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Major article

Are health care workers protected? An observational study of selection and removal of personal protective equipment in Canadian acute care hospitals

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Key Words:

Infection prevention and control

Respiratory illness

Hand hygiene

Background: The proper use of personal protective equipment (PPE) by health care workers (HCWs) is vital in preventing the spread of infection and has implications for HCW safety.

Methods: An observational study was performed in 11 hospitals participating in the Canadian Nosocomial Infection Surveillance Program between January 7 and March 30, 2011. Using a standardized data collection tool, observers recorded HCWs selecting and removing PPE and performing hand hygiene on entry into the rooms of febrile respiratory illness patients.

Results: The majority of HCWs put on gloves (88%, n = 390), gown (83%, n = 368), and mask (88%, n = 386). Only 37% (n = 163) were observed to have put on eye protection. Working in a pediatric unit was significantly associated with not wearing eye protection (7%), gown (70%), gloves (77%), or mask (79%). Half of the observed HCWs (54%, n = 206) removed their PPE in the correct sequence. Twenty-six percent performed hand hygiene after removing their gloves, 46% after removing their gown, and 57% after removing their mask and/or eye protection.

Conclusion: Overall adherence with appropriate PPE use in health care settings involving febrile respiratory illness patients was modest, particularly on pediatric units. Interventions to improve PPE use should be targeted toward the use of recommended precautions (eg, eye protection), HCWs working in pediatric units, the correct sequence of PPE removal, and performing hand hygiene.

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Personal protective equipment (PPE) is used to protect health care workers (HCWs) and patients from health care-associated infections. Specifically, the appropriate PPE items must be selected and removed correctly to minimize the risk of exposure. However, several studies suggest that PPE use is inadequate¹⁻⁷ and that correct use varies by type of HCW⁸ and clinical area.⁹

Experience during the severe acute respiratory syndrome outbreak and the 2009 H1N1 influenza pandemic have highlighted the need for the appropriate use of PPE to reduce HCW exposure to respiratory infections.¹⁰⁻¹⁵ There are many published studies that have focused on hand hygiene compliance¹⁶⁻¹⁹ or the use of 1 type of PPE^{9,20} among HCWs. To our knowledge, there have been no observational studies examining overall PPE use among HCWs

entering and leaving the rooms of patients with febrile respiratory illness (FRI). We therefore conducted an audit to observe the selection and removal of PPE, as well as to determine when hand hygiene is performed by HCWs upon entry and exit into the rooms of FRI patients in Canadian hospitals.

METHODS

An observational study was conducted in 11 tertiary, acute care hospitals participating in the Canadian Nosocomial Infection Surveillance Program (CNISP) between January and March 2011. All hospital personnel (eg, nurses, physicians, housekeeping, laboratory technicians, respiratory therapists, and others) who entered the room of a patient with FRI were eligible for inclusion and are referred to generally as HCWs. FRI was defined as a patient with a fever $>38^{\circ}\text{C}$ and with a new or worsening cough or shortness of breath. Visitors and volunteers were excluded from this study. All hospital inpatient or Emergency Department (ED) units that cared for FRI patients were included; outpatient ambulatory care units other than ED were excluded.

The Public Health Agency of Canada's Infection Control Research Working Group adapted the audit form from an observational tool used to assess an online infection control course in British Columbia.²¹ The audit form was piloted by 6 CNISP participating hospitals from February 9 to April 10, 2010. Observers collected data on the selection and removal of PPE. Hand hygiene following the removal of gloves, gown and mask, and/or eye protection was also observed. Trained observers included infection control professionals or students who were provided with instructions on how to complete the audit form and how to best observe HCWs. Whereas staff on care units were not informed in advance of the audit, no attempt was made to disguise the purpose of the observations. Patient rooms in which the HCWs PPE selection and removal could not be observed were excluded (eg, an anteroom without a window). Signs were posted outside of patient rooms describing additional precautions and what PPE were required. The Public Health Agency of Canada's guidelines Prevention and Control of Influenza During a Pandemic for all Healthcare Settings (Annexe F) was used to determine PPE requirements for an FRI patient.²² Instructions for the correct procedure to remove PPE were provided on the audit form and were further defined, when necessary, according to the facility's infection prevention and control policy. The correct sequence of PPE removal was defined in the following order: gloves, gown, eye protection, and then mask.²² A mask was defined as either an N95 respirator or surgical (procedure) mask. Eye protection was defined as either a face shield/mask combination or goggles. Eyeglasses were not considered to be eye protection.²² Observers were asked to identify the occupation of the observed HCW to the best of their ability, without asking the HCW. If they did not know the occupation, they selected the "don't know" response. A nurse was defined as a nursing assistant, nursing aid, or registered nurse. Allied health professional included respiratory therapists, occupational therapists, laboratory technicians and x-ray technicians. A student was defined as an intern, a resident, or a health care profession student.

Because the study was observational and did not involve any alteration in patient care, informed consent from the patient and HCW were not required. Because auditing of infection prevention and control practices is part of routine infection prevention and control activities institutional ethics review board approval was not sought. The data collected were confidential; no personal identifying information was collected. Proportions were calculated to describe the study population and for each PPE item and hand hygiene moment by occupation and clinical area. Logistic regression was performed to identify associations between PPE use,

clinical areas, and occupations. Odds ratios were reported; 95% confidence intervals and *P* values reflect a 2-tailed α level of .05. Missing data and unable to assess responses were removed from all calculations. Statistical analysis was performed using Stata version 11 (StataCorp, College Station, TX).

RESULTS

There were 442 observations collected from 11 CNISP participating hospitals across 6 provinces. Thirty-four percent of the observations were collected from hospitals in Ontario ($n = 149$), 30% ($n = 131$) from Alberta, 9% ($n = 41$) from Manitoba, 9% ($n = 41$) from Nova Scotia, 9% ($n = 40$) from Québec, and 9% ($n = 40$) from British Columbia. Of the 434 observations for which occupation was reported, 53% ($n = 228$) were nurses, 13% ($n = 57$) were students, 12% ($n = 53$) were physicians, 10% ($n = 42$) were allied health professionals, and 4% ($n = 19$) were housekeeping staff. Forty-five percent of the observations were collected on a medical unit ($n = 200$), 27% ($n = 121$) on a pediatric unit, 16% ($n = 70$) on an intensive care unit (ICU), and 6% ($n = 27$) in an ED.

PPE selection

Thirty-four percent of HCWs ($n = 149$) put on all PPE (gloves, gown, mask, and eye protection). The majority of HCWs put on gloves (88%, $n = 390$), gown (83%, $n = 368$), and mask (88%, $n = 386$). Only 37% ($n = 163$) were observed to have put on eye protection. Of those HCWs who put on a mask, 71% ($n = 274$) put on a surgical mask; 18% ($n = 70$) put on an N95 respirator; and, in 11% ($n = 42$), the type of mask worn was not specified. Allied health professionals and students were significantly more likely to put on gloves than physicians, and students were also more likely to put on a mask than physicians (Table 1). HCWs working in a pediatric unit were significantly less likely to put on all PPE as compared with HCWs working in an ICU, an ED, or a medical unit (Table 2).

PPE removal

Of those HCWs who put on PPE, the majority correctly removed their gloves (87%, $n = 313$), gown (82%, $n = 282$), mask (72%, $n = 264$), and eye protection (74%, $n = 110$). Nurses, allied health professionals, and students were significantly more likely to correctly remove their masks than physicians (Table 1). HCWs working in an ICU were significantly more likely to correctly remove their masks than those working in a pediatric unit (Table 2).

Half of the observed HCWs (54%, $n = 206$) removed their PPE in the correct sequence. Nurses and housekeeping staff were significantly more likely to remove PPE in the correct sequence compared with physicians (Table 1). HCWs working in a pediatric unit were significantly less likely to remove PPE in the correct sequence as compared with those working in an ICU, an ED, or a medical unit (Table 2).

Hand hygiene

Twenty-six percent of HCWs ($n = 99$) performed hand hygiene after removing their gloves, 46% ($n = 163$) after removing their gown, and 57% ($n = 212$) after removing their mask and/or eye protection. Nine percent of HCWs ($n = 36$) did not perform any hand hygiene. Difference in hand hygiene moments between clinical areas and occupations are shown in Table 3.

DISCUSSION

Findings from our audit suggest that, whereas the majority of HCWs put on gloves, mask, and gown upon entry into the room of

Table 1
Logistic regression: Personal protective equipment selection and removal by occupation

	No. (%)	Odds ratio	95% CI	P value
Glove selection				
Physician	42 (79)	1	Reference	
Nurse	200 (88)	1.87	0.86-4.05	.112
Allied health professional*	40 (95)	5.24	1.09-25.12	.038
Student	53 (93)	3.47	1.03-11.68	.045
Housekeeping	18 (95)	4.71	0.57-39.29	.152
Gown selection				
Physician	43 (81)	1	Reference	
Nurse	188 (82)	1.09	0.51-2.36	.82
Allied health professional*	39 (93)	3.02	0.78-11.79	.111
Student	47 (82)	1.09	0.41-2.88	.857
Housekeeping	15 (79)	0.87	0.24-3.20	.837
Eye protection selection				
Physician	14 (26)	1	Reference	
Nurse	93 (41)	1.92	0.99-3.73	.055
Allied health professional*	14 (33)	1.39	0.57-3.38	.463
Student	15 (26)	0.99	0.43-2.32	.991
Housekeeping	8 (42)	2.03	0.68-6.07	.207
Mask selection				
Physician	42 (79)	1	Reference	
Nurse	201 (89)	2.02	0.93-4.41	.076
Allied health professional*	37 (88)	1.94	0.62-6.10	.258
Student	53 (93)	3.47	1.03-11.68	.045
Housekeeping	15 (79)	0.98	0.27-3.56	.978
Glove removal				
Physician	38 (97)	1	Reference	
Nurse	157 (84)	0.14	0.02-1.08	.059
Allied health professional*	32 (82)	0.12	0.01-1.03	.053
Student	47 (98)	1.24	0.08-20.43	.882
Housekeeping	141 (82)	0.12	0.01-1.28	.08
Gown removal				
Physician	31 (76)	1	Reference	
Nurse	150 (84)	1.67	0.74-3.77	.219
Allied health professional*	30 (79)	1.21	0.42-3.48	.724
Student	35 (81)	1.41	0.49-4.02	.519
Housekeeping	13 (67)	4.19	0.49-36.19	.192
Eye protection removal				
Physician	8 (67)	1	Reference	
Nurse	68 (78)	1.79	0.49-6.59	.382
Allied health professional*	9 (69)	1.13	0.21-6.05	.891
Student	11 (85)	2.75	0.40-18.88	.303
Housekeeping	5 (63)	0.83	0.13-5.40	.848
Mask removal				
Physician	21 (53)	1	Reference	
Nurse	144 (75)	2.71	1.35-5.47	.005
Allied health professional*	27 (75)	2.71	1.02-7.21	.045
Student	40 (82)	4.02	1.56-10.43	.004
Housekeeping	10 (67)	1.81	0.52-6.25	.349
Correct removal sequence				
Physician	15 (36)	1	Reference	
Nurse	110 (56)	2.20	1.14-4.54	.020
Allied health professional*	22 (55)	2.20	0.91-5.34	.081
Student	25 (50)	1.80	0.78-4.17	.170
Housekeeping	14 (78)	6.30	1.76-22.61	.005

CI, Confidence interval.

*Includes respiratory therapists, occupational therapists, laboratory technicians, and x-ray technicians.

an FRI patient, few put on eye protection or removed their PPE in the correct sequence. HCWs working in pediatric units were less likely to use PPE when entering the room of an FRI patient. Furthermore, hand hygiene was infrequently performed after the removal of PPE. These findings indicate breaches in PPE use and hand hygiene that may provide opportunities for the transmission of respiratory infections to HCWs and thus should inform infection prevention and control education of HCWs.

Overall, PPE selection was unsatisfactory because only 76% of HCWs wore mask, gown, and gloves upon entry into the room of an FRI patient, and even fewer HCWs (34%) were observed to have used eye protection. There are several potential reasons why PPE

Table 2
Logistic regression: Personal protective equipment selection and removal by clinical area

	No. (%)	Odds ratio	95% CI	P value
Glove selection				
Pediatric unit	93 (77)	1	Reference	
ICU	63 (90)	2.71	1.11-6.58	.028
Medical unit	185 (93)	3.70	1.89-7.29	<.001
Emergency department	27 (100)	—	—	—
Gown selection				
Pediatric unit	85 (70)	1	Reference	
ICU	62 (86)	3.28	1.43-7.55	.005
Medical unit	177 (89)	3.26	1.82-5.84	<.001
Emergency department	26 (96)	11.01	1.44-84.26	.021
Eye protection selection				
Pediatric unit	9 (7)	1	Reference	
ICU	37 (53)	13.95	6.11-31.85	<.001
Medical unit	94 (47)	11.04	5.30-22.98	<.001
Emergency department	11 (41)	8.56	3.07-23.84	<.001
Mask selection				
Pediatric unit	95 (79)	1	Reference	
ICU	64 (91)	2.92	1.14-7.49	.026
Medical unit	178 (89)	2.32	1.24-4.34	.008
Emergency department	26 (96)	7.12	0.92-54.94	.060
Glove removal				
Pediatric unit	78 (88)	1	Reference	
ICU	48 (91)	1.35	0.44-4.14	.595
Medical unit	148 (87)	0.91	0.42-1.96	.805
Emergency department	22 (85)	0.76	0.22-2.68	.688
Gown removal				
Pediatric unit	67 (82)	1	Reference	
ICU	48 (92)	2.69	0.84-8.6	.096
Medical unit	136 (80)	0.90	0.46-1.76	.748
Emergency department	20 (80)	0.90	0.29-2.77	.848
Eye protection removal				
Pediatric unit	7 (78)	1	Reference	
ICU	23 (85)	1.64	0.25-10.95	.608
Medical unit	63 (70)	0.67	0.13-3.42	.627
Emergency department	7 (70)	0.67	0.08-5.30	.702
Mask removal				
Pediatric unit	64 (68)	1	Reference	
ICU	47 (89)	3.67	1.41-9.53	.008
Medical unit	120 (70)	1.10	0.64-1.90	.724
Emergency department	17 (68)	0.10	0.39-2.56	.994
Correct removal sequence				
Pediatric unit	25 (28)	1	Reference	
ICU	53 (83)	12.53	5.65-27.78	<.001
Medical unit	94 (51)	2.75	1.60-4.73	<.001
Emergency department	19 (70)	6.18	2.40-15.90	<.001

CI, Confidence interval.

selection was not 100%. Although we did not collect data on availability of PPE, it is possible that PPE was not readily available.^{23,24} In addition, risk perception has been known to influence the use of PPE.^{4,25,26} For example, HCWs working in pediatric units may feel less at risk of being infected and therefore less likely to wear PPE. Time pressures, perceived or real, may also influence the decision to wear PPE and may explain the poor adherence with PPE in EDs and among physicians.

Findings from the literature have shown that inconsistent or improper use of PPE has been significantly associated with respiratory infection among HCWs.²⁷ Our study found that only half of HCWs were observed to remove their PPE in the correct sequence, thereby creating opportunities for self-contamination. Hand hygiene adherence was suboptimal. The literature describes possible methods to improve hand hygiene adherence such as increasing the number of private rooms and ensuring easy access to alcohol hand rub dispensers in and outside patient rooms.^{28,29} These are strategies that should be applied to improve hand hygiene performance after PPE removal.

Our study has several limitations. First, the Hawthorne effect is common in observational studies. This potential bias arises when

Table 3
Logistic regression: Hand hygiene by clinical area and occupation

	No. (%)	Odds ratio	95% CI	P value
HH after glove removal				
Pediatric unit	28 (31)	1	Reference	
ICU	12 (20)	0.57	0.26–1.23	.15
Medical unit	52 (29)	0.91	0.52–1.57	.73
Emergency department	1 (4)	0.85	0.01–0.66	.02
HH after gown removal				
Pediatric unit	52 (64)	1	Reference	
ICU	22 (37)	0.33	0.17–0.67	.002
Medical unit	77 (44)	0.44	0.25–0.75	.003
Emergency department	8 (31)	0.25	0.10–0.64	.004
HH after face and/or eye protection removal				
Pediatric unit	28 (32)	1	Reference	
ICU	55 (86)	13.1	5.68–30.20	<.001
Medical unit	95 (55)	2.60	1.52–4.50	<.001
Emergency department	17 (63)	4.00	1.61–10.20	.003
HH after glove removal				
Physician	8 (20)	1	Reference	
Nurse	57 (30)	1.68	0.73–3.86	.23
Allied health professional*	12 (30)	1.71	0.61–4.79	.30
Student	11 (22)	1.10	0.40–3.06	.86
Housekeeping	5 (28)	1.54	0.42–5.59	.51
HH after gown removal				
Physician	15 (36)	1	Reference	
Nurse	90 (50)	1.78	0.89–3.57	.10
Allied health professional*	17 (45)	1.45	0.59–3.58	.41
Student	19 (41)	1.27	0.54–3.00	.59
Housekeeping	9 (60)	2.70	0.80–9.06	.11
HH after face and/or eye protection removal				
Physician	17 (43)	1	Reference	
Nurse	118 (61)	2.07	1.04–4.13	.038
Allied health professional*	21 (62)	2.19	0.86–5.56	.101
Student	25 (49)	1.30	0.57–3.00	.536
Housekeeping	10 (67)	2.71	0.78–9.38	.117

CI, Confidence interval; HH, hand hygiene.

*Includes respiratory therapists, occupational therapists, laboratory technicians, and x-ray technicians.

the act of being observed influences the behavior of the individual being observed. It is possible that the presence of an auditor may have artificially increased adherence with PPE use. Nonetheless, observational studies have been very useful in demonstrating gaps in recommended infection prevention and control measures despite the potential for overestimation of adherence.^{1,3,7–9} Second, our findings may not be generalizable to all HCW populations because only HCWs in large, acute care, tertiary hospitals were observed. Finally, our findings included only those situations in which HCWs could be observed. If there was a systematic difference in the adherence to PPE and hand hygiene according to whether the HCW was or was not observed, this could have altered the findings of our study in a direction that is difficult to predict. Our sense is that PPE and hand hygiene would be performed even more poorly in situations in which the HCW could not be observed, and our findings actually represent a best case scenario.

Our audit highlights gaps in PPE selection and removal that may increase the opportunity for transmission of respiratory infections and that represent educational opportunities in the health care setting. Few HCWs selected eye protection for patients with FRI. Working in a pediatric unit was associated with not wearing PPE when entering the room of an FRI patient. Only half of HCWs removed their PPE in the correct sequence, and hand hygiene was not routinely performed after removal of PPE. Therefore, interventions to improve PPE use should be targeted toward the use of recommended precautions, HCWs working in pediatric units, the correct sequence of PPE removal, and performing hand hygiene.

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Coming Soon in AJIC

Device-associated infection rates, device use, length of stay, and mortality in intensive care units of 4 Chinese hospitals: International Nosocomial Control Consortium findings

Impact of participation in the California Healthcare-Associated Infection Prevention Initiative on adoption and implementation of evidence-based practices for patient safety and health care-associated infection rates in a cohort of acute care general hospitals

National Healthcare Safety Network (NHSN) Report, Data Summary for 2011, Device-associated Module