Journal of Hospital Infection 102 (2019) 234–240

Available online at www.sciencedirect.com

Journal of Hospital Infection

journal homepage: www.elsevier.com/locate/jhin

Transferring knowledge into practice: a multi-modal, multi-centre intervention for enhancing nurses' infection control competency in Bangladesh

L. Ara*, F. Bashar, M.E.H. Tamal, N.K.A. Siddiquee, S.M.N. Mowla, S.A. Sarker

Nutrition and Clinical Services Division, icddr,b, Mohakhali, Dhaka 1212, Bangladesh

ARTICLE INFO

Article history:
Received 27 May 2018
Accepted 30 July 2018
Available online 3 August 2018

Keywords:
Multi-modal
Standard infection control practices
Nurse
Bangladesh

SUMMARY

Background: Nurses are considered as the key to infection prevention as they play a major role in treatment as well as taking care of patients.
Aim: To assess the role of a multi-modal intervention (MMI) in improving nurses' competency and adherence to standard infection control practices in Bangladesh.
Methods: The study adopted a pretest–post-test intervention approach, in three different periods (from 2012 to 2017) in five hospitals (two public, two private, and one autonomous) in Bangladesh. Each study period was divided into three phases: pretest, MMI, and post-test. Data were collected on 642 nurses using direct observation method through a structured checklist.
Findings: After implementing the MMI, overall hand hygiene compliance significantly increased before patient contact (from 1.3% to 50.2%; $P < 0.000$) and after patient contact (from 2.8% to 59.6%; $P < 0.000$). Remarkable improvements were also achieved in adherence to use of gloves (from 14.6% to 57.6%; $P < 0.000$), maintaining sterility of equipment during aseptic techniques (from 34.9% to 86%; $P < 0.000$), biomedical waste segregation (from 1.8% to 81.3%; $P < 0.000$) and labelling of procedural sites (from 0% to 85.7%; $P < 0.000$). Moreover, needlestick injury rate notably decreased (from 6.2% to 0.6%; $P < 0.000$).
Conclusion: MMI can play a vital role in improving nurses' compliance with the standard infection control practices. Such context-specific interventions, which are crucial for preventing healthcare-associated infections and for decreasing occupational hazards, should be replicated in resource-poor countries for achieving universal health coverage by 2030.

Introduction

Nurses hold the key to infection control challenges, representing a force of abilities that can shape and advance patients' outcomes. Being at the frontline of healthcare delivery, they are potentially regularly exposed to micro-organisms that may cause serious infections, and they may transmit these micro-organisms from one patient to another [1–4]. Therefore,

* Corresponding author. Address: Nutrition and Clinical Services Division (NCSD), icddr,b, Mohakhali, Dhaka 1212, Bangladesh. Tel.: +88 029827001-10, ext-3385.
E-mail address: lutfeara@icddrb.org (L. Ara).

https://doi.org/10.1016/j.jhin.2018.07.042

Table I
Matrix of study participants and settings

Name of the hospital	Study period	No. of nurses invited	No. of nurses participating	District
PriA (tertiary level private hospital)	2012–2013	97	96	Mymensingh
PriB (secondary level private hospital)	2016–2017	14	14	Sunamganj
GovA (secondary level public hospital)	2014–2015	271	262	Sirajganj
GovB (secondary level public hospital)	2016–2017	134	134	Sunamganj
Aut (tertiary level autonomous institute)	2014–2015	149	136	Dhaka
Total (five study settings)		665	642	

nurses can play a crucial role in reducing healthcare-associated infections (HCAIs) through adopting standard practice guidelines including some simple but cost-effective interventions such as maintaining hand hygiene, using personal protective equipment, aseptic precautions, careful handling of sharps, and proper waste disposal [5]. Nurses' knowledge and practice in infection control is therefore crucial in preventing transmission of micro-organisms in hospitals [6]. In low- and middle-income countries (LMICs), nurses working in most healthcare systems lack the knowledge and skills, and they are inadequately trained; consequently, they show suboptimal compliance with standard infection control practices [7–9]. This is probably a major contributor to HCAIs having a much higher prevalence in LMICs than in developed countries [10]. This is the situation in Bangladesh. In 1991, in a cross-sectional study in Dhaka Medical College Hospital, the nosocomial infection rate was 30% [11]. In another study in an improved setting, HCAI rate of 9.4% has been reported [12]. Several studies in Bangladesh also revealed significant knowledge deficit and poor compliance among nurses regarding universal infection prevention measures [13–15].

Quality training can act as a tool for increasing knowledge and improving nurses' compliance [7,8,16–18]. In one study, the educational intervention on hand hygiene improved the healthcare workers' compliance from 51% to 83% [19]. However, adopting only one strategy to control hospital infection might not ensure the desired outcomes. In 2006, the World Health Organization (WHO) piloted a multi-country multi-modal intervention (MMI) for improving hand hygiene compliance [20]. Based on evidence that these strategies improve compliance and decrease the rate of HCAI, the current 2016 WHO guideline on infection prevention and control programmes emphasizes use of multi-modal strategies to reduce the risk of HCAI [10].

There is a dearth of evidence for the role of the multi-modal approach in increasing nurses' adherence to standard infection control practices in hospitals in Bangladesh as well as other LMICs. This study was designed to investigate the influence of a multi-modal hospital-based intervention on nurses' competencies and compliance with standard infection control practices. We also sought to compare compliance at different types of clinical setting (public, private, and autonomous) in Bangladesh.

Methods

This study adopted a pretest–post-test quasi-experimental approach which is widely used to evaluate the effectiveness of a specific intervention [21]. The primary objective was to compare nurses' compliance with standard infection control practices in different types of clinical setting, and to determine the role of a multi-modal intervention in improving competencies and compliances with standard infection control practices. Data were collected in three different periods starting from 2012 to 2017 and lasted for one year in each study setting (Table I). To compare nurses' compliance with standard infection control practices, five hospitals (two public, two private, and one autonomous) from four different districts (Dhaka, Mymensingh, Sirajganj, and Sunamganj) of Bangladesh were chosen. Study sites were purposively selected, considering the lack of infection control practices as well as absence of any previous infection control intervention in those settings. To maintain anonymity, hospital names were also coded.

All nurses working in the hospitals were invited to participate, and verbal consent was obtained from those who agreed to participate. A brief description of the study sites and participants is given in Table I.

The study adopted a stepwise implementation approach in three different phases: pre-intervention, multi-modal intervention, and post-intervention.

Pre-intervention phase (three months)

Baseline data on nurses' infection control practices were obtained through a validated structured checklist by direct observation.

Intervention (six months)

A multi-modal, multi-faceted intervention approach was taken to educate the nurses as well as to assess their competency using the following variables: (i) use of alcohol-based hand rub (before and after patient contact); (ii) use of personal protective equipment (PPE); (iii) maintain sterility of equipment during aseptic techniques; (iv) sharp handling and disposal; (v) biomedical waste segregation; (vi) labelling (date and time for replacement) of procedural sites (cannula, catheter, nasogastric tube, intravenous fluid).

The multi-modal strategy was composed of:

- System change: Colour-coded waste bins and sharp injury reporting system were introduced as well as availability of alcohol-based hand rub and gloves at the point of patient care. These were ensured with the support from the senior administration of the study settings.
- Educational intervention: The multi-faceted educational intervention consisted of classroom training with visual

representations (videos) and hands-on training in the wards. Each educational session was interactive and participatory in nature and ~60 min in duration.
- Development of safety climate: A 10-member infection control team (ICT), consisting of administrative personnel, resident medical officer, medical officer, and nurses was formed to ensure sustainability of the programme.
- Visual reminders: Colourful posters with the picture and signs of different infection control measures were displayed in the wards including emergency ward, nursing stations and corridors as visual reminders for increasing compliance at the workplace.
- Monitoring and feedback: Nurses' compliance with standard infection control practices was monitored and feedback was given accordingly to both the participants and the administrative authorities regularly.

Post-intervention phase (three months)

After completion of the six-month intervention, a post-intervention evaluation was done with the same checklist and by the same observers to assess the compliance rate.

Direct observation is regarded as the reference standard method for evaluating hand hygiene compliance [22]. Compliance was determined by number of observations against number of opportunities. Data were collected by the study physicians and study nurses who were trained before commencement of the study by the same personnel to standardize observations and reducing error as well as to ensure quality of data collection. Data were coded and analysed by Stata 13 (Stata Corp., College Station, TX, USA). Comparison of adherence rates to standard infection control practices was calculated by χ^2-test. Univariate logistic regression model was applied, taking the type of hospitals as independent variable. The overall compliances and odds ratio (OR) were calculated with 95% confidence interval (CI) and $P < 0.05$ was considered as statistically significant.

Ethical clearance was obtained from the Ethical Review Committee of icddr,b (protocol number #17127). Written permissions were also acquired from the different institutional authorities of the study sites through signing of memoranda of understanding. After explaining the objective, procedures and activities of the study, rights of the participants and confidentiality issues, informed verbal consent was obtained from the participants. Participants' confidentiality was strictly maintained throughout the whole procedure and no personal information was disclosed.

Results

Hand hygiene

After intervention, overall hand hygiene compliance increased from 1.3% to 50.2% before patient contact, and from 2.8% to 59.6% after patient contact across the five study settings ($P < 0.000$). In all the study settings, hand hygiene compliance was greater 'after patient contact' compared to 'before patient contact' after the MMI (Table II). The rate of compliance was significantly higher in private hospitals before patient contacts compared to that of public hospitals, whereas after patient contact the difference was not significant (Supplementary Table I).

Use of personal protective equipment

Nurses' overall adherence to the use of gloves increased by 43% after the intervention ($P < 0.000$). Before the intervention, maximum compliance was observed in Aut (tertiary level autonomous institute) (42.6%), whereas after the MMI highest compliance (72.2%) was found in PriB (secondary level private hospital) (Table II). Private hospitals were significantly more compliant (15.8%) than the public hospitals both before and after the intervention (Supplementary Table I).

Maintaining sterility of equipment during aseptic techniques

Nurses' overall compliance with maintaining sterility of equipment during aseptic techniques improved significantly from 34.9% to 86% in all the study settings ($P < 0.000$) after the intervention. The pre-intervention compliance was significantly lower in public hospitals compared to private settings. PriA (tertiary level private hospital) showed highest compliance both in pre-intervention (78.5%) and post-intervention (100%) phases (Table II).

Rate of needlestick injury

The overall rate of needlestick injury in the five study sites notably decreased from 6.2% to 0.6% ($P < 0.000$). This injury rate was highest (32.3%) in PriA before the intervention, which decreased to 4.2% after the intervention. In other facilities, rate of decreasing needlestick injury was found to be very low after the intervention (Table II). This rate of decrease was significantly higher in private hospitals (5.1%) than in public hospitals (Supplementary Table I).

Compliance with biomedical waste segregation

In pre-intervention phase, adherence to standard waste segregation practice was almost absent in all study settings, except GovA (secondary level public hospital) (8.8%). However, during the post-intervention phase overall compliance with the biomedical waste segregation improved greatly from 1.8% to 81.3% ($P < 0.000$). PriB showed the most marked improvement (by 86%) in biomedical waste segregation (Table II). Again, after the intervention, private hospitals showed significant improvements (by 6.3%) over public hospitals (Supplementary Table I).

Labelling of procedural site

Labelling (date and time for replacement) of procedural sites (cannula, catheter, nasogastric tube, intravenous fluid) was initially completely absent across all the study settings. However, the MMI resulted in marked improvement across the study sites from 0% to 85.7% ($P < 0.000$) (Table II). Once again, private hospitals performed better, achieving significantly higher compliance (16.9%) than public hospitals (Supplementary Table I).

A logistic regression model showed that nurses' compliance with standard infection control practices was enhanced significantly in all types of healthcare setting after the MMI (Table III). Not only was the improvement significantly greater

Table II
Effect of World Health Organization multi-modal intervention on standard infection control practices in the five study settings

Study settings	Standard infection control practices (no. of observations/ no. of opportunities) (%)		Improvements in rate of compliance after the multi-modal intervention (%)	*P*-value
	Pre-intervention period	Post-intervention period		
Hand hygiene (before patient contact)				
PriA	9/96 (9.4%)	54/96 (56.3%)	46.9%	0.000
Aut	3/145 (2.1%)	87/145 (60%)	57.9%	0.000
PriB	12/782 (1.5%)	427/755 (56.6%)	55.1%	0.000
GovA	5/137 (3.6%)	82/137 (59.1%)	56.3%	0.000
GovB	1/1241 (0.1%)	487/1130 (43.1%)	43.0%	0.000
Overall compliance	30/2401 (1.3%)	1137/2263 (50.2%)	49.0%	0.000
Hand hygiene (after patient contact)				
PriA	10/96 (10.4%)	64/96 (66.7%)	56.3%	0.000
Aut	10/145 (6.9%)	99/145 (68.3%)	61.4%	0.000
PriB	32/782 (4.1%)	464/764 (60.7%)	56.6%	0.000
GovA	10/137 (7.3%)	81/137 (59.1%)	51.8%	0.000
GovB	6/1241 (0.5%)	647/1130 (57.3%)	56.8%	0.000
Overall compliance	68/2401 (2.8%)	1355/2272 (59.6%)	56.8%	0.000
Use of personal protective equipment				
PriA	10/116 (8.6%)	62/113 (54.9%)	46.3%	0.000
Aut	46/108 (42.6%)	51/75 (68%)	25.4%	0.001
PriB	47/189 (24.9%)	143/198 (72.2%)	47.4%	0.000
GovA	18/127 (14.2%)	71/117 (60.9%)	46.8%	0.000
GovB	19/421 (4.5%)	157/338 (46.5%)	41.9%	0.000
Overall compliance	140/961 (14.6%)	484/841 (57.6%)	43.0%	0.000
Use of sterile equipment				
PriA	91/116 (78.5%)	113/113 (100%)	21.6%	0.000
Aut	82/108 (75.9%)	74/75 (98.7%)	22.7%	0.000
PriB	129/189 (68.4%)	190/198 (95.1%)	27.6%	0.000
GovA	15/127 (11.8%)	62/117 (53.1%)	41.3%	0.000
GovB	18/421 (4.3%)	284/338 (84%)	79.7%	0.000
Overall compliance	335/961 (34.9%)	723/841 (86%)	51.1%	0.000
Rate of needlestick injuries				
PriA	32/99 (32.3%)	4/96 (4.2%)	−28.2%	0.000
Aut	8/101 (7.9%)	1/98 (1%)	−6.9%	0.035
PriB	1/273 (0.4%)	0/261 (0%)	−0.4%	0.327[a]
GovA	19/104 (18.5%)	1/102 (0.1%)	−17.5%	0.000
GovB	0/398	0/432	0%	[b]
Overall compliance	60/975 (6.2%)	6/989 (0.6%)	−5.5%	0.000
Waste segregation				
PriA	0/56	45/57 (78.1%)	78.1%	0.000
Aut	0/30	31/38 (81.6%)	81.6%	0.000
PriB	0/211	191/222 (86%)	86%	0.000
GovA	11/125 (8.8%)	84/122 (68.8%)	59.1%	0.000
GovB	0/194	161/191 (84.3%)	84.3%	0.000
Overall compliance	11/616 (1.8%)	512/630 (81.3%)	79.5%	0.000
Labelling of procedural sites				
PriA	0/96	96/96 (100%)	100%	0.000
Aut	0/89	66/69 (95.7%)	95.7%	0.000
PriB	0/579	524/541 (96.9%)	96.9%	0.000
GovA	0/65	56/72 (77.8%)	77.8%	0.000
GovB	0/1388	1167/1449 (80.5%)	80.5%	0.000
Overall compliance	0/2217	1909/2227 (85.7%)	85.7%	0.000

[a] $P > 0.05$.
[b] *P*-value could not be computed as number of observations was zero.

in private and autonomous settings compared to public settings, but tertiary hospitals performed better than secondary level hospitals, which were more likely to show poor compliance with standard infection control practices.

Discussion

The objective of this study was to improve nurses' competencies and compliances with standard infection control practices through MMI, and indeed we found that adopting the WHO multi-modal strategy was highly effective, at least for the duration of the latter phase of the study.

Despite the existence of a national hand hygiene guideline in Bangladesh since 2011, hand hygiene compliance was low among the nurses in all types of setting before the intervention [23]. This finding is consistent with a previous estimate of 9% hand hygiene compliance by healthcare workers in Bangladesh [15]. However, after the MMI, hand hygiene rates improved markedly, which is consistent with experience in other countries [24,25]. The highest rates of post intervention compliance were in private hospitals, probably because they are better resourced and have better lines of accountability. As in previous studies, greater compliance was observed after patient contact, which may be due to the instinctive tendency for people to self-protect [15,20,24].

Before the intervention, compliance rates with the use of gloves, and maintaining an aseptic field, during aseptic procedures was higher in private and autonomous settings. Some of these procedures (e.g. surgeries, deliveries, vaginal examinations, urinary catheterizations) were performed more frequently in the autonomous institute, and we speculate that this may have led to greater motivation among staff. Higher rates of glove usage in such special settings accords with previous findings [26,27]. However, our study shows that implementation of an MMI can greatly improve compliance in all settings. Effective self-supervision for quality improvement, supported by local hospital management, appeared to underpin the success, which was also found in other studies [28].

During the pre-intervention period, needlestick injuries were higher in the PriA, GovA and Aut study settings. Lack of knowledge and awareness may have been the determining factor for this situation. One key measure in preventing needlestick injuries is segregation of hospital waste, but we found that waste segregation was widely disregarded, as in previous studies [13,29,30]. After ensuring provision of colour-coded waste bins and institutional monitoring through the MMI, waste segregation improved markedly and NSI rates fell in all study settings; again this accords with previous studies [26,31,32]. Although pre-intervention needlestick injury rates were very low in GovB and PriB, this may have been due to substantial underreporting, because we found that there was no system for reporting of needlestick injuries in these settings.

The risks of thrombophlebitis and peripheral catheter colonization are greater when the devices are left for more than 72–96 h [33]. Thus, the simplest strategy to prevent these infections is to document device insertion and schedule timely replacement. Again, the MMI improved practice substantially.

Although improvements in infection control practices were observed in all settings, public healthcare settings did less well than private and autonomous settings. Previous studies have

Table III
Odds ratio (with 95% confidence interval) for compliance with standard infection control practices from binary logistic regression

Variable	HH before patient contact	HH after patient contact	Use of gloves	Use of sterile equipment	Rate of sharp injury	Compliance with waste segregation
Intervention period						
Pre	Ref	Ref	Ref	Ref	Ref	Ref
Post	79.8** (55.2–115.5)	50.7** (39.3–65.4)	7.9** (6.4–9.9)	11.4** (9.1–14.5)	9.5** (5.6–16.2)	238.6** (127.2–447.6)
Type of hospital						
Public	Ref	Ref	Ref	Ref	Ref	Ref
Private	1.5** (1.3–1.7)	1.3** (1.1–1.2)	2.1** (1.7–2.6)	9.3** (7.2–11.9)	2.7** (1.6–4.7)	1.1** (0.9–1.4)
Autonomous	1.6** (1.2–2.1)	1.5** (1.2–1.9)	3.1** (2.3–4.3)	9.5** (6.2–14.6)	2.4** (1.1–5.4)	1.2** (0.7–2.0)
Level of hospital						
Secondary	Ref	Ref	Ref	Ref	Ref	Ref
Tertiary	1.5** (1.2–1.8)	1.5** (1.2–1.8)	1.4** (1.1–1.8)	6.9** (5.0–9.4)	9.5** (5.6–16.2)	1.0 (0.7–1.4)

HH, hand hygiene; Ref, reference category.
*$P < 0.05$.
**$P < 0.01$.

identified that factors such as low staffing levels, insufficient logistic support, and lack of training and effective supervision, which are frequent in public hospitals, contribute to poor infection control practice [34]. Moreover, private and autonomous hospitals enjoy more autonomy in decision-making, relating to both administrative and financial matters. As other authors have found, we believe that this autonomy facilitates quality improvement [20,28,31,35]. A new approach may be required for public hospitals to achieve compliance comparable to that in the private sector. Nevertheless, considering the limitations faced by all hospitals in Bangladesh, it is encouraging that high levels of improvement from implementation of simple and cost-effective MMI were seen across all sectors of the healthcare system.

The WHO has now recommended the MMI strategy as a core component for infection prevention and control at both national and facility levels to combat the threats posed by antimicrobial resistance [10]. Most previous MMI-based studies have reported evidence on a limited number of indicators, e.g. hand hygiene compliance or glove use. To our knowledge, ours is the first report from an LMIC investigating an MMI covering a wide range of components of the standard infection control practice among nurses. Other commendable aspects of the study were the relatively large sample size, and inclusion of different types of hospital setting in different geographical locations.

However, our study does have some limitations. The implementation period and sample size differed between settings, and it was not possible to run the project simultaneously in all the facilities. Second, direct observation method was used to collect data. Although this is regarded as the standard method of data collection for observational studies it is potentially subject to the Hawthorne effect [20,21]. Nevertheless, in this study, the long-term presence of the observers in the facility probably helped minimize any such effect. Finally, due to the absence of a control group the observed improvements due to the MMI should be interpreted carefully.

In conclusion, we found that the WHO multi-modal strategy was effective, feasible and successful in improving compliance with standard infection control practices among nurses working at different settings in Bangladesh. Like other LMICs, the healthcare system in Bangladesh struggles with resource constraints. In this situation, the findings of this study are expected to be useful in providing guidance to the healthcare settings of LMICs on the use of simple and cost-effective standard infection control practices to prevent or minimize the huge burden of HCAIs. Further research is needed to capture patient outcomes (HCAI incidence) related to improvements in standard infection control practices.

Acknowledgements

The authors would like to thank GlaxoSmithKline (GSK), the study participants, team members, icddr,b and Government of Bangladesh for their support in conducting this research. The authors are also grateful to the Governments of Bangladesh, Canada, Sweden and the UK for providing core/unrestricted support.

Conflict of interest statement
None declared.

Funding source
This study was supported by GSK [grant number GR 01019]. The funder had no role in study design, data collection and analysis, decision to publish or preparation of the manuscript.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jhin.2018.07.042.

References

[1] Aiken LH, Sloane DM, Klocinski JL. Hospital nurses' occupational exposure to blood: prospective, retrospective, and institutional reports. Am J Publ Health 1997;87:103–7.
[2] Park S, Jeong I, Huh J, Yoon Y, Lee S, Choi C. Needlestick and sharps injuries in a tertiary hospital in the Republic of Korea. Am J Infect Control 2008;36:439–43.
[3] Chan R, Molassiotis A, Eunice C, Chan V, Ho B, Lai CY, et al. Nurses' knowledge of and compliance with universal precautions in an acute care hospital. Int J Nurs Stud 2002;39:157–63.
[4] McGaw CD, Tennant I, Harding HE, Cawich SO, Crandon IW, Walters C. Healthcare workers' attitudes to and compliance with infection control guidelines in the operating department at the university hospital of the West Indies, Jamaica. Int J Infect Control 2012;8.
[5] World Health Organization. Practical guidelines for infection control in health care facilities. Geneva: WHO; 2004.
[6] Reese SM, Gilmartin. HM infection prevention workforce: potential benefits to educational diversity. Am J Infect Control 2017;45:603–6.
[7] Luo Y, He G-P, Zhou J-W, Luo Y. Factors impacting compliance with standard precautions in nursing, China. Int J Infect Dis 2010;14:e1106–14.
[8] Ogoina D, Pondei K, Adetunji B, Chima G, Isichei C, Gidado S. Knowledge, attitude and practice of standard precautions of infection control by hospital workers in two tertiary hospitals in Nigeria. J Infect Prev 2015;16:16–22.
[9] Ameh CA, Kerr R, Madaj B, Mdegela M, Kana T, Jones S, et al. Knowledge and skills of healthcare providers in Sub-Saharan Africa and Asia before and after competency-based training in emergency obstetric and early newborn care. PLoS One 2016;11:e0167270.
[10] World Health Organization. Guidelines on core components of infection prevention and control programmes at the national and acute health care facility level. Geneva: WHO; 2016.
[11] Hussain T, Fazal M, Ahmed A. Nosocomial infection – a cross-sectional study in the surgical wards of Dhaka Medical College Hospital. J Prev Soc Med 1991;10:70–3.
[12] Afroz H, Fakruddin M, Masud MR, Islam K. Incidence of and risk factors for hospital acquired infection in a tertiary care hospital of Dhaka, Bangladesh. Bangl J Med Sci 2017;16:358–69.
[13] Sarker MAB, Harun-Or-Rashid M, Hirosawa T, Abdul Hai MS, Siddique MR, Sakamoto J, et al. Evaluation of knowledge, practices, and possible barriers among healthcare providers regarding medical waste management in Dhaka, Bangladesh. Med Sci Monit 2014;20:2590.
[14] Uddin MN, Islam MR, Yesmin K. Knowledge on hospital waste management among senior staff nurses working in a selected medical college hospital of Bangladesh. J Waste Manag 2014;2014.
[15] Horng L, Unicomb L, Alam M-U, Halder AK, Shoab AK, Ghosh PK, et al. Healthcare worker and family caregiver hand hygiene in Bangladeshi healthcare facilities: results from the Bangladesh National Hygiene Baseline Survey. J Hosp Infect 2016;94:286–94.

[16] Lee SS, Park SJ, Chung MJ, Lee JH, Kang HJ, Lee JA, et al. Improved hand hygiene compliance is associated with the change of perception toward hand hygiene among medical personnel. Infect Chemother 2014;46:165—71.
[17] Santosaningsih D, Erikawati D, Santoso S, Noorhamdani N, Ratridewi I, Candradikusuma D, et al. Intervening with health-care workers' hand hygiene compliance, knowledge, and perception in a limited-resource hospital in Indonesia: a randomized controlled trial study. Antimicrob Resist Infect Control 2017;6:23.
[18] Kermode M, Jolley D, Langkham B, Thomas MS, Holmes W, Gifford SM. Compliance with universal/standard precautions among health care workers in rural north India. Am J Infect Control 2005;33:27—33.
[19] Bischoff WE, Reynolds TM, Sessler CN, Edmond MB, Wenzel RP. Handwashing compliance by health care workers: the impact of introducing an accessible, alcohol-based hand antiseptic. Archs Intern Med 2000;160:1017—21.
[20] World Health Organization. WHO guidelines on hand hygiene in health care. Geneva: WHO; 2009.
[21] Harris AD, McGregor JC, Perencevich EN, Furuno JP, Zhu J, Peterson DE, et al. The use and interpretation of quasi-experimental studies in medical informatics. J Am Med Inform Assoc 2006;13:16—23.
[22] Boyce JM, Pittet D. Guideline for hand hygiene in health-care settings: recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Am J Infect Control 2002;30:S1—46.
[23] Government of Bangladesh. National guideline on hand hygiene for prevention of hospital acquired infection (HAI). 2011.
[24] Schmitz K, Kempker RR, Tenna A, Stenehjem E, Abebe E, Tadesse L, et al. Effectiveness of a multimodal hand hygiene campaign and obstacles to success in Addis Ababa, Ethiopia. Antimicrob Resist Infect Control 2014;3:8.
[25] Sakihama T, Honda H, Saint S, Fowler KE, Kamiya T, Sato Y, et al. Improving healthcare worker hand hygiene adherence before patient contact: a multimodal intervention of hand hygiene practice in three Japanese tertiary care centers. J Hosp Med 2016;11:199—205.
[26] Sadoh WE, Fawole AO, Sadoh AE, Oladimeji AO, Sotiloye OS. Practice of universal precautions among healthcare workers. J Nat Med Assoc 2006;98:722.
[27] Kuzu N, Özer F, Aydemir S, Yalcin AN, Zencir M. Compliance with hand hygiene and glove use in a university-affiliated hospital. Infect Control Hosp Epidemiol 2005;26:312—5.
[28] Rosenthal VD, McCormick RD, Guzman S, Villamayor C, Orellano PW. Effect of education and performance feedback on handwashing: the benefit of administrative support in Argentinean hospitals. Am J Infect Control 2003;31:85—92.
[29] Akter N, Chowdhury A, Kazi N. Hospital waste disposal in Bangladesh with special reference to Dhaka City and its environmental evaluation. International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR, B); 1999.
[30] Al-Khatib IA, Al-Qaroot YS, Ali-Shtayeh MS. Management of healthcare waste in circumstances of limited resources: a case study in the hospitals of Nablus city, Palestine. Waste Manag Res 2009;27:305—12.
[31] Larson E, Killien M. Factors influencing handwashing behavior of patient care personnel. Am J Infect Control 1982;10:93—9.
[32] Kumar R, Somrongthong R, Ahmed J. Effect of medical waste management trainings on behavior change among doctors versus nurses and paramedical staff in Pakistan. J Ayub Med Coll Abbottabad 2016;28:493—6.
[33] Maki DG, Ringer M. Risk factors for infusion-related phlebitis with small peripheral venous catheters: a randomized controlled trial. Ann Intern Med 1991;114:845—54.
[34] Islam F, Rahman A, Halim A, Eriksson C, Rahman F, Dalal K. Perceptions of health care providers and patients on quality of care in maternal and neonatal health in fourteen Bangladesh government healthcare facilities: a mixed-method study. BMC Health Serv Res 2015;15:237.
[35] Andaleeb SS. Public and private hospitals in Bangladesh: service quality and predictors of hospital choice. Health Policy Plann 2000;15:95—102.