Journal of Infection and Public Health 15 (2022) 950–954

Contents lists available at ScienceDirect

Journal of Infection and Public Health

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

Self-reported antibiotic stewardship and infection control measures from 57 intensive care units: An international ID-IRI survey

Rehab El-Sokkary[a], Hakan Erdem[b,*], Ravina Kullar[c], Abdullah Umut Pekok[d], Fatma Amer[a], Svjetlana Grgić[e], Biljana Carevic[f], Amani El-Kholy[g], Anna Liskova[h], Mehmet Özdemir[i], Ejaz Ahmed Khan[j], Yesim Uygun Kizmaz[k], Nenad Pandak[l], Nirav Pandya[m], Jurica Arapović[e,n], Rıdvan Karaali[o], Nefise Oztoprak[p], Michael M. Petrov[q], Rami Alabadla[r], Handan Alay[s], Jehan Ali El Kholy[t], Caroline Landelle[u], Reham Khedr[v], Dhruv Mamtora[w], Gorana Dragovac[x], Ricardo Fernandez[y], Emine Unal Evren[z], Lul Raka[aa], Antonio Cascio[ab], Nicolas Dauby[ac], Ahsen Oncul[ad], Safak Ozer Balin[ae], Yasemin Cag[af], Natalia Dirani[ag], Mustafa Dogan[ah], Irina Magdalena Dumitru[ai], Maha Ali Gad[aj], Ilad Alavi Darazam[ak], Behrouz Naghili[al], Rosa Fontana Del Vecchio[am], Monica Licker[an], Andrea Marino[ao], Nasim Akhtar[ap], Mostafa Kamal[aq], Goffredo Angioni[ar], Deana Medić[as], Aliye Esmaoğlu[at], Szabo Balint Gergely[au], André Silva-Pinto[av], Lurdes Santos[av], Ionela Larisa Miftode[aw], Recep Tekin[ax], Phunsup Wongsurakiat[ay], Mumtaz Ali Khan[az], Yesim Kurekci[ba], Hema Prakash Pilli[bb], Krsto Grozdanovski[bc], Egidia Miftode[aw], Rusmir Baljic[bd], Serhat Uysal[be], Haluk Vahabolgu[af], Jordi Rello[bf]

[a] *Department of Medical Microbiology and Immunology, Faculty of medicine, Zagazig University, Egypt*
[b] *ID-IRI Lead Coordinator, Ankara, Turkey*
[c] *Expert Stewardship, Inc., Los Angeles, CA, USA*
[d] *Department of Infectious Diseases and Clinical Microbiology, Bahcesehir University Medicine of Faculty, Turkey*
[e] *Department of Infectious Diseases, University Clinical Hospital Mostar, Mostar, Bosnia and Herzegovina*
[f] *Clinical Center of Serbia, Belgrade, Serbia*
[g] *Department of Clinical Pathology, Faculty of Medicine, Cairo University, Egypt*
[h] *Hospital Nitra, Nitra, Slovak Republic*
[i] *Necmettin Erbakan University, Meram Faculty of Medicine, Turkey*
[j] *Shifa International Hospital, Islamabad, Pakistan*
[k] *Kartal Kosuyolu High Specialization Training and Research Hospital, Turkey*
[l] *The Royal Hospital, Muscat, Oman*
[m] *Bhailal Amin General Hospital, Gujarat, India*
[n] *School of Medicine University of Mostar, Mostar, Bosnia and Herzegovina*
[o] *Istanbul University, Cerrahpasa Medical Faculty, Istanbul, Turkey*
[p] *Health Sciences University Antalya Training and Research Hospital, Turkey*
[q] *St. George" University Hospital, Plovdiv, Bulgaria*
[r] *European Gaza Hospital (EGH), Gaza, Palestine*
[s] *Ataturk University, School of Medicine, Erzurum, Turkey*
[t] *Department of Anesthesiology and Intensive Care, Faculty of Medicine, Cairo University, Egypt*
[u] *CHU Grenoble Alpes, France*
[v] *Department of Pediatric Oncology, National Cancer Institute – Cairo University / Children Cancer Hospital Egypt 57357, Egypt*
[w] *SL Raheja Hospital, Mumbai, India*
[x] *Clinical Center of Vojvodina, Novi Sad, Serbia*
[y] *Hospital Municipal de San Juan, Puerto Rico*
[z] *University of Kyrenia, Dr. Suat Gunsel Hospital, Cyprus*
[aa] *National Institute of Public Health of Kosova & University "Hasan Prishtina", Prishtina, Kosova*
[ab] *AOU Policlinico "P. Giaccone", Palermo, Italy*
[ac] *Environmental Health Research Centre, Public Health School, Université Libre de Bruxelles (ULB), Brussels, Belgium*
[ad] *Sisli Hamidiye Etfal Education and Research Hospital, Istanbul, Turkey*
[ae] *Fırat University Medical Faculty Hospital, Elazig, Turkey*

* Corresponding author.
E-mail address: hakanerdem1969@yahoo.com (H. Erdem).

https://doi.org/10.1016/j.jiph.2022.07.009

[af] Istanbul Medeniyet University, Goztepe Training and Research Hospital, Istanbul, Turkey
[ag] Dar al Amal University Hospital, Douris, Lebanon
[ah] Namık Kemal University School of Medicine, Hatay, Turkey
[ai] Clinical Infectious Diseases Hospital Constanta, Ovidius University of Constanta, Romania
[aj] Kasr Eliny Hospital, Cairo, Egypt
[ak] Loghman Hakim Hospital, Tehran, Iran
[al] Imam Reza hospital of Tabriz University of Medical Sciences), Iran
[am] Department of Clinical and Molecular Biomedicine, Division of Infectious Diseases, University of Catania, Garibaldi Nesima Hospital, Catania, Italy
[an] Victor Babes University of Medicine and Pharmacy Timisoara, Romania
[ao] Arnas Garibaldi Hospital, Catania, Italy
[ap] Pakistan Institute of Medical Sciences, Islamabad, Pakistan
[aq] ICU, RMCH, Rajshahi, Bangladesh
[ar] SS. Trinita' Hospital, Cagliari, Italy
[as] Institute for Child Health of Vojvodina, Serbia
[at] Erciyes University Medical School Hospital, Kayseri, Turkey
[au] South Pest Central Hospital, National Institute of Hematology and Infectious Diseases, Saint Ladislaus Campus, Budapest, Hungary
[av] Centro Hospitalar Universitário de São João, Portugal
[aw] St. Parascheva" Clinical Hospital of Infectious Diseases, Iasi, Romania
[ax] Dicle University, School of Medicine, Diyarbakir, Turkey
[ay] Siriraj Hospital, Mahidol University, Bangkok, Thailand
[az] National Institute of Health Islamabad, Pakistan
[ba] Arnavutkoy State Hospital, Istanbul, Turkey
[bb] GITAM Institute of Medical Sciences and Research, Rushikonda, Visakhapatnam, India
[bc] University Clinic for Infectious Diseases, Skopje, Macedonia
[bd] KCU Sarajevo, Bosnia and Herzegovina
[be] Department of Infectious Diseases and Clinical Microbiology, Kanuni Research and Training Hospital, Trabzon, Turkey
[bf] Critical care Department, Hospital Vall d'Hebron, Ciberes, Universitat Autonma de Barcelona, Spain

ARTICLE INFO

Article history:
Received 16 May 2022
Received in revised form 12 July 2022
Accepted 21 July 2022

Keywords:
Multidrug resistance
Infection control
Stewardship
Low- and upper-middle and high income
MDROs
Pan drug resistance

ABSTRACT

We explored the self-reported antibiotic stewardship (AS), and infection prevention and control (IPC) activities in intensive care units (ICUs) of different income settings. A cross-sectional study was conducted using an online questionnaire to collect data about IPC and AS measures in participating ICUs. The study participants were Infectious Diseases–International Research Initiative (IDI-IR) members, committed as per their institutional agreement form. We analyzed responses from 57 ICUs in 24 countries (Lower-middle income (LMI), n = 13; Upper-middle income (UMI), n = 33; High-income (HI), n = 11). This represented (~5%) of centers represented in the ID-IRI. Surveillance programs were implemented in (76.9%–90.9%) of ICUs with fewer contact precaution measures in LMI ones (**p = 0.02**); (LMI:69.2%, UMI:97%, HI:100%). Participation in regional antimicrobial resistance programs was more significantly applied in HI (**p = 0.02**) (LMI:38.4%,UMI:81.8%,HI:72.2%). AS programs are implemented in 77.2% of institutions with AS champions in 66.7%. Infectious diseases physicians and microbiologists are members of many AS teams (59%&50%) respectively. Unqualified healthcare professionals(42.1%), and deficient incentives(28.1%) are the main barriers to implementing AS. We underscore the existing differences in IPC and AS programs' implementation, team composition, and faced barriers. Continuous collaboration and sharing best practices on APM is needed. The role of regional and international organizations should be encouraged. Global support for capacity building of healthcare practitioners is warranted.

1. Background

Antimicrobial resistance (AMR) impends the practice of modern medicine[1]. By 2050, AMR is expected to cause 10 million deaths each year worldwide, leading to increased healthcare expenditures. In hospitals, core antimicrobial resistance prevention measures (APM) include antibiotic stewardship (AS), and infection prevention and control (IPC) programs [2]. These measures can help in curbing AMR [3,4] and limit the spread of multidrug-resistant micro-organisms (MDROs) [5].

Earlier global reports addressed differences between countries either in AS programs [11] or IPC programs [6,9], with a paucity of data about APM from LMICs, despite the high burden of AMR problem in these countries[7]. Continuous emphasis on addressing the variability of APM to understand differences, and find solutions for regional AS is warranted [8]. We explored the self-reported antimicrobial resistance prevention measures; IPC and AS comparing data in ICUs from different income settings.

2. Methods

This prospective cross-sectional study was conducted by the Infectious Diseases – International Research Initiative (ID-IRI); a network for clinical research on infectious diseases, and clinical microbiology (https://infectdisiri.com/). A self-administered online questionnaire was developed from published checklists [10] (Supplement 1), including IPC, and AS activities in intensive care units (ICUs). A Study Protocol-Invitation Letter informed all ID-IRI members. Researchers who committed, as per the institutional agreement form, to collaborate were eligible for participation. Participating centers were categorized as lower-middle-income (LMI), upper-middle-income (UMI), and high-income (HI)[11]. Data were analyzed by SPSS, version22(Armonk, NY: IBM Corp.). Detailed profile of the multidrug resistant organisms isolated from the investigated ICUs has been published earlier [12]. Categorical qualitative variables were expressed as absolute and relative frequencies; number and percentage. Categorical data were compared using Chi-square test. All tests were two sided. p-value < 0.05 was considered statistically significant.

Table 1
Infection prevention and control measures for MDROs at participating centers.

	LMI (n = 13)	UMI (n = 33)	HI (n = 11)	p
Surveillance for MDRO				
Hospital has a surveillance program to monitor MDROs	10 (76.9%)	30 (90.9%)	10 (90.9%)	0.311
The facility has an in-house microbiology lab	12 (92.3%)	23 (69.7%)	9 (81.8%)	0.148
Hospital participates in regional AMR prevention programs	5 (38.4)	27 (81.8)	8 (72.2)	**0.002**
Hospital has a list of MDROs for which Contact Precautions should be instituted	9 (69.2)	32 (97)	11 (100)	**0.02**
Hospital uses surveillance data to implement corrective actions	10 (76.9)	26 (78.8)	8 (72.2)	0.704
Infection control measures/supplies for MDROs				
Single rooms are used preferentially for patients with target MDROs	10 (76.9)	22 (66.7)	10 (90.9)	0.241
Hospital has a competency-based training program for hand hygiene	10 (76.9)	27 (81.8)	9 (81.8)	0.895
Hospital regularly audits adherence to hand hygiene	10 (76.9)	24 (72.7)	8 (72.2)	0.827
Hospital provides audits feedback for hand hygiene compliance	8 (61.6)	25 (75.8)	7 (63.6)	0.265
Hand hygiene supplies are accessible in-patient care areas	11 (84.6)	33 (100)	11 (100)	0.168
Hospital has a competency-based training program for environmental cleaning	10 (76.9)	27 (81.8)	7 (63.6)	0.442
Hospital has policies for cleaning and disinfection	11 (84.6)	22 (66.7)	7 (63.6)	0.186
Hospital regularly audits adherence to cleaning and disinfection procedures	10 (76.9)	27 (81.8)	6 (54.5)	0.175
Hospital provides audits feedback for cleaning and disinfection compliance.	10 (76.9)	27 (81.8)	5 (45.5)	0.05
Hospital has a competency-based training program for use of PPE	11 (84.6)	24 (72.7)	7 (63.6)	0.274
Hospital provides audits feedback for PPE use compliance.	9 (69.2)	20 (60.6)	4 (36.4)	0.159
Contact precaution supplies are available near point of use.	10 (76.9)	29 (77.9)	11 (100)	0.298
Hospital has policy to dedicate reusable medical equipment to patients with epidemiologically important MDROs when possible.	9 (69.2)	25 (75.8)	8 (72.2)	0.834
Patients with invasive devices are assessed, at least daily, for continued need for the device.	8 (61.6)	28 (84.8)	10 (90.9)	0.123
Identification and Communication of MDRO infected patients				
Hospital has mechanisms for timely notification of responsible staff when novel or targeted MDROs are detected.	8 (61.6)	28 (84.8)	8 (72.7)	0.142
Hospital has a system in place to identify patients at risk for MDROs.	7 (53.8)	18 (54.5)	5 (45.5)	0.810
Hospital has system to identify patients with targeted MDROs at readmission so appropriate precautions can be applied.	4 (30.8)	17 (51.5)	5 (45.5)	0.558
Hospital has a system for intra-facility communication to identify infectious status and isolation needs of patients prior to transfer within the hospital	8 (61.6)	21 (63.6)	7 (63.6)	0.970
Hospital has systems in place for inter-facility communication to identify infectious status and isolation needs of patients prior to transfer to other facilities.	5 (38.4)	19 (57.6)	7 (63.6)	0.520

LMI: Lower-middle income, UMI: Upper middle income, HI: High Income., MDRO: Multidrug resistant organisms, PPE: personal protective equipment, AMR: Antimicrobial resistance.

3. Results

Fifty-seven participating ICUs representing 24 countries from various geographical regions submitted their data [Supplement 2 and 3]. Approximately there are more than 1000 centers represented in the ID-IRI. When the research call was released 57 (~5%) of them were willing to join. Different economic levels were represented: LMI (n = 13), UMI (n = 33), and HI (n = 11).

Most of the investigated centers have running surveillance programs and used such data to implement corrective actions. Statistical significant differences are reported for joining regional AMR prevention programs (**p = 0.002**) and having a list of targeted MDROs for which contact precautions should be initiated (**p = 0.02**). Timely notification by the microbiology laboratory to responsible staff (e.g., clinicians, IPC) when novel/targeted MDROs were isolated had been established in most participating centers (61.6%–84.8%). Lower rates were reported for the identification of patients at risk of developing MDROs and for readmission of MDROs-infected patients. Inter- and intra-facility communication are functional in many centers [Table 1]. 44/57 institutions (77.2%) implemented AS programs (Table 2).

AS champions were either infectious diseases (ID) physicians (23/38, 60.5%), microbiologists (6/38, 15.8%), pharmacists (5/38, 13.2%), or physicians with interest/experience in ID (4/38, 10.5%). AS teams' composition: ID physicians and microbiologists are present in many teams (26/44, 59% & 22/44, 50%, respectively). Lower rates are reported for other physicians (15/44, 34%), pharmacists (16/44, 36.4%), epidemiologists (8/44, 18.2%), managers (6/44, 13.6%), and IPC nurses (6/44, 13.6%). In LMI, (7/9, 77.9%) of teams comprised primarily of microbiologists, pharmacists, physicians, and IPC nurses. In UMI, teams include: microbiologists (9/26, 45%), epidemiologists (7/26, 35%), and pharmacists (4/26, 20%). In the nine HI settings, microbiologists and pharmacists were included in (55.6%–77.8%) of the teams. The reported barriers to AS programs were unqualified healthcare (24/57, 42.1%), deficient incentives, and resources (16/57, 28.1%), and inefficient inter-professional interactions (7/57, 12.3%).

4. Discussion

Most participating centers have functional IPC and AS programs. This is encouraging given the fundamental importance of these programs for APM. Hence, we underscore the existing differences in programs implementation, team composition, and faced barriers.

Surveillance programs were running in most centers, with significantly fewer contact precaution measures implemented in LMI settings. Similar results were reported earlier [13]. The situation in limited-resource settings is challenging to accomplish due to the changes in workflow necessitated by this type of isolation [2,14]. We noted a significant discrepancy between different income settings for participation in regional Antimicrobial resistance prevention programs: HI and UMI settings participated at a much higher rate compared to LMI. A formal regional organization may help small countries with limited human and professional resources to pool their reserves collectively with more empowerment for individual ones [7]. Knowledge exchange through international and national platforms could play a critical role.

Surprisingly, no significant differences were between different income levels, and IPC elements were recorded. Prior studies have revealed that IPC programs were habitually weak in LMI countries due to financial limitations and lack of structured support; even when present, adherence is often limited [15]. The sampling technique could justify this, as we enrolled the institutions based on the willingness of ID-IRI members.

The investigated hospitals are in need to consider their readiness to cope with the influx of MDROs-infected patients, e.g., by offering a consistent identification system rather than discrete efforts. Our

Table 2
Antimicrobial stewardship programs within the participating facilities.

	LMI (n = 13)	UMI (n = 33)	HI (n = 11)	p
Presence of identified AS program	9 (69.2%)	26 (78.8%)	9 (81.8%)	0.798
Presence of AS program champion	9 (69.2%)	20 (60.6%)	9 (81.8%)	
Access of AS team to antimicrobial use data	9 (69.2%)	21 (63.6%)	8 (72.2%)	0.880
Annual AS team review of the facility's formulary	7 (53.8%)	16 (48.5%)	8 (72.2%)	0.476
The facility has defined criteria for use of restricted antimicrobials	9 (69.2%)	19 (57.6%)	9 (81.8%)	0.389
The facility developed an antibiogram	11 (84.6%)	20 (60.6%)	9 (81.8%)	0.153
Microbiology testing results are communicated to providers	10 (76.9%)	27 (81.8%)	11 (100%)	0.396
The facility has guidelines and clinical pathways for antimicrobial treatment of common infectious syndromes	10 (76.9%)	18 (54.5%)	9 (81.8%)	0.158
Antimicrobial prescribing is revised by ID/clinical pharmacist	8 (61.6%)	19 (57.6%)	8 (72.2%)	0.783
Parenteral-to-oral conversion opportunities are communicated to prescribers in a timely manner	7 (53.8%)	8 (24.2%)	5 (45.5%)	0.114
The facility has computer physician order entry (CPOE)	6 (46.2%)	21 (63.6%)	7 (63.6%)	0.285
The facility monitors adverse events associated with antimicrobials	8 (61.6%)	16 (48.5%)	3 (27.3%)	0.162

LMI: Lower-middle income, UMI: Upper-middle income, HI: High income, AS: Antibiotic stewardship, ID=infectious diseases physician.

results showed timely notification by the microbiology laboratory to IPC staff and clinicians when any MDRO isolate existed. Yet, a system to identify patients at risk of developing or being infected with targeted MDROs at readmission so that appropriate precautions could be applied was low. Earlier studies have revealed the importance of access to trained IPC practitioners to assist in the implementation and monitoring of infection control measures [16]. Good communication between the IPC team and other healthcare teams is essential to identify patients' needs before transfer [17].

In this study, 77.2% of the institutions had an AS use program, as previously published [13]. Re-consideration of the AS teams' construction is warranted. Infectious diseases (ID) physicians take part in the management of a significant portion of primary patients of other medical specialties and their importance in AS has long been known. Unfortunately, they are not available in most LMI settings [18]. Given the wide range of staff categories involved in stewardship in limited-resource settings, formal or on-the-job training on antibiotics and stewardship must be highly encouraged for the stewardship leads to ensure they are prepared to manage an AS program [19]. Notably, AS teams were well constructed in ~80% of LMI settings. Remarkably, the epidemiologists are absent from a majority of high resource settings despite their crucial role in driving efforts in healthcare AS. Similarly [2,20], We reported incompetent healthcare professionals and the lack of adequate incentives and resources as the primary barrier to AS program.

A strength of our methodology was the usage of a standard questionnaire for all hospitals, which allowed uniformity in comparisons across different settings. However, the use of convenience samples could interfere with the generalizability of data and may lead to an imperfect picture of APM within certain countries. The subjectivity of a self-reported questionnaire remains the main limitation of the study. We tried to overcome this by disseminating a clear definition of all requested items in the questionnaire, and in case of bizarre results we contacted the corresponding investigator to discuss such findings. However, we shed some light on many differences in APM notably in surveillance programs, joining regional antimicrobial resistance programs, stewardship team composition, and inter-professional communication. Low-, middle-, and HI countries should collaborate and share best practices on APM. The role of regional and international organizations should be encouraged. Global support for capacity building of healthcare practitioners and proper allocation of resources are warranted.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.jiph.2022.07.009.

References

[1] Erdem H, Inan A, Altindis S, Carevic B, Askarian M, Cottle L, et al. Surveillance, control and management of infections in intensive care units in Southern Europe, Turkey, and Iran - A prospective multicenter point prevalence study. J Infect 2014;68:131–40. https://doi.org/10.1016/j.jinf.2013.11.001

[2] El-Sokkary RH, Negm EM, Othman HA, Tawfeek MM, Metwally WS. Stewardship actions for device associated infections: An intervention study in the emergency intensive care unit. J Infect Public Health 2020;13:1927–31. https://doi.org/10.1016/j.jiph.2020.10.003

[3] Dellit TH, Owens RC, McGowan JE, Gerding DN, Weinstein RA, Burke JP, et al. Summary of the Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. Clin Infect Dis 2007;44:159–77. https://doi.org/10.1097/IPC.0b013e318068b1c0

[4] J. O'Neill, Tackling drug-resistance infections globally: final report and recommendations, 2016. Available: ⟨https://amr-review.org/sites/default/files/160518_Final%20paper_with%20cover.pdf⟩ [Accessed 2 December 2020] n.d.

[5] World Health Organization [WHO]. The evolving threat of antimicrobial resistance: options for action. Geneva: WHO; 2012. n.d.

[6] Center for disease dynamics economics & policy the state of the world's antibiotics, 2015. ⟨https://cddep.org/publications/state_worlds_antibiotics_2015/⟩ (accessed 18 April 2021).

[7] Forde CA, Martindale Y, Patel S. The Real Scenario in Infection Prevention and Control in Low- and Middle-Income Countries: the Challenge of "Starting From Scratch.". Curr Treat Options Infect Dis 2019;11:281–91. https://doi.org/10.1007/s40506-019-00196-3

[8] Howard P, Pulcini C, Levy Hara G, West RM, Gould IM, Harbarth S, et al. An international cross-sectional survey of antimicrobial stewardship programmes in hospitals. J Antimicrob Chemother 2014;70:1245–55. https://doi.org/10.1093/jac/dku497

[9] Keizer J, Braakman-Jansen LMA, Kampmeier S, Köck R, Al Naiemi N, Te Riet-Warning R, et al. Cross-border comparison of antimicrobial resistance (AMR) and AMR prevention measures: The healthcare workers' perspective. Antimicrob Resist Infect Control 2019:8. https://doi.org/10.1186/s13756-019-0577-4

[10] Hudson S, Alllen G, Hurt D, editors. Forms & Checklists for Infection Prevention. 1st ed..,Wachington, D.C.: Association for Professionals in Infection Control and Epidemiology (APIC); 2017.

[11] Updated country income classifications for the World Bank's 2020 fiscal year. 2020. ⟨https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups⟩ Accessed [2 february, 2020].

[12.] El-Sokkary R, Uysal S, Erdem H, Kullar R, Pekok AU, Amer F, Grgić S, Carevic B, El-Kholy A, Liskova A, Özdemir M, Khan EA, Uygun-Kizmaz Y, Pandak N, Pandya N, Arapović J, Karaali R, Oztoprak N, Petrov MM, Alabadla R, Alay H, Kholy JAE, Landelle C, Khedr R, Mamtora D, Dragovac G, Fernandez R, Evren EU, Raka L, Cascio A, Dauby N, Oncul A, Balin SO, Cag Y, Dirani N, Dogan M, Dumitru IM, Gad MA, Darazam IA, Naghili B, Del, Vecchio RF, Licker M, Marino A, Akhtar N, Kamal M, Angioni G, Medić D, Esmaoğlu A, Gergely SB, Silva-Pinto A, Santos L, Miftode IL, Tekin R, Wongsurakiat P, Khan MA, Kurekci Y, Pilli HP, Grozdanovski K, Miftode E, Baljic R, Vahabolgu H, Rello J. Profiles of multidrug-resistant organisms among patients with bacteremia in intensive care units: an international ID-IRI survey. Eur J Clin Microbiol Infect Dis 2021;40(11):2323–34.

[13] Safdar N, Sengupta S, Musuuza JS, Juthani-Mehta M, Drees M, Abbo LM, et al. Status of the prevention of multidrug-resistant organisms in international settings: a survey of the society for healthcare epidemiology of america research network. Infect Control Hosp Epidemiol 2017;38:53–60. https://doi.org/10.1017/ice.2016.242

[14] Yanke E, Zellmer C, Van Hoof S, Moriarty H, Carayon P, Safdar N. Understanding the current state of infection prevention to prevent clostridium difficile infection: a human factors and systems engineering approach eric. Am J Infect Control 2015;43:241–7.

[15] Weinshel K, Dramowski A, Hajdu Á, Jacob S, Khanal B, Zoltán M, et al. Gap analysis of infection control practices in low- and middle-income countries. Infect Control Hosp Epidemiol 2015;36:1208–14. https://doi.org/10.1017/ice.2015.160

[16] Lipke V, Emerson C, McCarthy C, Briggs-Hagen M, Farley J, Verani AR, et al. Highlighting the need for more infection control practitioners in low- and middle-income countries. Public Heal Action 2016;6:160–3. https://doi.org/10.5588/pha.16.0027

[17] Ong MS, Magrabi F, Post J, Morris S, Westbrook J, Wobcke W, et al. Communication interventions to improve adherence to infection control precautions: A randomised crossover trial. BMC Infect Dis 2013;13. https://doi.org/10.1186/1471-2334-13-72

[18] Antimicrobial stewardship programmes in health-care facilities in low- and middle-income countries: a WHO practical toolkit, 2019. https://doi.org/10.1093/jacamr/dlz072. n.d.

[19] CDC, Core Elements of Antibiotic Stewardship, 2018. ⟨https://www.cdc.gov/antibiotic-use/healthcare/implementation.html⟩ Accessed [2nd April, 2020]. n.d.

[20] Pakyz AL, Moczygemba LR, Vanderwielen LM, Edmond MB, Stevens MP, Kuzel AJ. Facilitators and barriers to implementing antimicrobial stewardship strategies: Results from a qualitative study. Am J Infec 2014;42:S257–63. https://doi.org/10.1016/j.ajic.2014.04.023