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Infection control bundles in intensive care: an international cross-sectional survey in low- and middle-income countries

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SUMMARY

Background: In low- and middle-income countries (LMICs), the burden of healthcare-associated infections (HCAIs) is not known due to a lack of national surveillance systems, standardized infection definitions, and paucity of infection prevention and control (IPC) organizations and legal infrastructure.

Aim: To determine the status of IPC bundle practice and the most frequent interventional variables in LMICs.

Methods: A questionnaire was emailed to Infectious Diseases International Research Initiative (ID-IRI) Group Members and dedicated IPC doctors working in LMICs to examine self-reported practices/policies regarding IPC bundles. Responding country incomes were classified by World Bank definitions into low, middle, and high. Comparison of LMIC results was then made to a control group of high-income countries (HICs).

Findings: This survey reports practices from one low-income country (LIC), 16 middle-income countries (MICs) (13 European), compared to eight high-income countries (HICs). Eighteen (95%) MICs had an IPC committee in their hospital, 12 (63.2%) had an annual agreed programme and produced an HCAI report. Annual agreed programmes (87.5% vs 63.2%, respectively) and an annual HCAI report (75.0% vs 63.2%, respectively) were more common in HICs than MICs. All HICs had at least one invasive device-related surveillance programme. Seven (37%) MICs had no invasive device-related surveillance programme, six (32%) had no ventilator-associated pneumonia prevention bundles, seven (37%) had no catheter-associated urinary tract infection prevention bundles, and five (27%) had no central line-associated bloodstream infection prevention bundles.

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Conclusion: LMICs need to develop their own bundles with low-cost and high-level-of-evidence variables adapted to the limited resources, with further validation in reducing infection rates.

Introduction

Healthcare-associated infections (HCAIs) cause an important global patient safety problem due to significant patient morbidity, mortality, and economic burden [1]. In high-income countries (HICs), there are well-established surveillance systems and infection prevention and control (IPC) policies. However, HCAIs still affect 3.5–12% of patients in the hospitals in these countries. Every year, more than four million patients are affected by HCAIs in Europe, and 1.7 million patients are affected in the USA [1]. In low- and middle-income countries (LMICs), the burden of HCAIs is not known due to a lack of national surveillance systems, standardized infection definitions, and paucity of IPC organizations and legal infrastructure [2].

Some studies, particularly in Eastern Mediterranean, Latin American and some Asian countries have reported HCAI prevalence of more than 10% and as high as 50% in intensive care units (ICUs). However, these studies are usually from individual centres and are not nationwide [3,4]. The International Nosocomial Control Consortium (INICC) is an international, multicentred, HCAI surveillance programme in developing countries using the US Centers for Disease Control and Prevention (CDC) definitions and methodology. In these studies, device-associated infection (DAI) rates were significantly higher in developing countries than US hospitals, and the observed HCAI rates were strongly associated with socioeconomic levels of the participating countries [5–8].

HCAIs are most prevalent in ICUs due to invasive device usage, severity of illness, comorbidities, workload and poor IPC practices. In the recent years, IPC bundles have been implemented comprising three to five key IPC elements based on evidence or derived from well-accepted guidelines. Many studies from HICs showed that the bundle care approach was effective in IPC [9–11]. INICC also initiated a multidimensional approach programme with IPC bundles for reduction of device HCAI rates in dedicated hospitals and showed a reduction in HCAIs even in LMICs [12–15]. However, little is known about IPC of DAIs and the implementation of IPC bundles in LMICs. Our hypothesis is that in LMICs, there is a lack of DAI surveillance and limited awareness of IPC bundles.

This survey thus aimed to determine the status of IPC and bundle practice in ICUs and regulations in LMICs, compared with high-income countries (HICs) with the further goal of reflecting on results, updating the bundle approach, and informing the prioritization of their use. A secondary objective emerged (based on the responses received) to compare European (EU) and non-EU high-income countries (MICs).

Methods

The study aimed to identify IPC practices in ICUs throughout the participating centres in 2017. An invitation to complete a questionnaire was emailed in November 2017 to 314 members of the Infectious Diseases International Research Initiative (ID-IRI) group as well as dedicated IPC doctors working in HICs and LMICs (52 doctors) who were in contact with the authors. It examined self-reported practices/policies regarding IPC bundles using the checklist rules reported by Pulcini and Leibovici [16]. The survey collected data on key aspects of infection control activities; such as establishment of infection control committee in hospital, annual agreed programme, surveillance of device-related infections, and IPC bundle strategy. The study protocol and questionnaire form were published previously [17]. HCAI rates were reported from their surveillance reports. Because this was a quality assessment survey (which did not address patients' data), no informed consent or ethical board approval was required.

Responding country incomes were classified by World Bank definitions into low-income countries (LICs) (having a gross national income (GNI) per capita of $1005 or less); middle-income countries (MICs) (between $1006 and $12,235); high-income countries (HICs) ($12,236 or more). Countries with incomes lower than $12,236 were thus the focus of this study [18].

The collected information was processed using version 20.0 of the Statistical Package for Social Sciences (SPSS) for Windows. Responses were analysed using descriptive statistics, reporting proportions (percentages). Data were reported as median (interquartile range) when a non-normal distribution occurred. The data sets supporting the conclusions of this article are available upon request.

Results

A total of 38 (10.4%) respondents from 25 countries completed the questionnaire. Among 25 countries, eight (28.5%) were HICs, 16 (67.8%) were MICs and one (3.5%) was an LIC (Nepal). Indeed, data from MICs (19 centres) were compared with a control group of HICs (eight centres), represented by Ireland, Netherlands, Austria, Italy, Puerto Rico, Australia, Bahrain, and Saudi Arabia. MICs had representation from 13 European centres (Albania (two centres), Bosnia, Bulgaria, Georgia, Serbia (two centres), Kosova, Romania, Turkey (11 centres), Azerbaijan (two centres) and Kazakhstan). Because there were 11 responses from Turkey, only one representative was selected for comparison. Finally, six centres from non-European middle-income countries (India, Pakistan, Thailand, Bangladesh, Jordan, Nigeria) were represented. IPC practices of the countries are compared between MICs and HICs (Table I) and European and non-European MICs (Table II).

Seventeen (63%) respondents' hospitals were acute tertiary referral centres and 18 (69%) hospitals combined adult and paediatric patients.

Nurse:patient ratio was 1:1 in two (25%) HIC centres but this ratio was not found in any MIC centres. On the other hand,

Table I

Survey comparison of infection control practices between middle- and high-income countries

Hospital variables and bundle implementation	Middle-income counties ($N = 19$)	High-income countries ($N = 8$)
Total no. of beds in ICU		
≤8	3 (15.8%)	0
9–16	8 (42.1%)	2 (25.0%)
≥16	8 (42.1%)	6 (75.0%)
Nurse:patient ratio		
1	0	2 (25.0%)
2–3	10 (52.6%)	6 (75.0%)
3–6	9 (47.4%)	1 (12.5%)
Infection control facilities		
Any infection control committee in hospital	18 (94.7%)	7 (87.5%)
Annual agreed programme	12 (63.2%)	7 (87.5%)
Annual report about nosocomial infection rates	12 (63.2%)	6 (75.0%)
Any full-time equivalent infection control doctor	10 (52.6%)	5 (62.5%)
Any full-time equivalent infection control nurse	15 (78.9%)	7 (87.5%)
Surveillance		
Any device-related infection surveillance programme in ICUs	12 (63.2%)	8 (100.0%)
VAP	13 (68.4%)	5 (62.5%)
CAUTI	12 (63.2%)	5 (62.5%)
CLABSI	14 (73.7%)	8 (100.0%)
Nosocomial infection rates in ICU in 2015		
VAP, median (range) ($N = 14$)	20 (5.0–61.0%)	10 (1.3–20.0%)
CAUTI, median (range) ($N = 13$)	23.0 (2.53–45.0%)	11.5 (1.9–40.0%)
CLABSI, median (range) ($N = 14$)	13.5 (0.0–19.0%)	4.1 (0.40–30.0%)
Bundles to prevent		
VAP	16 (84.2%)	6 (75.0%)
With process monitoring	9 (50.0%)	5 (83.3%)
Continuous process	10 (58.8%)	6 (85.7%)
CAUTI	13 (68.4%)	6 (75.0%)
With process monitoring	10 (58.8%)	5 (71.4%)
Continuous process	8 (50.0%)	5 (71.4%)
CLABSI	16 (88.9%)	7 (87.5%)
With process monitoring	12 (70.6%)	5 (62.5%)
Continuous process	10 (62.5%)	5 (62.5%)
Prevent dissemination of multidrug-resistant pathogens	11 (57.9%)	4 (50.0%)
With process monitoring	6 (35.3)	3 (50.0)
Continuous process	4 (25.0)	2 (33.3)
The introduction of bundles in hospital accompanied	($N = 17$)	($N = 8$)
by convening a group to oversee this	11 (64.7%)	6 (75.0%)
A multi-disciplinary group including, for example, doctors and nurses	11 (64.7%)	7 (87.5%)
Examination of the evidence base for the bundle parameters	6 (35.3%)	7 (87.5%)
A group(s) to assess bundle monitoring, ensuring that results are fed back to the relevant clinicians	8 (47.1%)	6 (75.0%)
Results of the bundle programme reviewed at least annually	8 (47.1%)	4 (50.0%)
Prevention bundles		
Regulated by government		
VAP	3 (17.6%)	1 (12.5%)
CAUTI	2 (11.8%)	1 (12.5%)
CLABSI	4 (23.5%)	3 (37.5%)
Recommended by department of health		
VAP	6 (35.3%)	5 (62.5%)
CAUTI	7 (41.2%)	5 (62.5%)
CLABSI	7 (41.2%)	6 (75.0%)
Recommended by professional organizations		
VAP	9 (52.9%)	3 (37.5%)
CAUTI	10 (58.8%)	5 (62.5%)

Table I (*continued*)

Hospital variables and bundle implementation	Middle-income counties ($N = 19$)	High-income countries ($N = 8$)
CLABSI	9 (52.9%)	6 (75.0%)
Inspected at external accreditation/inspection visits		
VAP	4 (23.5%)	3 (37.5%)
CAUTI	3 (18.8%)	3 (37.5%)
CLABSI	4 (23.5%)	4 (50.0%)

ICU, intensive care unit; VAP, ventilator-associated pneumonia; CAUTI, catheter-associated urinary infection; CLABSI, central line-associated bloodstream infection.

Table II
Survey comparison of infection control practices between European and non-European middle-income countries (MICs)

Hospital variables and bundle implementation	European MIC ($N = 13$)	Non-European MIC ($N = 6$)	*P*-value
Total no. of beds in ICU			
≤8	2 (15.4%)	1 (16.7%)	0.943
9–16	5 (38.5%)	3 (50.0%)	0.636
≥16	6 (46.2%)	2 (33.3%)	0.659
Nurse:patient ratio			
1	0	0	–
1–3	7 (53.8%)	3 (50.0%)	0.876
3–6	6 (46.2%)	3 (50.0%)	0.876
Infection control facilities			
Any infection control committee in hospital	12 (92.3%)	6 (100.0%)	0.485
Annual agreed programme	10 (76.9%)	2 (33.3%)	0.129
Annual report about nosocomial infection rates	9 (69.2%)	3 (50.0%)	0.617
Any full-time equivalent infection control doctor	10 (76.9%)	0	0.003
Any full-time equivalent infection control nurse	12 (92.3%)	3 (50.0%)	0.071
Surveillance			
Any device-related infection surveillance programme in ICUs	8 (61.5%)	4 (66.7%)	0.829
VAP	8 (61.5%)	5 (83.3%)	0.605
CAUTI	7 (53.8%)	5 (83.3%)	0.333
CLABSI	9 (69.2%)	5 (83.3%)	0.631
Nosocomial infection rates in ICU in 2015			
VAP, median (range) ($N = 10$)	24.3 (5.0–53.0)	20.0 (8.0–61.0)	0.914
CAUTI, median (range) ($N = 9$)	24.0 (2.53–36.0)	20.0 (16.0–45.0)	0.905
CLABSI, median (range) ($N = 8$)	16.9 (0.0–19.0)	0.75 (0.50–1.0)[a]	0.286
Bundles to prevent			
VAP	11 (84.6%)	5 (83.3%)	0.943
With process monitoring	7 (53.8%)	2 (40.0%)	0.599
Continuous process	7 (53.8%)	3 (75.0%)	0.643
CAUTI	10 (76.9%)	3 (50.0%)	0.320
With process monitoring	8 (61.5%)	2 (50.0%)	0.682
Continuous process	6 (46.2%)	2 (66.7%)	0.786
CLABSI	12 (92.3%)	4 (80.0%)	0.457
With process monitoring	10 (76.9%)	2 (50.0%)	0.538
Continuous process	8 (61.5%)	2 (66.7%)	0.571
Prevent dissemination of multidrug-resistant pathogens	7 (53.8%)	4 (66.7%)	0.659
With process monitoring	3 (23.1%)	3 (75.0%)	0.099
Continuous process	2 (16.7%)	2 (50.0%)	0.440
The introduction of bundles in hospital accompanied by	($N = 12$)	($N = 5$)	0.547
convening a group to oversee this	9 (75.0%)	2 (40.0%)	
A multi-disciplinary group including, for example, doctors and nurses	8 (66.7%)	3 (60.0%)	0.793
Examination of the evidence base for the bundle parameters	5 (41.7%)	1 (20.0%)	0.600
A group(s) to assess bundle monitoring and ensure that results are fed back to the relevant clinicians	7 (58.3%)	1 (20.0%)	0.294
Results of the bundle programme reviewed at least annually	7 (58.3%)	1 (20.0%)	0.294

(*continued on next page*)

Table II (*continued*)

Hospital variables and bundle implementation	European MIC ($N = 13$)	Non-European MIC ($N = 6$)	*P*-value
Prevention bundles			
Regulated by government			
VAP	3 (25.0%)	0	0.515
CAUTI	2 (16.7%)	0	0.383
CLABSI	4 (33.3%)	0	0.261
Recommended by department of health			
VAP	4 (33.3%)	2 (40.0%)	0.793
CAUTI	5 (41.7%)	2 (40.0%)	0.949
CLABSI	5 (41.7%)	2 (40.0%)	0.949
Recommended by professional organizations			
VAP	7 (58.3%)	2 (40.0%)	0.620
CAUTI	8 (66.7%)	2 (40.0%)	0.551
CLABSI	7 (58.3%)	2 (40.0%)	0.620
Inspected at external accreditation/inspection visits			
VAP	1 (8.3%)	3 (60.0%)	0.053
CAUTI	1 (8.3%)	2 (40.0%)	0.136
CLABSI	1 (8.3%)	3 (60.0%)	0.053

ICU, intensive care unit; VAP, ventilator-associated pneumonia; CAUTI, catheter-associated urinary infection; CLABSI, central line-associated bloodstream infection.

[a] Reported by only two centres.

nurse:patient ratio was higher than 3:6 in nine (47.4%) MICs and in one (12.5%) high-income country (Saudi Arabia). Most of the countries had an infection control committee in their hospital, including in MICs (94.7%). However, only 63% of MIC centres had an annual agreed infection control programme and reported their infection rates annually. Additionally, in non-European MICs an annual agreed programme was established in 33% compared to 77% in European MICs. Fifty percent of non-European MICs produced an annual HCAI rate report compared to 69% of European MICs. A full-time equivalent IPC doctor (76.9% vs 0%, $P = 0.003$) and nurse (92.3% vs 50.0%, $P = 0.071$) were more common in European MICs than non-European MICs.

All HICs had central line-associated bloodstream infection (CLABSI) surveillance programme. However, in 37% of MICs no invasive device-related surveillance programme was implemented, 32% had no ventilator-associated pneumonia (VAP) surveillance programme, 37% had no catheter-associated urinary tract infection (CAUTI) surveillance programme and 27% had no CLABSI surveillance programme (Table I).

Also, DAI rates were reported to be two- to three-fold higher in MICs than in HICs. When we compared European and non-European MICs, device-related infection surveillance programme and bundle strategy were not different from each other and DAI rates were similarly high (Table II).

There was only one LIC centre (Nepal) reporting that an IPC committee was present in their hospital, but they did not have an IPC programme or surveillance of HCAIs. Additionally, they did not have IPC bundles in their hospital.

When we evaluated bundle strategy in ICUs, there was no difference between HICs and MICs, nor between European and non-European MICs. In MICs, the most commonly used bundle parameters are reported in Figures 1–3. The most preferred bundle parameters for VAP prevention were: elevation of head of bed to 30–45°, hand hygiene before care of patients, aspiration of subglottic secretions, and deep vein thrombosis prophylaxis. For CAUTI prevention, bundles comprised: hand hygiene and standard precautions, insertion of catheters using aseptic technique and sterile equipment, collecting urine samples aseptically, use of adequately trained persons to insert and maintain catheters, and a daily review of necessity for a catheter. For CLABSI, bundles comprised: scrubbing the access site by appropriate antiseptic solution before insertion, hand hygiene before catheter insertion and care, using subclavian site for catheter insertion, and maximum barrier precautions.

In HICs, the introduction of bundles in hospital accompanied by convening a multidisciplinary group to supervise (87.5% vs 64.7%, respectively) and an examination of the evidence base for bundle parameters were more common than in MICs (87.5% vs 35.3%, respectively). Both in HICs and MICs, bundle strategy was recommended by the Department of Health and professional organizations (Table I). Additionally, in European MICs, an examination of the evidence base for the bundle parameters and a review of the results of the bundle programme, at least annually, were more common than in non-European MICs (Table II). In Turkey, due to statutes reported by the Ministry of Health in 2005, all hospitals have IPC committees, as well as a national surveillance system and an IPC programme. Bundle strategy was implemented in more than half of the Turkish hospitals participating in the study and DAI rates were similar to those in HICs (Table III).

Discussion

This survey showed that one-third of MICs still do not have annual agreed programmes for IPC. In this survey, 94.7% of MICs had an IPC committee in their hospital and it is interesting that so few have still not introduced an IPC programme. DAI rates were reported to be two- to three-fold higher in MICs than HICs. When we compared European and non-European MICs, device-related infection surveillance programmes, bundle strategies and DAI rates were similar. Our data showed a significant difference comparing HICs and MICs in terms of the nurse:patient ratio, suggesting that this is important for the effective implementation of infection

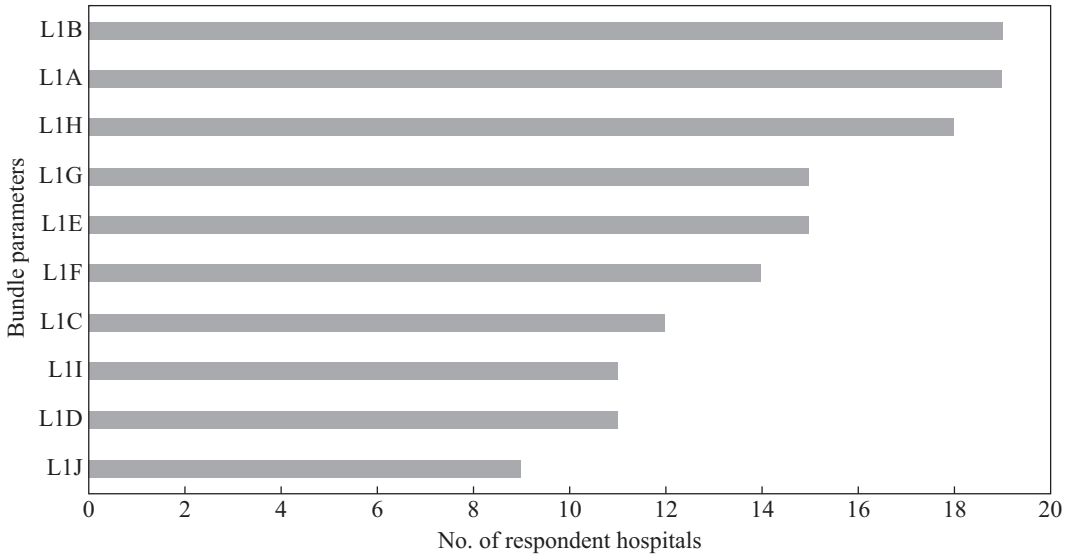

Figure 1. Bundle parameters in ventilator associated pneumonia. L1B, elevation of the head of bed to 30–45°; L1A, hand hygiene before care of patients; L1H, aspiration of subglottic secretions; L1G deep vein thrombosis prophylaxis; L1E daily sedation vacation and assessment of readiness to extubate; L1F, peptic ulcer disease prophylaxis; L1C, daily oral care with chlorhexidine; L1I, manual control of endotracheal cuff pressure (of $\geq$20 cmH_2O) at least every 8 h; L1D, daily oral care with antiseptic agent other than chlorhexidine; L1J, continuous endotracheal cuff.

control bundles. There was also a difference in the employment of a full-time infection control doctor between HICs and MICs.

Infection prevention and control is essential for patient safety in hospitals because HCAIs are associated with significant morbidity. HICs constitute only one-fourth of the world population and most of the world population are living in LMICs, with 72% in MICs. These people struggle to receive high quality of healthcare, resulting in HCAIs and antimicrobial resistance [19,20]. On the other hand, the twenty-first century has been defined as the 'century of migration'. This movement of people has the potential for transmission of infectious diseases and antibiotic resistance worldwide. Consequently, countries have to share their experience and resources. Most of the HCAIs can be prevented with good hygiene and standardization of the healthcare delivery processes. An annual agreed programme and bundle strategy in ICUs with basic and low-cost IPC measures would effectively reduce DAIs. Additionally, in MICs a bundle strategy should be accompanied by a supervisory group to review the results at least annually.

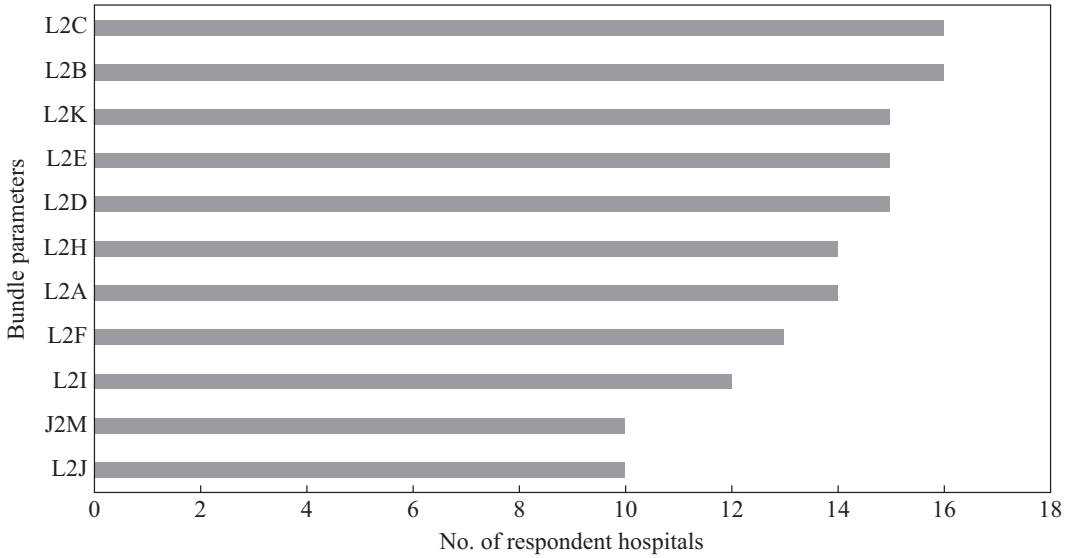

Figure 2. Bundle parameters for catheter-associated urinary tract infections. L2C, hand hygiene and standard (or appropriate isolation) precautions; L2B, insert catheters using aseptic technique and sterile equipment; L2K, obtain urine samples aseptically; L2E, only properly trained persons insert and maintain catheters; L2D, daily reviewing of necessity of the catheter; L2H, maintain unobstructed urine flow; L2A, consideration of alternatives to indwelling urinary catheterization; L2F, maintain a closed drainage system; L2I, meatal cleaning with appropriate antiseptic solution; J2M, use a catheter with the smallest gauge; L2J, meatal cleaning with normal saline.

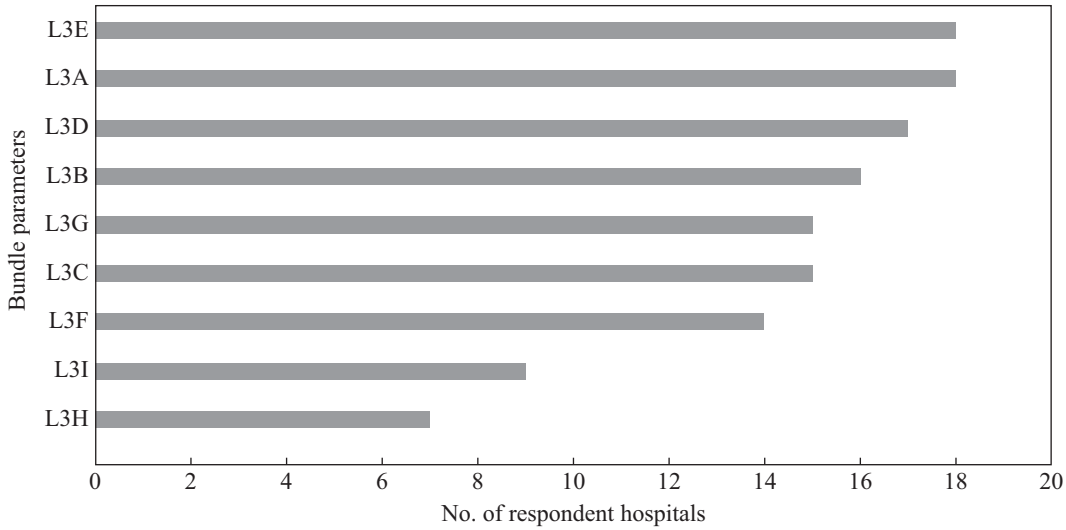

Figure 3. Bundle parameters for central line-associated bloodstream infections. L3E, minimize contamination risk by scrubbing the access site with an appropriate antiseptic; L3A, decontaminate hands with either antiseptic-containing soaps or alcohol-based gels/foams before inserting, repairing, replacing, or dressing a CVC; L3D, whenever possible, use the subclavian site, rather than the jugular or femoral sites; L3B, use a cap, mask, sterile gown, sterile gloves, a sterile full-body drape when inserting CVC; L3G, the use of trained personnel dedicated to the placement of CVCs in ICU and hospitalized patients; L3C prepare clean skin with chlorhexidine preparation with alcohol before CVC insertion and during dressing changes; L3F, daily evaluation and prompt removal of CVCs that are no longer clinically warranted; L3I, use of chlorhexidine gluconate-impregnated dressing (or equivalent approach); L3H, use of antiseptic-coated CVCs in all or selected patients …?

The organization of IPC teams and full-time equivalent infection control nurse (ICN) and infection control doctor (ICD) are recommended in standards for the effective management of all IPC activities in hospitals [1]. In MICs, 78.9% of hospitals had a full-time equivalent ICN, but a full-time ICD was only present in half of MICs. However, there was a significant difference between non-European MICs and European MICs regarding full-time equivalent ICDs (0% vs 76.9%, respectively) and ICNs (50% vs 92.3%, respectively).

Severely ill patients with multiple comorbidities are admitted in ICUs leading to high HCAI rates. In the European EPIC II study, which included LMICs, HCAI affected 51% of ICU patients [21]. Invasive devices are the most common risk factors for HCAI, and bundle strategy is recommended for the prevention of invasive device-related infections. The bundled strategy has been shown to be effective in reducing infection rates in LMICs [22,23]. INICC is a research network that includes prospective, targeted, outcome, and process surveillance designed to identify and reduce HCAIs, especially in LMICs [5]. The bundles of IPC measures from the INICC multidimensional approach follow the recommendations in the guidelines and have led to a significant reduction in DAIs in LMICs [12–15].

All HICs in this survey reported having a CLABSI surveillance programme. However, in MICs, seven (37%) had no invasive device-related surveillance programme, six (32%) had no VAP surveillance programme, seven (37%) had no CAUTI surveillance programme, and five (27%) had no CLABSI surveillance programme. There were no differences in the bundled strategy between HICs and MICs. Interestingly, the reported bundle parameters used in MICs were not costly and could easily be applied in low-resource settings.

Multidrug-resistant micro-organisms (MDROs) are increasing worldwide and the burden of HCAIs with MDROs is much higher in ICUs in LMICs. MDROs can successfully be controlled by early detection of carriers by active surveillance and prompt isolation of all suspected/confirmed cases with standard and contact IPC precautions on admission [2]. In this survey, only half of centres (55.5%) reported that bundle implementation prevented MDROs, and there was no difference between HICs and MICs.

HCAIs lead to significant financial pressures on healthcare systems, which influences the economy. A national IPC implementation policy (with legal regulations if required) is an important step for LMICs. In this survey, both within HICs and MICs, bundle strategy was recommended by the respective department of health and professional organizations. Turkey is a good example of infection control organization in an MIC. A well-organized IPC programme has been started across the country that was reflected by the survey results. Indeed, due to statutes reported by the Ministry of Health in 2005, all Turkish hospitals have IPC committees, as well as a national surveillance system and IPC programme. Additionally, a bundle strategy was implemented in more than half the hospitals participating in the study and DAI rates were similar to the rates of HICs (Table III).

An appropriate number of trained nurses is the mainstay of IPC in ICUs to prevent cross-transmission. However, in LMICs, the patient population is often higher, with overcrowding and high workload for healthcare personnel. Hugonnet *et al.* demonstrated an association between low nurse:patient ratio and increased risk of HCAIs, estimating that 30% of infections could be prevented with a ratio of >2.2 nurses to every patient in an HIC [24]. In LMICs, the numbers of nurses are usually low; moreover, IPC training of these personnel is often inadequate, further compounding the issue. This survey has also highlighted nurse:patient ratios, which was higher than 3:6 in 47.4% of MICs and in one HIC (Saudi Arabia).

Table III
Survey data from Turkey

Hospital variables and bundle implementation	Turkey ($N = 11$)
Total no. of beds in ICU	
≤8	3 (27.3%)
9–16	2 (18.2%)
≥16	6 (54.5%)
Nurse:patient ratio	
1	0
2–3	8 (72.7%)
3–6	3 (27.3%)
Infection control facilities	
Any infection control committee in hospital	11 (100.0%)
Annual agreed programme	11 (100.0%)
Annual report about nosocomial infection rates	11 (100.0%)
Any full-time equivalent infection control doctor	11 (100.0%)
Any full-time equivalent infection control nurse	11 (100.0%)
Surveillance	
Any device-related infection surveillance programme in ICUs	10 (90.9%)
VAP	10 (90.9%)
CAUTI	10 (90.9%)
CLABSI	10 (90.9%)
Nosocomial infection rates in ICU in 2015	
VAP median (range)	15.5 (6.9–109.0)
CAUTI median (range)	3.5 (0.92–40.0)
CLABSI median (range)	3.7 (0.0–59.0)
Bundles to prevent	
VAP	8 (72.7%)
With process monitoring	7 (63.6%)
Continuous process	4 (36.4%)
CAUTI	6 (54.5%)
With process monitoring	6 (54.5%)
Continuous process	3 (27.3%)
CLABSI	8 (72.7%)
With process monitoring	8 (72.7%)
Continuous process	5 (45.5%)
Prevent dissemination of multidrug-resistant pathogens	2 (18.2%)
With process monitoring	2 (18.2%)
Continuous process	1 (9.1%)
The introduction of bundles in	($N = 10$)
hospital accompanied by convening a group to oversee this	6 (60.0%)
A multi-disciplinary group including, for example, doctors and nurses	6 (60.0%)
Examination of the evidence base for the bundle parameters	6 (60.0%)
A group(s) to assess the bundle monitoring and ensure that results are fed back to the relevant clinicians	6 (60.0%)
Results of the bundle programme reviewed at least annually	6 (60.0%)
Prevention bundles	
Regulated by government	
VAP	0
CAUTI	0
CLABSI	0
Recommended by department of health	
VAP	0
CAUTI	0
CLABSI	0
Recommended by professional organizations	
VAP	4 (40.0%)
CAUTI	4 (40.0%)
CLABSI	4 (40.0%)
Inspected at external accreditation/inspection visits	
VAP	0
CAUTI	0
CLABSI	0

ICU, intensive care unit; VAP, ventilator-associated pneumonia; CAUTI, catheter-associated urinary infection; CLABSI, central line-associated bloodstream infection.

The major limitation of this study is the poor response from LICs and low response rates (10.4%) from other MICs. The small number of responses might affect statistical analysis and the results may not be generalizable. Thus, *P*-values were not evaluated in the analysis and descriptive statistics were used. Also, the ID-IRI group is a global clinical research platform with many researchers from all over the world; we do not know all the group members' countries and how much of this group represents LMICs. This might represent a selection bias. It is also unclear whether individual answers represent a full country; therefore, caution is needed in generalizing the results. On the other hand, the aim of this study was to determine the status of IPC bundle practice in ICUs and regulations in LMICs, whereas only one LIC was involved. Indeed, this study should be considered as a snapshot from MICs about the organization of IPC and bundle strategies. This survey may be generalized to LMICs for the awareness of bundle strategies in ICUs.

In conclusion, this study reports the variability in DAIs and implementation of IPC bundles in ICUs, depending on the national income. Our findings suggest that LMICs need to develop their own bundles with low-cost and high-level-of-evidence variables, adapted to the limited resources, with further validation to reduce HCAI rates.

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Conflict of interest statement
None declared.

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