Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

American Journal of Infection Control 41 (2013) 8-13

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major article

Behind the mask: Determinants of nurse's adherence to facial protective equipment

Kathryn Nichol PhD *, Allison McGeer MD, Philip Bigelow PhD, Linda O'Brien-Pallas PhD, James Scott PhD, D. Linn Holness MD

Occupational Health Services Program, St Michael's Hospital, Toronto, ON, Canada

Key Words:
Health care workers
Respiratory protection
Communicable respiratory illness
Adherence
N95 respirator
Surgical mask
Eye protection
Acute care hospital

Background: As the predominant occupation in the health sector and as the health worker with the most patient interaction, nurses are at high risk for occupational transmission of communicable respiratory illness. The use of facial protective equipment (FPE) is an important strategy to prevent occupational transmission.

Methods: A 2-phased study was conducted to examine nurse's adherence to recommended use of FPE. Phase 1 was a cross-sectional survey of nurses in selected units of 6 acute care hospitals in Toronto, Canada. Phase 2 was a direct observational study of critical care nurses.

Results: Of the 1,074 nurses who completed surveys (82% response rate), 44% reported adherence to recommended use of FPE. Multivariable analysis revealed 6 predictors of adherence: unit type, frequency of equipment use, equipment availability, training, organizational support, and communication. Following the survey, 100 observations in 14 intensive care units were conducted that revealed a 44% competence rate with proper use of N95 respirators and knowledge as a significant predictor of competence.

Conclusion: Whereas increasing knowledge should enhance competence, strategies to improve adherence to recommended use of FPE in a busy and complex health care setting should focus on ready availability of equipment, training and fit testing, organizational support for worker health and safety, and good communication practices.

With the recent decade of health threats from respiratory infections (severe acute respiratory syndrome [SARS], avian influenza, bioterrorism events, H1N1), there is heightened concern about occupational transmission of communicable respiratory illnesses in health care. Important primary prevention efforts include vaccination, hand hygiene, and use of personal protective equipment. Protection efforts are hindered by a lack of data on modes of transmission of respiratory pathogens such as influenza, on effectiveness of protection provided by different types of equipment, and on how to ensure adherence to safe work practices.[1]

Adherence to personal protective equipment generally has been identified as a long-standing problem in the health sector, and most proposed solutions have either had minimal impact or been unsustainable. Adherence to personal protective equipment (such as gloves) to prevent the spread of bloodborne disease is an area that has been well studied.[2] Adherence to facial protective equipment (FPE) (respirators, surgical masks, eye/face protection) to prevent the spread of communicable respiratory illness has only recently become the focus of research. Studies have shown that adherence to FPE was the most problematic of all types of personal protective equipment in health care.[3-5]

Recent survey-based studies of adherence used contextual models that examined the environment within which the person operates.[6] A revised version of the PRECEDE (Predisposing, Reinforcing and Enabling Constructs in Educational Diagnosis and Evaluation) model,[7] Moore et al's theoretical framework[8] was used in a pilot study to examine nurse's adherence to recommended use of FPE and categorized factors influencing adherence as individual, environmental, and organizational. Results from the pilot study suggested that environmental and organizational factors were the most significant predictors of nurse's adherence.[9] We report the results of a larger and more comprehensive study of nurse's

* Address correspondence to Kathryn Nichol, PhD, 30 Bond Street, Toronto, ON, Canada.

E-mail address: k.nichol@utoronto.ca (K. Nichol).

Supported by the Research Advisory Council of the Workplace Safety and Insurance Board of Ontario.

Conflicts of interest: None to report.

doi:10.1016/j.ajic.2011.12.018

adherence to recommended use of FPE to identify determinants of adherence that can be used to implement interventions to improve adherence, reduce illness, and enhance the work and health of nurses.

METHODS

This study used a 2-phased approach. Phase 1 was a cross-sectional survey of nurses who were regularly required to use FPE at work. Phase 2 was a direct observational study of nurses using FPE in the intensive care unit (ICU) setting. Funding for the study was granted by the Research Advisory Council of the Workplace Safety and Insurance Board of Ontario.

Six acute care hospitals in the Greater Toronto Area participated. Ethics approval was obtained from the administering hospital and all participating hospitals. The chief nursing executive at each hospital identified units where FPE was regularly worn by nursing staff including ICUs, emergency departments, and in-patient medical units that regularly received patients with respiratory symptoms. The researcher conducted 4 visits to each unit, each 2 to 4 hours in length, to recruit participants. Consent for phase 1 of the study was implied when participants agreed to complete the questionnaire. In all units except the ICUs, the survey was anonymous.

During phase 1 of the study, written consent was obtained from ICU nurses for participation in phase 2. One to 3 months after phase 1, a trained research assistant attempted to covertly observe participating nurses on 2 separate visits to evaluate adherence to FPE. If an opportunity for observation did not occur after 2 attempts, the observer identified themselves and requested a demonstration of donning and doffing FPE for a patient requiring airborne precautions. These demonstrations allowed an evaluation of competence (the demonstrated ability to apply knowledge and skills) but not an evaluation of adherence (the degree to which an individual follows a set of guidelines in real life).[10,11]

Measures

Survey tool

For this study, 3 measures were added to our previous survey tool,[9] resulting in an 8 page, 84-item questionnaire (available on request).

Participant observation record and guide

A 2-page observation record was developed for phase 2, based on observation tools to measure adherence to hand hygiene[12-15] and government and manufacturer guidelines.[16-18] Each participating organization reviewed and approved the tool. The research assistant used an observation guide to ensure consistency.

Definitions

In phase 1, adherence was defined as present when the participant answered always or mostly to at least 7 of the 8 items within the adherence scale. In phase 2, adherence (or competence for demonstrations) was defined as present when the participant carried out at least 5 of 6 critical steps when using FPE for a patient on respiratory precautions.

Statistical analysis

Data entry was carried out in Microsoft Access and Excel (Microsoft Corp, Redmond, WA), and data were analyzed using Statistical Analysis Software (SAS Institute, Cary, NC) version 9.1.3.[19] Initially, the data were cleaned and edited, and summary descriptive statistics were computed on all variables. Reliability of scales was assessed using Cronbach coefficient α. Exploratory factor analysis was performed using the principal components analysis with an oblique rotation (promax).[20,21] The χ^2 test for categorical data and the Wilcoxon rank-sum test for non-normally distributed continuous variables were used in bivariate analysis. Variables of theoretical importance and those with a P value $< .1$ were selected for inclusion in multivariable logistic regression models to determine those factors with independent predictive value.[22] The backward elimination logistic procedure was used to analyze the effect of specific interactions. Interactions between the following organizational level variables were examined: training and organizational support, training and absence of job hindrances, organizational support and absence of job hindrances, training and communication, organizational support and communication and absence of job hindrances and communication. These were identified as potential interactions of interest because of their inherent relationships in the workplace.

RESULTS

Phase 1: Cross-sectional survey

Demographics

Of the 1,313 surveys distributed, 1,074 were completed for a response rate of 82%. This represented 51% of the 2,127 nurses employed on the 46 units at the time of the study. Most respondents were female registered nurses working full-time (Table 1).

Adherence

Forty-four percent of survey respondents met the case definition of adherence. Twenty-five percent answered “always” or “mostly” to all 8 items.

Multivariable analysis

Eighteen variables with a bivariate P value $< .10$ were selected for inclusion in the stepwise logistic regression model in an effort to take number of predictors, previous literature, and correlations among predictors into account. Six predictors of adherence were revealed (Table 2).

Further analysis examining interactions between organizational level variables revealed the same predictors of adherence with similar odds ratios as the model described above, but the effect of training and fit testing depended on an absence of job hindrances ($P = .025$).

Table 1
Demographic characteristics of survey population: N = 1,074

Variable	Level	n (%)
Sex	Female	976 (91)
Nurse type	RN	1,018 (95)
	RPN	54 (5)
Education	Certificate	42 (4)
	Diploma	496 (47)
	Degree	487 (46)
	Master's	38 (4)
Work status	Full-time	816 (77)
Supervisor status	Yes	502 (47)
Age, yr	38.8 (20-67)*	
Tenure as a nurse, yr	14.4 (0-49)*	
Tenure on the unit, yr	6.5 (0-36)*	
Hospital type	Community	581 (54)
	Teaching	493 (46)
Unit type	Critical care	393 (37)
	Emergency	308 (29)
	Medicine	355 (34)

RN, registered nurse; *RPN*, registered practical nurse.
*Sample mean (range).

Table 2
Adjusted odds ratios for adherence to recommended use of FPE: c = 0.77*

Variable category	Variable	Level	*P* value	Odds ratio (95% CI)
Demographic	Tenure as a nurse	Mean	.31	1.01 (0.99-1.03)
	Education	Degree vs no degree	.15	1.34 (0.9-1.98
	Hospital	B vs A	.82	1.09 (0.51-2.31)
		C vs A	.14	1.77 (0.83-3.8)
		D vs A	.31	1.45 (0.69-3.25)
		E vs A	.13	2.06 (0.8-5.25
		F vs A	.13	1.74 (0.86-3.51)
	Unit type	Emergency vs critical care	<.0001	0.41 (0.26-0.64)
		Medical vs critical care	.32	1.25 (0.8-1.96)
Individual	Frequency of use	Daily/weekly/monthly vs rarely/never	.0029	2.45 (1.36-4.42)
	Knowledge: using FPE ($\alpha = .42$)	Knowledgeable vs not	.16	1.3 (0.9-1.87)
	Knowledge: transmission of Influenza ($\alpha = 0.53$)	Knowledgeable vs not	.18	1.28 (0.89-1.83)
	Effectiveness of preventative actions ($\alpha = .35$)	Perceived preventative actions to be effective vs not	.08	1.42 (0.96-2.09)
	Health effects (self) ($\alpha = .79$)	Contracted occupational illness or suffered adverse health effects vs not	.0504	0.68 (0.46-1.001)
	Personal barriers to using FPE ($\alpha = .92$)	Reported personal barriers to using FPE vs no personal barriers	.27	0.78 (0.5-1.21)
Environmental	Cleanliness/orderliness of unit ($\alpha = .89$)	Perceived unit clean/orderly vs no	.88	0.97 (0.64-1.46)
	Availability of FPE ($\alpha = .92$)	Perceived FPE to be available vs no	.03	1.53 (1.05-2.22)
	Media coverage ($\alpha = .89$)	Reported media influenced work vs not	.88	1.03 (0.71-1.5)
Organizational	Training and fit testing ($\alpha = .92$)	Trained and fit tested vs not	.009	1.66 (1.32-2.43)
	Knowledge of N95	Knew N95 fit tested for vs did not know	.14	1.31 (0.91-1.88)
	Organizational support for H&S ($\alpha = .87$)	Perceived organizational support vs not	.003	1.98 (1.27-3.09)
	Absence of job hindrances ($\alpha = .78$)	Perceived absence of job hindrances vs not	.64	0.91 (0.61-1.34)
	Communication ($\alpha = .9$)	Perceived positive communication in workplace vs not	.002	2.13 (1.31-3.44)

CI, confidence interval; *H&S*, health and safety.
*The c-statistic was used to measure goodness-of-fit of the logistic model. A value > .7 indicates acceptable discriminative power.[22]

Phase 2: Participant observations

Demographics

Forty-two percent (140) of ICU nurses completing the survey consented to participate in the observational component: 112 observations were completed (80%). There were no statistically significant differences in the demographic characteristics between the survey population (n = 1,074) and the observational study population (n = 112) except those that would be expected (hospital type, unit type, and nurse type), and no differences between nurses who participated and those who did not (Table 3).

Competence

Of the 112 observations, only a small percentage were true observations; a result of the relative rarity of nurses being assigned to care for patients on precautions requiring facial protection. Thus, competence (but not adherence) in airborne precautions was evaluated. In 44% of evaluable episodes, nurses demonstrated competence when using a disposable N95 respirator (Table 4).

Multivariable analysis

Three variables with a bivariate *P* value <.20 and 1 variable of theoretical importance (fit tested within the last 2 years) were selected for inclusion in multivariable analysis; only knowledge of recommended use of FPE was retained in the final model (Table 5).

DISCUSSION

Demographics

According to the 2007 Canadian Nurses Association *RN Workforce Profiles by Area of Responsibility*, this cross-sectional survey sample of 1,074 nurses was generally representative of the population of nurses working in Canadian acute care hospitals regarding age and gender, although the study population had a higher proportion of nurses working full-time and educated at a baccalaureate level.[23]

Adherence to recommended use of FPE

Consistent with previous reports, fewer than half of nurses met the criteria for adherence to recommended use of FPE.[3,4,24-31] This

Table 3
Demographic characteristics of the observational study population and comparison of critical care nurses who were observed and not observed

Variable	Level	Observed, n = 112, n (%)	Not observed, n = 281, n (%)	*P* value
Sex	Female	99 (88)	254 (90)	.55
Nurse type	RN	112 (100)	281 (100)	n/a
Education	Certificate	4 (3.5)	4 (1)	.45
	Diploma	54 (48)	130 (47)	
	Degree	51 (46)	132 (47)	
	Master's	3 (2.5)	13 (5)	
Work status	Full-time	87 (78)	215 (77)	.82
Supervisor status	Yes	24 (22)	124 (44)	.12
Age, yr*		39.7 (21-61)	40.7 (20-63)	.44
Tenure as a nurse, yr*		15.3 (0-39)	16 (0-40)	.78
Tenure on the unit, yr*		7.4 (0-30)	7.3 (0-30)	.96
Hospital type	Community	49 (44)	150 (53)	.08
	Teaching	63 (56)	131 (47)	
Unit type	Critical care	112 (100)	281 (100)	n/a

RN, registered nurse.
NOTE. The χ^2 significance test used unless otherwise indicated.
*Sample mean (range) and Wilcoxon rank-sum test for non-normally distributed continuous variables used.

Table 4
Descriptive findings for observational study: n = 100

Variable	Level	n (%)
Six critical steps	1. Chose N95 respirator	100 (100)
	2. Straps positioned correctly	76 (76)
	3. Adjust nose piece	92 (92)
	4. Seal check	24 (24)
	5. Refrain from touching face piece	39 (40)*
	6. Direct disposal	98 (100)*
Level of competence	Carried out 6/6 steps	11 (11)*
	Carried out at least 5/6 steps	43 (44)*
	Carried out at least 4/6 steps	79 (81)*
	Carried out at least 3/6 steps	93 (95)*
	Carried out at least 2/6 steps	98 (100)*
Eye protection	Wore eye protection	74 (74)
Fit tested for this respirator	Yes	79 (80)

*N = 98 because 2 nurses went behind curtains during use and doffing/disposal.

long-standing problem of substandard adherence to safe work practices in health care highlights not only the need for improvement but also the need for novel approaches.

In this study, adherence was defined as answering "always" or "mostly" to 7 of 8 items identified by federal and provincial government sources as critical to the protection of workers. Although this definition may seem stringent, nonadherence to any one item could result in disease transmission so that the self-reported adherence rate of 44% may actually be an overestimate.

Competence with recommended use of N95 respirators

Fewer than half of observed nurses demonstrated competence when using an N95 respirator. This is true despite the Toronto SARS experience and the resulting attention to worker protection against communicable respiratory illness. In the literature, observational studies of adherence with safe work practices were limited because of a myriad of organizational and environmental barriers, and no studies were found that examined competence in place of adherence. To mitigate barriers, most studies used only partial measures of adherence,[24-26,32] and findings were likely overestimates of true observed adherence. Even though barriers to evaluating observed adherence were anticipated and experienced in our study, comprehensive definitions of outcome variables were used to provide more accurate findings.

Determinants of adherence

As in previous studies, most demographic factors were not associated with adherence to infection control procedures.[6] However, unit type was a significant predictor of adherence, with emergency room nurses 60% less likely to report adherence than critical care nurses. This is consistent with several studies that found adherence to safe work behaviors was better among ICUs than in other types of units[33,34] and a report that found rates of adherence to be lowest in emergency departments.[35] The reasons for this have not been elucidated but may lie in the work environment. Emergency room nurses may report higher nonadherence because of the fast-paced, busy work environment where clinical practice is focused on making rapid diagnoses, managing crises, and dealing with unanticipated events.

Individual factors

Similar to demographic factors, individual factors have not been found to be consistently associated with adherence to infection control practices.[6,36-38] In this study, the only individual factor significantly associated with adherence was routine (daily, weekly, or monthly) use of FPE. Although this relationship may have some inherent contributory bias, it may have implications for policy and practice. If organizations could designate a relatively limited number of staff to care for patients with communicable respiratory illness, this might result in better staff adherence to FPE. Other benefits of such cohorting could include the following: concentrating resources in 1 area, making it possible to designate certain equipment for use with patients and thereby reduce the risk of possible fomite transmission; facilitation of concentrated infection control activities; and the physical separation of patients from others in the hospital.[39] However, limiting the number of experienced workers could also be a problem if the regular cohort of workers were to be depleted through absences because of illness or redeployment. In addition, less experienced workers caring for patients mistakenly thought to be low risk might also result in an overall increase in transmission risk.

Environmental factors

This study was consistent with the literature supporting a relationship between availability of equipment and adherence to FPE.[2,40] The measure of "ready" availability used in this study was supported by the literature examining compliance with universal precautions[37,41] and was defined as equipment being available at point-of-use, meaning less than 3 m away from the room entrance.[13] From a policy and practice perspective, it is important for organizational leaders to develop a system to ensure ready availability of individual-specific equipment on all patient care units.

Organizational factors

Organizational factors were identified in the literature as the most important determinant of adherence to safe work behaviors to prevent the transmission of bloodborne disease[2,36-38,42] and communicable respiratory illness.[8,43] In this study, 3 organizational level variables showed a significant relationship with adherence: training and fit testing, organizational support, and good communication. These findings highlight the importance of implementing measures that support an organizational climate of safety in health care.

Training and fit testing

Whereas only half of the survey population reported being trained and fit tested within the last 2 years, those who were trained and fit tested were 1.66 times more likely to report adherence with recommended use of FPE. Similar results were

Table 5
Adjusted odds ratios for competence with recommended use of an N95 respirator: c = .7

Variable category	Variable	Level	*P* value	Odds ratio (95% CI)
Individual	Frequency of use	Daily/weekly/monthly vs rarely/never	.12	0.25 (0.05-1.4)
	Knowledge: using FPE	Knowledgeable	.02	2.9 (1.2-7.2)
Environmental	Fit tested in last 2 years	Fit tested	.33	0.58 (0.19-1.76)
Organizational	Absence of job hindrances	Perceived absence of job hindrances	.08	2.3 (0.92-5.6)

CI, confidence interval.

reported in the literature.[2,6,40,42] Regular cycles of education, refresher training, verification of knowledge transfer, and further research into identifying the formative training and continuing education strategies that are most effective are critical. That the effect of training and fit testing on adherence was dependent on an absence of job hindrances such as a heavy workload or a lack of time highlights the importance of processes, such as coverage on the unit, to facilitate attendance at training and fit testing sessions.

Organizational support

Nurses who perceived their organization supported the health and safety of employees were almost 2 times more likely to report adherence to recommended use of FPE. This finding is also consistent with previous research on universal precautions[2,38,44] and adherence with general infection control practices to prevent the spread of communicable respiratory illness.[8] This relationship highlights how important it is that nurses think their health and safety is valued by their employer. At the policy level, interventions targeted at developing and implementing policies and procedures and establishing steps to follow in proper use of FPE should be carried out. At the unit level, front-line managers should involve workers in issues related to FPE and enforce adherence with legislation and workplace policy.

Communication

Nurses who perceived good communication regarding health and safety within their organization were 2.13 times more likely to report adherence to recommended use of FPE. Again, this finding was consistent with the literature.[45,46] The communication scale used in the survey also included elements of feedback on performance, which has been previously reported to predict adherence.[2,36,47]

Each of the 3 organizational predictors of adherence (training and fit testing, organizational support, and good communication), along with the environmental level predictor "ready availability of FPE," are important components of an organization's safety climate, itself an important predictor of worker adherence to safe work behaviors in health care.[2,6,9,44,48,49]

Determinants of competence

Results of the observational study showed nurses who were knowledgeable in the recommended use of FPE were 2.9 times more likely to demonstrate competent use of an N95 respirator. Because competence was measured outside of the work environment, it makes sense that it would be influenced by an individual level factor such as knowledge. Measuring competence through worker demonstration eliminates the interaction between the worker and the work environment that is so critical when measuring adherence. Of interest, the organizational variable "absence of job hindrances," although of borderline statistical significance, is quite a strong predictor of competence, with an odds ratio of 2.3.

In the nursing literature, much attention has been given to the measurement of competence versus performance or adherence. Although manual skills have been identified as the foundation of nursing performance and continue to be the focus of evaluation in the academic environment, many disagree with this competence-based model of training and evaluation for the same reasons that we chose to use a framework for evaluating adherence that explored organizational characteristics and the work environment.

Limitations

Results of this study may not be generalizable to all professions, geographic locations, or type of health care facility. The utilization of a cross-sectional study design precluded the determination of causality. Self-selection bias may have been a limitation because participation in the study was voluntary. Self-selection bias was likely minimized by the high participation rate. Subject recall and social desirability bias may have been a problem given the reliance on self-report data but would have been mitigated through survey anonymity. Survey results were based on subjective data. Reliability testing for 3 of the explanatory measures fell below the acceptable range ($<.70$). Similar results were reported in the pilot study and are likely due to variables inherently representing multiple content domains (types of illness, modes of transmission, and types of equipment). Because of a low number of patients on respiratory precautions, adherence could not be evaluated in the observational study. Multivariable analysis of the predictors of competence found knowledge to be a significant predictor, but a wide confidence interval suggested that a larger sample size was needed.

Areas of future research

This study has generated several important areas of future research in the areas of improving adherence to infection control practices, understanding the relationship between competence and adherence, and evaluating observational study methodologies in the acute health care setting. The most important determinants of adherence to recommended use of FPE were found to be the organizational characteristics of the workplace. As a follow-up to this study, intervention studies testing different strategies targeting these organizational dimensions are needed. Competence with recommended use of an N95 respirator for a patient on airborne precautions was examined in phase 2 of this study, and knowledge was found to be the primary determinant of competence. No relationship between self-reported adherence and observed competence was found in this study, but one could hypothesize that, whereas competence does not always lead to effective performance or adherence, it could be seen as one of its many determinants. Further research examining the relationship between competence and adherence would be valuable. This area of research is particularly important because studies of observed adherence to recommended use of FPE are logistically difficult in the acute health care sector. Finally, the examination of different methodologies for investigating adherence to FPE could be part of future research studies. Using the current methodology, we were unable to measure observed adherence but were able to measure competence. The future areas of research generated by this study provide exciting opportunities for researchers to advance the current body of knowledge on adherence to important infection control practices. It also provides opportunities to merge fields of study that have traditionally not been linked.

CONCLUSION

This study highlights the historical problem of substandard adherence to safe work practices in health care and the need for a novel approach to this complex issue. Findings demonstrated that, despite the SARS experience and the resulting investment in worker protection, nurse's adherence to recommended use of FPE and competence with recommended use of an N95 respirator remains suboptimal. Whereas knowledge was found to predict competence, organizational factors and other safety climate dimensions were the primary determinants of adherence to recommended use of FPE. Interventions targeting these determinants

should support the reduction of occupational transmission of communicable respiratory illness, better protect health care workers, and strengthen the workforce that is so critical to the success of our Canadian public health system.

References

1. Institute of Medicine. Preparing for an influenza pandemic: personal protective equipment for healthcare workers. Washington [DC]: The National Academies Press; 2008.
2. Gershon R, Karkashian C, Grosch J, Murphy L, Escamilla-Cejudo A, Flanagan P, et al. Hospital safety climate and its relationship with safe work practices and workplace exposure incidents. Am J Infect Control 2000;28:211-21.
3. Park B, Peck A, Kuehnert M, Newbern C, Smelser C, Comer J, et al. Lack of SARS transmission among healthcare workers, United States. Emerg Infect Dis 2004; 10:244-8.
4. Loeb M, McGeer A, Henry B, Ofner M, Rose D, Hlywka T, et al. SARS among critical care nurses, Toronto. Emerg Infect Dis 2004;10:251-5.
5. Yassi A, Moore D, Fitzgerald J, Bigelow P, Hon C, Bryce E. Research gaps in protecting healthcare workers from SARS and other respiratory pathogens: an interdisciplinary, multi-stakeholder, evidence-based approach. J Occup Environ Med 2005;47:41-50.
6. Gershon R, Vlahov D, Felknor S, Vesley D, Johnson P, Delclos G, et al. Compliance with universal precautions among health care workers at three regional hospitals. Am J Infect Control 1995;23:225-36.
7. Green L, Kreuter M, Deeds S, Partridge K. Health education planning: a diagnostic approach. Palo Alto [CA]: Mayfield; 1980.
8. Moore D, Gilbert M, Saunders S, Bryce E, Yassi A. Occupational health and infection control practices related to severe acute respiratory syndrome: health care worker perceptions. J Am Assoc Occup Health Nurses 2005;53:257-66.
9. Nichol K, Bigelow P, O'Brien-Pallas L, McGeer A, Manno M, Holness L. The individual, environmental and organizational factors that influence nurses' use of facial protection to prevent occupational transmission of communicable respiratory illness in acute care hospitals. Am J Infect Control 2008;36:481-7.
10. Kak N, Burkhalter B, Cooper M. July 2001. Measuring the competence of health providers. USAID Health Care Improvement Project. Available from: http://www.hciproject.org/node/925. Accessed September 8, 2009.
11. International Organization for Standardization. ISO 9000 Quality management. Geneva [Switzerland]: ISO; 2000.
12. World Health Organization. Tools for evaluation and feedback. World Health Organization. Available from: http://www.who.int/gpsc/5may/tools/evaluation_feedback/en/index.html; 2006. Accessed September 11, 2009.
13. Institute for Healthcare Improvement. How-to guide: improving hand hygiene—a guide for improving practices among health care workers. The Society for Healthcare Epidemiology of America. Available from, http://www.shea-online.org/Assets/files/IHI_Hand_Hygiene.pdf; 2006. Accessed September 11, 2009.
14. Ontario Ministry of Health and Long-Term Care. February 2006. Hand hygiene observation tool. Just Clean Your Hands. Available from: http://www.oahpp.ca/services/jcyh/index.html. Accessed September 11, 2009.
15. Pashman J, Bradley E, Wang H, Higa B, Fu M, Dembry L. Promotion of hand hygiene techniques through use of a surveillance tool. J Hosp Infect 2007;66: 249-54.
16. Public Health Agency of Canada. Routine practices and additional precautions for preventing the transmission of infection in health care: revision of isolation and precaution techniques. Public Health Agency of Canada. Available from: http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/99vol25/25s4/; 1999. Accessed June, 2009.
17. Ontario Ministry of Health and Long-Term Care. Emergency infection control kit: donning and removal of personal protective equipment. Ontario Ministry of Health and Long-Term Care. Available from: http://www.health.gov.on.ca/english/providers/program/emu/emerg_kit/kit_donning.html; 2003. Accessed July 30, 2009.
18. 3M Company. March 26, 2004. 3M fitting instructions for 3M filtering facepiece respirators. Available from: http://multimedia.3m.com/mws/mediawebserver?mwsId=66666UuZjcFSLXTtMXMc5x46EVuQEcuZgVs6EVs6E666666–&fn=10003_FacepieceRespirator.pdf. Accessed July 30, 2009.
19. SAS Institute, Inc. SAS Software Version 9.1. Cary [NC]: SAS Institute, Inc; 2005.
20. Conway J, Huffcutt A. A review and evaluation of exploratory factor analysis practices in organizational research. Organ Res Methods 2003;6:147-68.
21. Ford J, MacCallum R, Tait M. The application of exploratory factor analysis in applied psychology: a critical review and analysis. Personnel Psychol 1986;39: 291-314.
22. Hosmer D, Lemeshow S. Applied logistic regression. second edition. New York [NY]: John Wiley & Sons, Inc; 2000.
23. Canadian Nurses Association. RN workforce profiles by area of responsibility. Canadian Nurses Association. Available from: http://multimedia.3m.com/mws/mediawebserver?mwsId=66666UuZjcFSLXTtMXMc5x46EVuQEcuZgVs6EVs6E666666–&fn=10003_FacepieceRespirator.pdf; July 2009. Accessed December 14, 2009.
24. Tokars J, McKinley G, Otten J, Woodley C, Sordillo E, Caldwell J, et al. Use and efficacy of tuberculosis infection control practices at hospitals with previous outbreaks of multidrug-resistant tuberculosis. Infect Control Hosp Epidemiol 2001;2:449-55.
25. Kellerman S, Saiman L, San Gabriel P, Besser R, Jarvis W. Observational study of the use of infection control interventions for mycobacterium tuberculosis in pediatric facilities. Pediatr Infect Dis J 2001;20:566-73.
26. Sutton P, Nicas M, Reinisch F, Harrison R. Evaluating the control of tuberculosis among healthcare workers: adherence to CDC guidelines of three urban hospitals in California. Infect Control Hosp Epidemiol 1998;19:487-93.
27. Shigayeva A, Green K, Raboud J, Henry B, Simor A, Vearncombe M, et al. Factors associated with critical-care healthcare workers' adherence to recommended barrier precautins during the Toronto severe acute respiratory syndrome outbreak. Infect Control Hosp Epidemiol 2007;28:1275-83.
28. Skowronski D, Li Y, Tweed S, Tam T, Petric M, David S, et al. Protective measures and human antibody response during an avian influenza H7N3 outbreak in poultry in British Columbia, Canada. Can Med Assoc J 2007;176:47-53.
29. Morgan O, Kuhne M, Nair P, Verlander N, Preece R, McDougal M, et al. Personal protective equipment and risk for avian influenza (A7N3). Emerg Infect Dis 2009;15:59-62.
30. Centers for Disease Control and Prevention. Interim guidance for infection control for care of patients with confirmed or suspected novel influenza A (H1N1) virus infection in a healthcare setting. Centers for Disease Control and Prevention. Available from: http://www.cdc.gov/h1n1flu/guidelines_infection_control.htm; May 13, 2009. Accessed September 8, 2009.
31. Perez-Padilla R, de la Rosa-Zamboni D, Ponce de Leon S, Hernandez M, Quiñones-Falconi F, Bautista E, et al. Pneumonia and respiratory failure from swine-origin Influenza A (H1N1) in Mexico. N Engl J Med 2009;361:1-10.
32. Biscotto C, Pedroso E, Starling C, Roth V. Evaluation of N95 respirator use as a tuberculosis control measure in a resource-limited setting. Int J Tuberc Lung Dis 2005;9:545-9.
33. Clock S, Cohen B, Behta Pharm M, Ross B, Larson E. Contact precautions for multidrug-resistant organisms: current recommendations and actual practice. Am J Infect Control 2011;39:839-43.
34. Duggan J, Hensley S, Khuder S, Papadimos T, Jacobs L. Inverse correlation between level of professional education and rate of handwashing compliance in a teaching hospital. Infect Control Hospl Epidemiol 2008;29:534-8.
35. Creedon S, Slevin B, De Souza V, Mannix M, Quinn G, Boyle L, et al. Hand hygiene compliance: exploring variations in practice between hospitals. Nurs Times 2008;104:32-5.
36. DeJoy D, Murphy L, Gershon R. The influence of employee, job/task, and organizational factors on adherence to universal precautions among nurses. Int J Ind Ergon 1995;16:43-55.
37. DeJoy D, Searcy C, Murphy L, Gershon R. Behavioral-diagnostic analysis of compliance with universal precautions among nurses. J Occup Health Psychol 2000;5:127-41.
38. McGovern P, Vesley D, Kochevar L, Gershon R, Rhame F, Anderson E. Factors affecting universal precautions compliance. J Bus Psychol 2000;15:149-61.
39. Srinivasan A, McDonald L, Jernigan D, Helfand R, Ginsheimer K, Jernigan J, et al. Foundations of the Severe Acute Respiratory Syndrome preparedness and response plan for healthcare facilities. Infect Control Hosp Epidemiol 2004;25: 1020-5.
40. Lau J, Fung K, Wong T, Kim J, Wong E, Chung S, et al. SARS transmission among hospital workers in Hong Kong. Emerg Infect Dis 2004;10:280-6.
41. Green-McKenzie J, Gershon R, Karkashian C. Infection control practices among correctional healthcare workers: effect of management attitudes and availability of protective equipment and engineering controls. Infect Control Hosp Epidemiol 2001;22:555-9.
42. Michalsen A, Delclos G, Felknor S, Davidson A, Johnson P, Vesley D, et al. Compliance with universal precautions among physicians. J Occup Environ Med 1997;39:130-7.
43. Yassi A, Lockhart K, Copes R, Kerr M, Corbiere M, Bryce E, et al. Determinants of healthcare workers' compliance with infection control procedures. Healthc Q 2007;10:44-52.
44. Rivers D, Aday L, Frankowski R, Felknor S, White D, Nichols B. Predictors of nurses' acceptance of an intravenous catheter safety device. Nurs Res 2003;52: 249-55.
45. Bero L, Grilli R, Grimshaw J, Harvey E, Oxman A, Thomson M. Closing the gap between research and practice: an overview of systematic reviews of interventions to promote implementation of research findings by health care professionals. Br Med J 1998;317:465-8.
46. Digiacomo J, Hoff W, Rotondo M, Martin K, Kauder D, Anderson H, et al. Barrier precautions in trauma resuscitation: real-time analysis utilizing videotape review. Am J Emerg Med 1997;15:34-9.
47. Moongtui W, Gauthier D, Turner J. Using peer feedback to improve handwashing and glove usage among Thai healthcare workers. Am J Infect Control 2000;28:365-9.
48. Vaughn T, McCoy K, Beekmann S, Woolson R, Torner J, Doebbeling B. Factors promoting consistent adherence to safe needle precautions among hospital workers. Infection Control and Hospital Epidemiology 2004;25:548-55.
49. McDiarmid M, Condon M. Organizational safety culture/climate and worker compliance with hazardous drug guidelines: lessons from the blood-borne pathogen experience. J Occup Environ Med 2005;47:740-9.