11.5)	11.3 (9.7 - 13.2)	11.8 (9.5 - 14.5)	9.1 (5.8 - 14.1)	0.46
Bloody/ productive cough, chest pain, fever, weight loss (indicative of tuberculosis)	5.8 (5.1 - 6.5)	4.9 (4.1 - 5.8)	6.7 (5.4 - 8.2)	6.7 (5.0 – 8.9)	7.5 (4.5 - 12.2)	0.015
Itchy rash and blisters (indicative of chicken pox)	14.6 (13.6 - 15.6)	14.5 (13.2 - 16.0)	15.3 (13.4 - 17.4)	14.2 (11.7 - 17.1)	12.3 (8.3 – 17.8)	0.64
Sore throat, runny nose, sneezing, mild cough (indicative of upper respiratory infection)	24.3 (23.1 - 25.6)	21.3 (19.7 - 22.9)	27.0 (24.6 - 29.5)	28.5 (25.1 - 32.1)	32.1 (25.8 - 39.1)	<0.001
Diarrhea, vomiting, stomachache (indicative of gastroenteritis)	14.3 (13.3 - 15.3)	14.6 (13.2 - 16.0)	13.7 (11.9 - 15.7)	14.8 (12.2 - 17.7)	12.8 (8.8 - 18.4)	0.65
Dry, uncontrollable cough (indicative of pertussis)	29.4 (28.1 - 30.7)	26.7 (25.0 - 28.5)	30.8 (28.3 - 33.4)	34.2 (30.7 - 38.0)	38.5 (31.8 - 45.6)	<0.001
Immunocompromised Patient (chemotherapy, transplant patient, steroid therapy)	13.2 (12.3 - 14.3)	12.6 (11.4 - 14.0)	13.8 (12.0 - 15.8)	14.0 (11.5 - 16.9)	15.5 (11.0 - 21.4)	0.15

Table 5
Proportion of bundle components correctly identified

Scenario	Hand Hygiene	Gowns	Gloves	Medical/Surgical Masks	N95 Respirators
Fever, cough, sore throat (indicative of influenza or Respiratory Syncytial Virus)	95.6 (95.0 - 96.2)	11.9 (11.0 - 12.9)	56.3 (54.9 - 57.7)	77.2 (75.9 - 78.4)	
Bloody/ productive cough, chest pain, fever, weight loss (indicative of tuberculosis)	93.8 (93.0 - 94.4)	53.7 (52.2 - 55.1)	22.4 (21.2 - 23.7)	55.0 (53.6 - 56.4)	50.6 (49.1 - 52.0)
Itchy rash and blisters (indicative of chicken pox)	93.6 (92.9 - 94.3)	31.6 (30.3 - 33.0)	85.6 (84.5 - 86.6)	26.3 (25.1 - 27.6)	
Sore throat, runny nose, sneezing, mild cough (indicative of upper respiratory infection)	94.9 (94.2 - 95.5)	85.6 (84.6 - 86.6)	41.0 (39.6 - 42.5)	73.2 (71.9 - 74.5)	
Diarrhea, vomiting, stomachache (indicative of gastroenteritis)	94.2 (93.5 - 94.9)	34.1 (32.8 - 35.5)	71.9 (70.6 - 73.2)	69.5 (68.2 - 70.8)	91.6 (90.8 - 92.4)
Dry, uncontrollable cough (indicative of pertussis)	92.6 (91.8 - 93.4)	86.1 (85.1 - 87.1)	47.9 (46.5 - 49.4)	75.8 (74.5 - 77.0)	
Immunocompromised Patient (chemotherapy, transplant patient, steroid therapy)	90.3 (89.4 - 91.1)	60.8 (59.4 - 62.2)	30.7 (29.3 - 32.0)	42.7 (41.2 - 44.1)	82.9 (81.8 - 83.9)

Cells with blue background are the bundle components which were appropriate for the clinical scenario. Cells with yellow background are the bundle components which were not appropriate for the clinical scenario.

was consistent with previous data showing that medical masks were tolerated by HCP for longer time periods than N95 respirators.[19]

Reported baseline survey data showed that when presented with a description of a symptom complex in patients suggesting acute infection or risk for infection, their ability to select the proper PPE to execute the appropriate infection control bundle was low. The survey questions were challenging, mimicking the situation faced by front line staff when encountering a patient with symptoms of infection, requiring them to correctly identify a clinical syndrome based on the symptoms described, and select the proper infection prevention measures. Failure to recognize the need for isolation precautions has been shown to be a contributor to outbreaks in outpatient settings.[24] Our study demonstrated a low level of infection prevention and control literacy among healthcare personnel in the outpatient setting that may contribute to failure to apply proper isolation precautions. If transmission-based precautions are to be implemented effectively in outpatient settings, additional strategies, such as local infection control champions, may need to be employed to assist personnel in identifying cases requiring infection prevention precautions.

Education of healthcare personnel is an essential strategy in infection prevention and control. However, typical educational strategies alone are relatively weak at enhancing adherence to guidance, regulations and institutional policies.[15, 25] Dubbert et al. found that a series of classes about hand hygiene resulted in only temporary improvements in behavior. However, when they employed a strategy that was rooted in the daily practice of HCP, i.e., observation of behaviors and feedback, durable improvements were achieved.[26] Using these research methods, which align well with experiential educational strategies, attitudes toward medical masks and N95 respirators improved.

The origins of ResPECT are rooted in the response to the 2009 H1N1 influenza pandemic, and its findings are relevant to the current COVID-19 pandemic. After 2009, interest in pandemic preparedness, infection control, and prevention of viral respiratory illness was high, and funding was increased to study these topics.[27] However, interest quickly waned. It is a question not of if, but when, the next pandemic will occur and thus it is essential to learn the lessons of COVID-19 to be better prepared for the next pandemic. Prior to the COVID-19 pandemic, medical masks and respirators were often seen as a nuisance, whereas during the COVID-19 pandemic, they are recognized as essential measures for protection of HCP. Our study shows that many HCPs believed that masks and respirators would interfere with performing their duties; however, their attitudes improved with time and experience with the masks and respirators in the study. During the COVID-19 pandemic, due to mandatory mask policies for source control at most healthcare facilities, masks became necessary to allow HCPs to continue performing their duties safely.[28-30]

Participant survey data from ResPECT showed that HCP knowledge was lacking about the proper PPE and infection prevention measures required to diminish exposure to respiratory pathogens. Moving forward, it will be critical to increase infection control literacy among HCP. The COVID-19 pandemic has drawn increased attention to expanding the knowledge required for HCP to safely navigate the use of PPE. Supplies of PPE have frequently been low during the

Table 6
HCP knowledge of prevention bundles, analysis by occupation group with all scenarios combined

	Nursing Group				Provider Group				Clinical TechnicianSupport Staff				AdministrativeClericalRegistrationReceptionSocial WorkPastoral CareEnvironmental Services				Other			
Years Participated	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
N	991	536	273	76	281	123	71	22	352	230	115	46	497	247	119	33	358	121	65	10
Proportion of bundles correct (%)	13.0 (12.3 – 13.8)	15.8 (14.6 – 17.0)	15.3 (13.7 – 17.0)	17.9 (14.8 – 21.3)	20.9 (19.2 – 22.7)	23.0 (20.3 – 25.9)	25.6 (21.9 – 29.6)	27.9 (21.4 – 35.5)	12.8 (11.6 – 14.2)	15.7 (14.0– 17.5)	15.8 (13.4 – 18.5)	15.6 (12.0 – 19.9)	16.3 (15.1 – 17.6)	18.6 (16.9 – 20.5)	21.7 (19.1 – 24.7)	17.3 (13.0 – 22.7)	16.0 (14.6 – 17.4)	14.9 (12.6 – 17.4)	15.6 (12.6 – 19.2)	15.7 (9.0 – 26.0)
Proportion of bundles correct for all Years Combined (%)	14.3 (13.7 – 14.9)				22.4 (21.0 – 23.8)				14.3 (13.4 – 15.3)				17.7 (16.8 – 18.7)				15.7 (14.6 – 16.9)			
P value for trend	0.0001				0.0104				0.025				0.004				0.69			

COVID-19 pandemic, requiring health systems and HCP to make difficult decisions about re-use, extended use, and prioritization of N95 respirators for the highest risk situations. Knowledge among frontline HCP regarding safe practices should be reassessed.

ResPECT participants changed their beliefs and attitudes towards PPE by experiential learning in the context of a voluntary study. During COVID-19, the entire healthcare workforce has been subject to on-the-job experiential learning that may affect their opinions of, and adherence to, respirator and mask usage in the future. HCP attitudes towards PPE may have improved due to their experience during COVID-19, and perhaps widespread masking will become a permanent feature at healthcare facilities during influenza season. The lessons learned about HCP protection during the 2009-10 H1N1 influenza pandemic and the current COVID-19 pandemic can be used to inform ways to improve the culture of safety in healthcare delivery. Further research is needed to assess the effects of COVID-19 on these attitudes, beliefs, and knowledge about appropriate PPE and isolation precautions. Further educational efforts should aim to maintain the current high interest in infection control and pandemic preparedness to ensure that the lessons learned from COVID-19 are not forgotten before the next pandemic.

Our study has at least two limitations. Participants may differ from HCP who chose not to participate. Some participants did not respond to the surveys, yet paired surveys were available from 88.1% of participants, which compared favorably to other survey studies. Furthermore, survey respondents were similar to non-respondents in demographic measures and job description. The knowledge survey was administered only at the beginning of the season, limiting our ability to assess improvements in knowledge during the season. However, most HCP who participated for multiple seasons demonstrated improvement over successive seasons.

These results may inform efforts to improve HCP adherence with infection prevention and control procedures in the outpatient arena. When incentivized by study participation to adhere to processes toward which they had initial negative attitudes, HCP realized that medical masks and N95 respirators were comfortable enough to wear for patient encounters and interfered with their work processes less than expected. HCP knowledge of infection prevention and control precautions, as measured by their ability to recognize a description of a clinical syndrome and apply appropriate transmission-based precautions, was poor, suggesting a need for better infection prevention and control support and education in the outpatient setting.

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DISCLAIMER

The findings and conclusions in this manuscript are the authors' own and do not necessarily represent the views of the United States Government, the National Institute for Occupational Safety and Health, the Centers for Disease Control and Prevention, the Department of Veterans Affairs, or other affiliates. Mention of product names does not imply endorsement.

ROLES AND RESPONSIBILITIES

The principal investigators (LJR and TMP) had full access to all the data and final responsibility for the study design, protocol development, and decision to submit for publication. The site and affiliate lead investigators had a primary role in study monitoring, data management, statistical analyses, critical protocol review, study procedures, data collection, and reviewing and approving the protocol. The manuscript was drafted by the corresponding (first) author. All the authors critically reviewed, edited, and approved the manuscript and made the decision to submit it for publication. The final version of the manuscript was reviewed and approved for publication by the funding organizations. All authors assume responsibility for the accuracy and completeness of the data and for the fidelity of the study to the protocol.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.ajic.2021.06.011.

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