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Major Article

Current status of personnel and infrastructure resources for infection prevention and control programs in the Republic of Korea: A national survey

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Background: There is significant variability in personnel and infrastructural resources for infection prevention and control (IPC) among health care institutions. The aim of this study is to evaluate the current status of individual hospital-based IPC programs in the Republic of Korea (ROK).

Methods: A multicenter cross-sectional survey of 100 hospitals participating in the national surveillance programs for multidrug-resistant organisms (MDROs) in the ROK was conducted in September 2015. The survey consisted of 140 standardized Web-based questionnaires.

Results: The survey response rate was 41.0%. The responding hospitals are largely organized with multibed rooms, with an insufficient numbers of single rooms. Employment status of infection specialists and hand hygiene resources were better in larger hospitals. The responding hospitals had 1 full-time infection control nurse per 400.3 ± 154.1 beds, with wide variations in training and experience. Facilities have great diversity in their approach to preventing MDROs. There appeared to be no difference in supplies consumption and protocols for IPC among the hospitals, stratified according to size.

Conclusions: A greater availability of specialist personnel, single rooms, and a comprehensive IPC program, with the support of a policy-oriented management, is necessary to achieve effective IPC.

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programs. However, there is scarce information on the details of the current status of infection prevention and control programs in acute care hospitals in the ROK. The purpose of this study is to examine hospitals participating in the national surveillance programs for MDROs to evaluate personnel, structure resources, and strategies associated with infection prevention and control in the ROK.

METHODS

Study design and participants

A multicenter cross-sectional survey was conducted in the ROK in September 2015. Blueprints for this study were drafted on the basis of the SENIC Project design, originally developed by the Centers for Disease Control and Prevention in the United States in the 1970s. Basic information of the 100 hospitals participating in the national surveillance programs for MDROs was obtained from the Korean Association of Infection Control Nurses. To protect the confidentiality of hospitals, researchers compiled a list of the 100 hospitals and directly e-mailed the directors of each infection control unit, inviting them to respond to the Web-based survey. To increase survey response rates, repeat contact by weekly e-mail was made over 4 weeks. Only 1 person in each institution participated in the survey. The study protocol was approved by the institutional review boards prior to starting the study, and the requirement for informed consent was waived (AN15359-001).

Questionnaire

A modified survey form was developed on the basis of the questionnaire used in the SENIC Project. The survey consisted of 140 standardized Web-based questionnaires. There were 3 sections: (1) infrastructure, equipment facilities, and accreditation for infection control programs; (2) human resources, including staff numbers, infection control training, employment status and work experience of ICNs, ICPs, and other support personnel; and (3) detailed practices of infection control activities for MDROs, such as antibiotic stewardship, collection, and analysis of data on the incidence of infections, staff training on infection prevention and control policies and procedures, daily isolation and cohort practices, conference organization and development of policies, employee health, product evaluation, emergency preparedness, and reporting of notifiable diseases.

Statistical analysis

Data were analyzed using descriptive statistics. Nominal variables were presented as the number of subjects (percentage) and analyzed using a χ² test. Continuous variables were expressed as mean ± SD or median (interquartile range [IQR]) and analyzed using the Mann-Whitney U test or Student t test, as appropriate. Analysis of variance and χ² tests were used to identify differences between the infection prevention and control programs according to hospital size, determined by the total number of beds. All tests were 2-tailed, and a P value <.05 was considered statistically significant. Analyses were performed with SPSS Statistics version 20.0 (IBM, Armonk, NY) and SAS 9.2 (SAS Institute, Cary, NC).

RESULTS

The survey response rate was 41.0%, with 41 hospitals divided into categories according to bed size: 200-499 beds (n = 7), 500-699 beds (n = 9), 700-899 beds (n = 17), and >900 beds (n = 8). Most of the hospitals were located in the metropolitan area (n = 29, 70.7%). All hospitals were teaching institutions. Univariate analysis found no significant difference in the number of beds (P > .999) and the ratio of the number of beds to infection control personnel (P = .943) between respondents and nonrespondents.

Infrastructure

The average number of personnel members specializing in infection prevention and control per hospital was 3.1 ± 1.7 (median, 3; IQR, 2-4; range, 1-10). Of these, 2.2 ± 1.5 (median, 2; IQR, 1-3; range, 1-9) were employed in a full-time position. The rest were employed on a temporary basis. The average number of full-time ICNs was 2.1 ± 1.4 (median, 2; IQR, 1-3; range, 0-8), with 1 full-time ICN per 400.3 ± 154.1 beds. On average, the ICNs had 63.5 months of experience in infection prevention and control and had 15-141. Of the responding hospitals, 85.4% and 80.5% employed a specialist in infectious disease and clinical microbiology, respectively. The median year in which infection control units were established was 2002 (IQR, 1996-2005; range, 1991-2008).

Infection control activities

All hospitals established written guidelines on the control of MDROs and setup a committee for infection prevention and control. All facilities have held periodic conferences on infection prevention and control. Frequency was evaluated as follows: <3 times per year (n = 12, 29.3%), 3 times per year (n = 23, 56.1%), and >3 times per year (n = 6, 14.6%). Of the responding hospitals, 97.6% monitored resistance trends of major MDROs and adapted clinical practice accordingly. Routine surveillance culture for MDROs was performed in 51.2% of facilities for the following microorganisms: MRSA (n = 10, 24.4%), VRE (n = 10, 24.4%), MRAB (n = 7, 17.1%), MRPA (n = 5, 12.2%), and CRE (n = 8, 19.5%), on the ICUs. Hospital-wide surveillance cultures were performed for MRSA (n = 4, 9.8%), VRE (n = 5, 12.2%), MRAB (n = 4, 9.8%), MRPA (n = 3, 7.3%), and CRE (n = 3, 7.3%). Contact precautions for carriers of MDROs were implemented in 95.1% of ICUs and 65.5% of hospitals. Single-room isolation was implemented in 14 hospitals (34.1%) for patients on ICUs and in only 8 facilities (19.5%) for those on general wards, respectively. On ICUs, single-room isolation was required for MRSA (n = 4, 9.8%), VRE (n = 25, 61.0%), MRAB (n = 8, 19.5%), MRPA (n = 4, 9.8%), and CRE (n = 22, 53.7%). Single-room isolation within the hospital generally was required for MRSA (n = 2, 4.9%), VRE (n = 25, 61.0%), MRAB (n = 2, 4.9%), MRPA (n = 1, 2.4%), and CRE (n = 19, 46.3%).

All hospitals had a hand hygiene monitoring program and feedback system, and 37 facilities (90.2%) implemented these on a regular basis throughout the hospital. All hospitals have organized educational sessions for staff to improve hand hygiene measures. The frequency of these sessions was either once per year (n = 34, 82.9%) or at least twice per year (n = 7, 17.1%). Staff education seminars on infection prevention and control were held annually in 22 hospitals (53.7%). Thirty-eight hospitals (92.7%) implemented an antibiotic
stewardship program. Of these, 90.2% ran computerized antibiotic stewardship programs. In 23 hospitals (56.1%), infection control units implemented quality management systems for medical devices, including sterilization products.

Of the responding hospitals, 34 (82.9%) participated in the Korean Nosocomial Infections Surveillance System, which is the nationwide monitoring system for nosocomial infection in the ICUs, consisting of a standardized protocol and a Web-based prompt response network. Twelve facilities (29.3%) conducted environmental cultures to detect MRSA, VRE, MRAB, MRPA, or CRE on a routine basis. Regular environmental disinfection on the ICUs was performed once a day (n = 14, 34.1%), twice a day (n = 13, 31.7%) or 3 time a day (n = 10, 24.4%).

**Infection prevention and control program by hospital size**

There was no significant difference in the ratio of number of beds to infection control personnel among the 4 groups (Table 1). More infection specialists and the lower bed numbers per handwash stands were noted in larger hospitals (Table 1). However, supplies consumption and protocols for infection prevention and control seemed to have no difference by the size of the hospitals (Tables 1 and 2). Also, there were no differences among the groups in the rates of active environmental surveillance cultures, average number of cultures performed per hospital bed, and consumption of hand sanitizers and disposable gowns per hospital bed (Table 2).

**Changes in infection prevention and control program since 2010**

A number of changes have been observed since 2010, after the implementation of a surveillance network for MDROs and the creation of infection control committees under the Infectious Disease Control and Prevention Act. Three facilities (7.3%) have complied with the regulation of infection prevention and control since the introduction of legislation. Five hospitals (12.2%) employed a full-time IPC. Thirteen hospitals (31.7%) introduced the use of disposable tissue towels, and 3 hospitals (7.3%) introduced hand sanitizers and disinfectants. Twenty-three facilities (51.6%) introduced a monitoring and feedback program for hand hygiene in 2010, and 15 hospitals (36.6%) commenced regular education seminars for MDRO infection prevention and control. A significant increase was observed between 2009 and 2014 in the median number of personnel specialized in infection control within each hospital (1.6 ± 2.4 vs 2.4 ± 1.9, P <.011). Between 2009 and 2014, monitoring of the prevalence of MRSA (57.4% vs 42.6%, P = .118) and VRE (60.0% vs 40.0%, P = .024) and active surveillance for carriers of MRSA (66.7% vs 33.3%, P = .022) and VRE (64.3% vs 35.7%, P = .062) were scaled down. Conversely, monitoring (12.5% vs 87.5%, P < .001) and active surveillance programs (11.1% vs 88.9%, P = .013) for CRE were strengthened, whereas there were no changes in monitoring or active surveillance programs for carriers of MRPA and MRAB during this time. In terms of isolation practices, using a single room or a cohort program followed similar trends to the MDRO detection policies: isolation of patients with MRSA (75.0% vs 25.0%, P = .026) or VRE (60.9% vs 39.1%, P < .001) was stopped in some hospitals, whereas isolation of patients with CRE (15.4% vs 84.6%, P < .001) was introduced in others.

**DISCUSSION**

In the ROK, a 2015 outbreak of Middle East respiratory syndrome coronavirus with large clusters of nosocomial infections increased our interest in infection prevention and control programs. This study provides comprehensive information on the current status of facilities and staff personnel for infection prevention and control programs among hospitals in the ROK. These findings may help to identify the optimal strategies to manage infection control and prevention programs effectively in the ROK.

The structure of the hospital facilities and medical equipment or supplies are the critical components for effective infection prevention and control. It is a well-known fact from the outbreak of Middle East respiratory syndrome coronavirus in the ROK that multibed rooms enable the spread of infectious diseases, and this represents part of the chronic problems of the Korean health care system. In this study, the median number of single rooms in each hospital was 5 (range, 0-63). Patients with known or suspected infectious diseases acquired by contact or droplet routes or airborne droplet nuclei should be physically isolated from other patients. The use of single-room isolation with adherence to the requirements of isolation can be a cornerstone in the prevention and control of MDROs in hospitals. However, this practice is a challenge in the ROK where hospitals are largely organized in multibed rooms, with insufficient numbers of single rooms. A health care organization that
is planning to expand its facility may now consider the need for single rooms.

In 1999, the Centers for Disease Control and Prevention's National Nosocomial Infections Surveillance System recommended 1 full-time ICN per 100 hospital beds and 1 full-time ICN for each additional 250 beds.\(^1\)\(^2\)\(^3\) Actually, the average number of infection control professionals per 100 beds was 1.2 in U.S. hospitals enrolled in the National Health and Safety Network and 0.8 in Canadian acute care hospitals.\(^4\)\(^5\) Although infection prevention and control policies have largely improved the medical environmental on infection prevention and control, changes in the use of specialized personnel for infection prevention and control fell short of recommendations. For example, the ratio of the number of beds to ICNs in the ROK (1 full-time ICN per 100 hospital beds and 1 full-time ICN for each additional 250 beds) was lower than in other countries.\(^6\)\(^7\) \(^8\)\(^9\)\(^10\)\(^11\)\(^12\)\(^13\)\(^14\)\(^15\) \(^16\)\(^17\)\(^18\)\(^19\) Our study found a wide variation in the training and experience of ICNs. To date, there is no formal certification process to assess the practice of ICNs and ensure a minimum level of competence. The Korean Society for Healthcare-associated Infection Control and Prevention has recently attempted to provide a formal educational program for the updated practice for infection prevention and control. Promoting the training and appointment of specialist personnel to support and expand infection prevention and control programs should be the ongoing focus of effective policy-oriented management. The buildup of a highly qualified workforce should be based on the political support of continuous human resource development.

Of the responding hospitals, 97.6% have monitored the resistance proportion of major MDROs and have shared their results in clinical practice. Routine surveillance culture for targeted MDROs was conducted in 51.2% of hospitals; however, only some hospitals isolated the carriers to single rooms: 34.1% for the patients in the ICUs, and 19.5% for those in the general ward. Screening for carriers of MDROs and isolation of positive carriers appear to have a significant role in the reduction of the pool of colonized patients and in the prevention of cross-transmission.\(^17\)\(^18\) However, these studies only identified carriers of MDROs and did not establish isolation of patients with contact precautions.

The increasing prevalence of gram-negative MDROs has recently become a significant threat worldwide, including in the ROK.\(^19\) This study shows that the active surveillance culture introduced in 2014 has targeted gram-negative MDROs rather than gram-positive organisms. It is likely that the emergence of carbapenem-resistant organisms will result in changes in the choice of organisms for active surveillance cultures. However, facilities have great diversity in their approach to preventing gram-negative MDROs. The definitions of multidrug resistance and the criteria of isolation were not even unified, compared with those for gram-positive MDROs.\(^20\) On the
other hand, the centralized management of the increase in MDROs can be temporarily effective, under conditions of finite resources. However, a comprehensive and multifaceted approach simultaneously covering the various MDROs should be designed to minimize opportunity costs. 21

Over the last 5 years, the newly implemented Infectious Disease Control and Prevention Act and the hospital accreditation have resulted in substantial investment in infection prevention and control by hospitals throughout the ROK. However, the current fee-for-service payment system in the ROK does not offer reasonable incentives for infection prevention and control programs. Reflecting on the current state of the health care system, our study found a shortage of skilled workforce and inferior facilities for handwashing and a shortage of single rooms in relatively scaled-down hospitals. The lack of financial incentives for these activities potentially limits quantitative and qualitative improvement in infection prevention and control programs. A reasonable medical insurance fee should be established based on the multidisciplinary approach for effective execution of ideal infection prevention and control programs.

Our study has several limitations. Although this is the first report, to our knowledge, on the changes introduced since the implementation of a national surveillance network for MDROs, the sample size is small. Furthermore, the possibility of survey selection bias and information bias cannot be excluded.

CONCLUSIONS

This study demonstrates that despite policy changes, personnel resources for effective infection prevention and control programs in the ROK need reinforcement, both in terms of the numbers of specialists and the quality of their training. Investment in development of single rooms and implementation of a comprehensive program are also required, with the support of a sensible policy on medical insurance fees.

References

1. Haley RW, Culver DH, White JW, Morgan WM, Emori TG, Munn VP, et al. The efficacy of infection surveillance and control programs in preventing nosocomial infections in US hospitals. Am J Epidemiol 1985;121:182-205.

2. Scheckler WE, Brimhall D, Buck AS, Farr BM, Friedman C, Garibaldi RA, et al. Requirements for infrastructure and essential activities of infection control and epidemiology in hospitals: a consensus panel report. Society for Healthcare Epidemiology of America. Infect Control Hosp Epidemiol 1998;19:114-24.

3. Struelens MJ. Professional organization of healthcare-associated infection control: time for action across the patient care system. Curr Opin Infect Dis 2004;17:283-8.

4. Korea Centers for Disease Control and Prevention (KCDC). 2011 case definitions for national notifiable infectious diseases. Available from: http://www.cdc.go.kr/CDC/cms/content/58/12558_view.html. Accessed January 11, 2016.

5. Oh HS, Chung HW, Kim JS, Cho SI. National survey of the status of infection surveillance and control programs in acute care hospitals with more than 300 beds in the Republic of Korea. Am J Infect Control 2006;34:223-33.

6. Haley RW, Quade D, Freeman HE, Bennett JV, The SENIC Project. Study on the efficacy of nosocomial infection control (SENIC Project). Summary of study design. Am J Epidemiol 1980;111:472-85.

7. The SENIC Project. Appendix B: design of the Preliminary Screening Questionnaire and specifications for computing indexes of surveillance and control. Am J Epidemiol 1980;111:613-23.

8. Kim DH. Structural factors of the Middle East respiratory syndrome coronavirus outbreak as a public health crisis in Korea and future response strategies. J Prev Med Public Health 2015;48:265-70.

9. World Health Organization. Practical guidelines for infection control in health care facilities. 2004. Available from: http://www.wpro.who.int/publications/docs/practical_guidelines_infection_control.pdf. Accessed September 22, 2016.

10. Kilpatrick C, Prieto J, Wigglesworth N. Single room isolation to prevent the transmission of infection: development of a patient journey to support safe practice. Br J Infect Cont 2008;9:19-25.

11. Richards C, Emori TG, Edwards J, Fridkin S, Tolson J, Gaynes R. Characteristics of hospitals and infection control professionals participating in the National Nosocomial Infections Surveillance System 1999. Am J Infect Control 2000;28:400-3.

12. Stone PW, Pogorzelska-Maziarz M, Herzig CT, Weiner LM, Furuya EY, Dick A, et al. State of infection prevention in US hospitals enrolled in the National Health and Safety Network. Am J Infect Control 2014;42:94-9.

13. Zoutman DE, Ford BD. A comparison of infection control program resources, activities, and antibiotic resistant organism rates in Canadian acute care hospitals in 1999 and 2005: pre- and post-severe acute respiratory syndrome. Am J Infect Control 2008;36:711-7.

14. Nguyen CT, Proctor SE, Sinkowitz-Cochran RL, Garrett DO, Jarvis WR. Status of infection surveillance and control programs in the United States, 1992-1996. Association for Professionals in Infection Control and Epidemiology, Inc. Am J Infect Control 2000;28:392-400.

15. Zoutman DE, Ford BD, Bryce E, Gourdeau M, Hébert G, Henderson E, et al. The state of infection surveillance and control in Canadian acute care hospitals. Am J Infect Control 2003;31:266-72, discussion 272-3.

16. Stricoff RL, Schabes RA, Tserenpuntsag B. Infection control resources in New York State hospitals, 2007. Am J Infect Control 2008;36:702-9.

17. Siegel JD, Rhinehart E, Jackson M, Chiarello L. Management of MDROs in healthcare settings, 2006. Available from: www.cdc.gov/hicpac/pdf/MDRO/ MDROGuideline2006.pdf. Accessed January 15, 2016.

18. Pelleg AY, Hooper DC. Hospital-acquired infections due to gram-negative bacteria. N Engl J Med 2010;362:1804-13.

19. Yong D, Shin HB, Kim YK, Cho J, Lee WG, Ha GY, et al. Increase in the prevalence of carbapenem-resistant Acinetobacter isolates and ampicillin-resistant non-typhoidal salmonella species in Korea: a KONSAR study conducted in 2011. Infect Chemother 2014;46:84-93.

20. Drees M, Pineles L, Harris AD, Morgan DJ. Variation in definitions and isolation procedures for multidrug-resistant Gram-negative bacteria: a survey of the Society for Healthcare Epidemiology of America Research Network. Infect Control Hosp Epidemiol 2014;35:362-6.

21. Cassier N, Thomas G, Hraiech S, Brunet J, Fournier PE, La Scola B, et al. Chlorhexidine daily bathing: impact on health care-associated infections caused by gram-negative bacteria. Am J Infect Control 2015;43:640-3.