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Major Article

National surveillance of health care–associated infections in Egypt: Developing a sustainable program in a resource-limited country

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Background: Health care–associated infections (HAIs) are a major global public health concern. The lack of surveillance systems in developing countries leads to an underestimation of the global burden of HAI. We describe the process of developing a national HAI surveillance program and the magnitude of HAI rates in Egypt.

Methods: The detailed process of implementation of a national HAI surveillance program is described. A 3-phase surveillance approach was implemented in intensive care units (ICUs). This article focuses on results from the phase 2 surveillance. Standard surveillance definitions were used, clinical samples were processed by the hospital laboratories, and results were confirmed by a reference laboratory.

Results: Ninety-one ICUs in 28 hospitals contributed to 474,544 patient days and 2,688 HAIs. Of these, 30% were bloodstream infections, 29% were surgical site infections, 26% were pneumonia, and 15% were urinary tract infections. Ventilator-associated pneumonia had the highest incidence of device-associated infections (4.3/1,000 ventilator days). The most common pathogens reported were *Klebsiella* spp (28.7%) and *Acinetobacter* spp (13.7%). Of the *Acinetobacter* spp, 92.8% (157/169) were multidrug resistant, whereas 42.5% (151/355) of the *Klebsiella* spp and 54% (47/87) of *Escherichia coli* were extended-spectrum β-lactamase producers.

Conclusions: Implementation of a sustainable surveillance system in a resource-limited country was possible following a stepwise approach with continuous evaluation. Enhancing infection prevention and control programs should be an infection control priority in Egypt.

Health care–associated infections (HAIs) are the most frequent adverse events threatening patient's safety worldwide[1] and cause significant morbidity and mortality. A growing proportion of HAIs are related to antimicrobial resistant pathogens, such as methicillin-resistant *Staphylococcus aureus* and multidrug-resistant gram-negative bacilli.[2-4]

The global burden of HAIs is underestimated because data from resource-limited countries are sparse. Very few countries of low and middle income have national HAI surveillance programs,[5] which may be related to a lack of strong infection prevention and control (IPC) programs in most developing countries, limited human resources and expertise in the design and implementation of a surveillance

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program, or a lack of microbiology laboratory capacity at the hospitals. In countries such as the United States, Australia, Canada, England, and Germany, IPC programs have instituted HAI surveillance as an essential element of health care.[6-10] These developed countries focus mainly on device-associated infection (DAI) surveillance, allowing them to further analyze the impact of specific risk factors and guide targeted interventions.[11] In the developing countries of the Eastern Mediterranean region, limited efforts have been done to institutionalize national HAI surveillance programs.

Sentinel site surveillance in tertiary care hospitals in Egypt showed high HAI rates.[12-14] During the last decade, while IPC activities were progressing in Egypt, it was deemed important to implement a standardized national HAI surveillance program to define the magnitude and scope of HAIs in the country and to allow for interhospital comparisons of HAI rates. Therefore, a plan to implement a nationwide HAI surveillance program in intensive care units (ICUs) was developed with support from several partners: the U.S. Centers for Disease Control and Prevention's (CDC's) Global Disease Detection (GDD) Program in Egypt, the U.S. Naval Medical Research Unit (NAMRU-3), and the U.S. Agency for International Development in Egypt. The objectives of the national HAI surveillance were to estimate the incidence of HAIs, obtain national benchmarks, describe the microbiologic profile of pathogens causing HAIs, and inform prevention activities of HAIs. This report describes the process of developing a national HAI surveillance program in Egypt, including progress, challenges, future plans, and findings of the interim (phase 2) surveillance.

METHODS

Baseline assessment of hospitals

An initial baseline assessment across 37 hospitals in Egypt was conducted between October and December 2010 to assess laboratory and surveillance capacity. Trained personnel interviewed hospital directors, infection control personnel, and senior physicians and evaluated the microbiology laboratories. The baseline assessment revealed that most hospitals had some sort of IPC program; however, HAI case definitions varied widely across hospitals. Although all hospitals had microbiology laboratories, only 30% performed pathogen identification and susceptibility testing. The baseline assessment provided useful information on the hospital needs and informed the design of the surveillance approach.

Formation of a panel of experts

A panel of experts was composed of members from the CDC, World Health Organization, U.S. universities, Ministry of Health and Population in Egypt, and universities. The panel of experts was responsible for defining the strategic approach for the surveillance program, providing regular evaluation, and updating the surveillance methodology over time.

Surveillance strategy and stepwise implementation of surveillance

The surveillance approach recommended by the panel of experts was a 3-phase approach: phase 1) small-scale and pilot surveillance to assess feasibility, define optimal methodology, including case definitions, and inform phase 2; phase 2) expansion to additional hospitals to inform the design and conduct of full-scale surveillance; and phase 3) full-scale surveillance. All surveillance phases were active prospective surveillance and focused on ICU patients, a vulnerable patient population at increased risk of HAI because of severity of illness, high exposure to invasive procedures and devices, and high use of broad-spectrum antibiotics.[15,16] Surveillance case definitions were derived from the CDC's National Healthcare Safety Network (NHSN) HAI case definitions published in 2008.[17]

Surveillance phases

For hospitals to participate in the surveillance, they had to meet the following eligibility criteria: (1) presence of an IPC team with at least 1 full-time employee, (2) capacity for data entry and transfer, (3) functional laboratory with supplies and personnel able to perform culture of all specimens and full bacterial identification and antimicrobial susceptibility testing, and (4) presence of ICUs and IPC link nurses to monitor HAIs. Hospitals that were not ready for surveillance implementation were supported by GDD-Egypt and NAMRU-3 to enhance their capabilities to join the surveillance activities at later stages.

Phase 1 surveillance (pilot)

The aim of this phase was to pilot the surveillance program in ICUs at 11 hospitals. Phase 1 was conducted from April 2011-March 2012. The 2008 NHSN case definitions were used.[17] The methods implemented and the results of phase 1 surveillance have been previously published.[18]

Phase 2 surveillance

The results of phase 1 showed a predominance of 3 HAI types: hospital-acquired pneumonia, primary bloodstream infections (BSI), and urinary tract infections (UTI). The panel of experts suggested limiting the surveillance activities to the 3 most prevalent HAI types to reduce data collection burden and to allow for an expanded rollout to other hospitals while ensuring collection of good quality data. They also suggested adding surgical site infection (SSI) identified in ICUs and excluding ICUs with an average length of patient stay <3 days. Adaptation of the primary BSI case definition was done to address the limitations identified in phase 1 and to increase the sensitivity of the surveillance program as follows: (1) instituting the clinical sepsis case definition for adult and neonates given blood cultures were not routinely collected; (2) considering only 1 blood culture for the diagnosis of BSI in patients with clinical signs of infection (even if the organism is a possible contaminant) given that collection of 2 blood culture bottles was very uncommon because of the lack of resources; and (3) excluding the requirement of antibiotic treatment as a component of the BSI case definition given the widespread use of antibiotics at Egyptian hospitals. Finally, HAI types were not restricted to DAIs given that 58% of BSIs were not central line associated and a large proportion of pneumonias were also not ventilator associated.[18]

Phase 1 surveillance was conducted from April 2012-August 2014. The 11 hospitals that started phase 1 surveillance transitioned into phase 2, and an additional 17 hospitals joined the program for a total 28 hospitals, 91 ICUs, and 989 ICU beds in phase 2 surveillance.

Phase 3 surveillance

Phase 3 surveillance started in September 2014, and as of February 2016, the HAI surveillance program included 61 hospitals with 216 ICUs and 2,035 ICU beds. The surveillance methods remained the same as phase 2, and the only changes implemented were related to improving the electronic reporting system of data, including improvements of the electronic algorithm for HAI type.

Surveillance definitions

For this surveillance, only ICU-onset infections were captured. An ICU-onset infection was defined as an infection occurring on or after 3 calendar days after ICU admission or an SSI identified while

the patient was in the ICU. Only ICU onset infections that met primary BSI, UTI, pneumonia, or SSI definitions were analyzed.

SSI was defined as an ICU patient with an infection at the surgery site within 30 days after the operative procedure or within 90 days if a device or foreign material was implanted. According to the level of the infection, SSIs were classified as superficial (only skin is involved), deep (skin and soft tissues are involved), or organ space.[19] Primary BSI was further classified as central line–associated bloodstream infection (CLABSI) if a central line was present within ±2 days of positive blood culture. A UTI was classified as catheter-associated urinary tract infection (CAUTI) if there was documentation of symptomatic urinary tract infections while the patient was with a urinary catheter or during 48 hours after catheter removal. Finally, pneumonia was classified as ventilator-associated pneumonia (VAP) if the patient's chest radiograph showed new or progressive infiltrates, consolidation, or cavitation in a patient on mechanical ventilation (or within 48 hours after removal of mechanical ventilation) supported with at least one of the previously described pneumonia clinical signs or symptoms.[17] Pooled mean incidence density was calculated for pneumonia, BSI, and UTI using patient days as the denominator, whereas incidence for DAIs was calculated using the device days as the denominator. The device utilization ratio (DUR) was calculated as device days divided by the patient days.[6]

Electronic data entry and reporting

The data collection process has been previously described.[18] In brief, personal digital assistants (PDAs) were used since the beginning of the surveillance program in April 2011 to facilitate data entry. The PDAs were programmed using a decision-based tree to help with classifications of HAIs based on surveillance definitions. Hospital surveillance coordinators were responsible for screening ICU patients in collaboration with treating physicians for any signs or symptoms suggestive of infection. They also reviewed laboratory and radiologic reports. For patients suspected to have an HAI, demographic, clinical, and laboratory data were entered into the PDA. Depending on the information entered, the PDA would direct the surveillance officer to the relevant section. For example, if a patient had a positive blood culture, then the PDA would direct to a screen with questions about other sites of infections and the definitions for the secondary site of infections. If all answers were no, then the PDA would classify as primary BSI and would direct to the section of central line insertion and removal date.

A secured Web-based surveillance application hosted on the cloud was developed at the end of 2014 to allow surveillance coordinators to upload the PDA data immediately to the Web. This Web application included automatic data checks using predefined criteria and allowed hospital IPC teams to generate automated reports with their data analyzed.

Laboratory procedures

Pathogens causing HAIs were first identified by the hospital microbiology laboratories. Isolates were inoculated as a pure colony onto vials containing trypticase soya broth and sent to the NAMRU-3 laboratory on a monthly basis for confirmatory testing, which included identification and antimicrobial susceptibility testing according to Clinical and Laboratory Standards Institute guidelines.[20] Only NAMRU-3 laboratory data are included in this report. Methicillin-resistant *S aureus* was defined as any *S aureus* isolate resistant to oxacillin or cefoxitin, whereas vancomycin-resistant *Enterococcus* was defined as any *Enterococcus* spp isolate resistant to vancomycin. For the gram-negative organisms, extended-spectrum β-lactamase (ESBL) was defined as any *Escherichia coli* or *Klebsiella* spp isolate resistant to ceftazidime or cefotaxime confirmed phenotypically using the combined disc with clavulanic acid; carbapenem resistance was defined as any *E coli* or *Klebsiella* spp isolate resistant to imipenem or ertapenem. Multidrug resistance was defined as any *Acinetobacter* spp or *Pseudomonas* spp isolate resistant to 1 agent in at least 3 antimicrobial classes by standard susceptibility testing.[21]

RESULTS OF PHASE 2 SURVEILLANCE

Infection rates

There were 91 ICUs in 28 hospitals including 989 ICU beds that participated in phase 2 surveillance. The characteristics of the 28 hospitals that contributed data to this report are shown in Table 1. There were 2,688 ICU-onset infections reported during the surveillance period. Of these, 30% (n = 812) were primary BSIs (laboratory confirmed or clinical sepsis), 29% (n = 784) were SSIs, 26% (n = 686) were pneumonia, and 15% (n = 406) were UTIs. After exclusion of SSIs, 1,904 ICU-onset infections were reported for 474,544 patient days, with an overall HAI rate of 4 per 1,000 patient days. Out of 1,904 ICU-onset infections, 1,243 (65.3%) were laboratory confirmed.

The pooled mean rate of ICU-onset pneumonia was 1.4 per 1,000 patient days, ranging from 0.1 per 1,000 patient days in the pediatric surgical ICUs to 5.6 per 1,000 patient days in the trauma ICUs. The pooled mean rate of primary BSIs was 1.7 per 1,000 patient days, ranging from zero in pediatric cardiothoracic ICUs to 6.6 per 1,000 patient days in trauma ICUs, whereas the pooled mean rate of UTIs was 0.9 per 1,000 patient days and reached 3.1 infections per 1,000 patient days in trauma ICUs (Table 2). Incidence for SSIs per surgical procedure was not calculated because SSIs were only monitored in ICU patients and not across all patients that underwent surgery.

VAP represented 76.2% of total ICU-associated pneumonia, whereas CLABSI and CAUTI represented 63.4% and 98.3% of BSIs and UTIs, respectively. The incidence of DAIs varied by location. VAP had the highest incidence (4.3/1,000 ventilator days) compared with CLABSI (2.6/1,000 central line days) and CAUTI (1.9/1,000 urinary catheter days). The trauma ICU had the highest rates of VAP (12.6/1,000 ventilator days) and CLABSI (9.2/1,000 central line days) as shown in Table 3. The pooled mean DUR for mechanical ventilation use was 0.3, for central line use was 0.4, and for urinary catheter use was 0.5.

Organisms causing HAIs

Among 1,904 ICU-onset infections reported (excluding SSIs), 2,073 organisms were identified. Out of those, 1,235 clinical isolates were processed at NAMRU-3 laboratories for identification and antimicrobial susceptibility (Table 4). Relative frequencies of the most

Table 1
Characteristics of hospitals participating in intensive care unit surveillance (April 2012-August 2014)

	Bed size category			
Hospital type	51-200	201-500	>500	Total
Teaching hospitals				
Pediatrics	0	4	0	4
Obstetrics	1	2	0	3
Surgical	0	1	1	2
Medical	0	1	1	2
General	3	0	4	7
*Others	2	1	0	3
Public general hospitals	3	3	0	6
Private	0	1	0	1
Total	9	13	6	28

*Bone marrow and emergency hospitals.

Table 2
Incidence of HAIs by type of location, April 2012-August 2014

Type of location	No. of ICUs	No. of HAIs reported	Patient days	Pooled mean incidence of HAI	Pneumonia		Bloodstream infections		Urinary tract infections	
					n	Pooled mean	n	Pooled mean	n	Pooled mean
Burn	3	29	6,834	4.2	6	0.9	16	2.3	7	1.0
Medical cardiac	10	71	43,063	1.6	32	0.7	11	0.3	28	0.7
Medical critical care	10	275	62,065	4.4	108	1.7	102	1.6	65	1.0
Medical-surgical	13	279	69,900	4.0	116	1.7	61	0.9	102	1.5
Neurologic	2	46	6,654	6.9	20	3.0	8	1.2	18	2.7
Neurosurgical	8	229	29,382	7.8	109	3.7	45	1.5	75	2.6
NICU	11	468	135,193	3.5	118	0.9	350	2.6	NA	NA
Pediatric cardiothoracic	1	32	7,231	4.4	29	4.0	0	0.0	3	0.4
Pediatric medical	9	70	32,738	2.1	28	0.9	38	1.2	4	0.1
Pediatric surgical	3	13	5,220	2.5	0	0.0	10	1.9	3	0.6
Prenatal-surgical	2	46	7,955	5.8	1	0.1	41	5.2	4	0.5
Respiratory	4	65	16,097	4.0	20	1.2	21	1.3	24	1.5
Surgical cardiothoracic	5	17	13,827	1.2	7	0.5	7	0.5	3	0.2
Surgical critical care	7	209	35,190	5.9	74	2.1	81	2.3	54	1.5
Trauma	3	49	3,195	15.3	18	5.6	21	6.6	10	3.1
Total	91	1,904	474,544	4.0	686	1.4	812	1.7	400	0.9

NOTE. Rates calculated as HAIs per 1,000 patient days.
HAI, health care–associated infection; *ICU*, intensive care unit; *NA*, not applicable (urinary catheters are not used in NICU patients). *NICU*, neonatal intensive care unit.

Table 3
Incidence of DAIs by type of location, April 2012-August 2014

ICU type	No. of ICUs	Patient days	VAP				CLABSI				CAUTI			
			n	MV days	Rate	DUR	n	CL days	Rate	DUR	n	UC days	Rate	DUR
Burn	3	6,834	3	741	4.0	0.1	13	5,008	2.6	0.7	7	5,531	1.3	0.8
Medical cardiac	10	43,063	22	2,021	10.9	0.0	4	6,052	0.7	0.1	27	10,602	2.5	0.2
Medical critical care	10	62,065	64	17,019	3.8	0.3	76	34,403	2.2	0.6	63	41,130	1.5	0.7
Medical-surgical	13	69,900	104	29,330	3.5	0.4	58	44,888	1.3	0.6	102	56,371	1.8	0.8
Neurologic	2	6,654	0	230	0.0	0.0	5	1,954	2.6	0.3	17	4,980	3.4	0.7
Neurosurgical	8	29,382	76	12,328	6.2	0.4	33	19,576	1.7	0.7	75	27,573	2.7	0.9
Neonatal intensive care	11	135,193	115	25,029	4.6	0.2	198	26,958	7.3	0.2	NA	NA	NA	NA
Pediatric cardiothoracic	1	7,231	15	2,445	6.1	0.3	0	5,759	0.0	0.8	3	1,892	1.6	0.3
Pediatric medical	9	32,738	25	11,533	2.2	0.4	19	12,111	1.6	0.4	4	9,866	0.4	0.3
Pediatric surgical	3	5,220	0	1,032	0.0	0.2	7	1,513	4.6	0.3	3	904	3.3	0.2
Prenatal-surgical	2	7,955	1	793	1.3	0.1	25	2,800	8.9	0.4	4	6,706	0.6	0.8
Respiratory	4	16,097	16	6,145	2.6	0.4	13	6,747	1.9	0.4	23	10,508	2.2	0.7
Surgical cardiothoracic	5	13,827	6	2,078	2.9	0.2	5	9,023	0.6	0.7	3	6,495	0.5	0.5
Surgical critical care	7	35,190	61	10,851	5.6	0.3	39	19,888	2.0	0.6	52	26,663	2.0	0.8
Trauma	3	3,195	15	1,194	12.6	0.4	20	2,185	9.2	0.7	10	3,025	3.3	0.9
Total	91	474,544	523	122,769	4.3	0.3	515	198,865	2.6	0.4	399	213,901	1.9	0.5

NOTE. Rates calculated as DAIs per 1,000 patient days.
CAUTI, catheter-associated urinary tract infection; *CL*, central line; *CLABSI*, central line–associated bloodstream infection; *DAI*, device-associated infection; *DUR*, device utilization ratio; *ICU*, intensive care unit; *MV*, mechanical ventilation; *NA*, not applicable (urinary catheters are not used in neonatal ICU patients); *UC*, urinary catheter; *VAP*, ventilator-associated pneumonia.

commonly isolated microorganisms in ICU-onset infections are reported in Table 4. *Klebsiella* spp were the most commonly reported organisms, accounting for 28.7% of all organisms, followed by *Acinetobacter* spp (13.7%). Among the gram-negative pathogens, 42.5% of *Klebsiella* spp and 54% of *E coli* were ESBL producers, whereas 48.1% and 13.7% were carbapenem-resistant, respectively. Multidrug-resistance phenotypes were also identified in *Acinetobacter* spp (92.8%) and in *Pseudomonas* spp (59.8%). Among the gram-positive pathogens, 78.9% of *S aureus* isolates were methicillin-resistant *S aureus*, and 35.0% of *Enterococcus* spp were vancomycin resistant (Table 4).

DISCUSSION

This report describes the process of developing a national HAI surveillance program in Egypt. Standardized surveillance methodology was used to allow for the determination of HAI rates and for comparison across hospitals. As of February 2016, the HAI surveillance program covered 61 hospitals (including 2,035 ICU beds) out of 244 hospitals (including 4,500 ICU beds) in Egypt. The target is to implement the surveillance program in all hospitals with ICUs before September 2018.

The surveillance program showed high rates of ICU-onset HAIs, and a high resistance pattern of organisms causing HAIs, representing a major risk to patient safety. Trauma ICUs showed the highest rates of infection for all 3 HAI types (pneumonia, BSIs, and UTIs). This is comparable with the acute care hospitals in the United States where the highest infection rates for VAP, CLABSI, and UTIs were in trauma ICUs[6] and comparable with China, where the highest VAP rates (39.2/1,000 mechanical ventilation days) were described in trauma ICUs.[22] Trauma ICU patients are at high risk of infection because of multiple surgical procedures, underlying conditions, need for mechanical ventilation, multiple blood transfusions, and high device utilization rate compared with other ICUs.[23]

The pooled DUR ranged from 0.3 for ventilator use to 0.5 for urinary catheter use and is lower than the DUR reported in other developing countries, which ranged from 0.5 for ventilator use to 0.7 for both central lines and urinary catheters.[24] The data of the 2012 NHSN report showed almost similar DURs, ranging from 0.3 for ventilators to 0.6 for urinary catheters.[6]

Table 4
Distribution of pathogens associated with intensive care unit–associated infections and their patterns of resistance, April 2012-August 2014

Pathogen type and pattern of resistance	n	Resistance, n (%)
Klebsiella spp	355	
ESBL production		151 (42.5)
Carbapenem resistance		171 (48.1)
Acinetobacter spp	169	
Multidrug resistance		157 (92.8)
Pseudomonas spp	117	
Multidrug resistance		70 (59.8)
Escherichia coli	87	
ESBL production		47 (54.0)
Carbapenem resistance		12 (13.8)
Staphylococcus aureus	71	
MRSA		56 (78.9)
Enterococcus spp	20	
VRE		7 (35.0)
Coagulase-negative staphylococci	91	
Candida albicans	116	
Proteus spp	45	
Others	164	
Total	1,235	

ESBL, extended-spectrum β-lactamase; *MRSA*, methicillin-resistant *S aureus*; *VRE*, vancomycin-resistant *Enterococcus*.

The VAP rate we observed (4.3/1,000 ventilator days) was lower than the surveillance data from Germany (5.4/1,000 ventilator days)[25] and comparable with that reported in the United States in 2012 where the pooled mean VAP rate ranged from 0-4.4 per 1,000 device days.[6] The rate of CLABSI in limited-resource countries (Argentina, Brazil, India, Iran, Mexico, Thailand, Tunisia, Turkey, and Peru) ranged from 1.6-44.6 per 1,000 central line days in adult and pediatric ICUs and from 2.6-60 per 1,000 central line days in neonatal ICUs. The CLABSI rates we observed were much lower than what has been reported from other developing countries and more comparable with the 2012 U.S. report of 1.5 per 1,000 central line days (95% confidence interval, 1.3-1.5) in medical-surgical ICUs and 2.9 per 1,000 central line days (95% confidence interval, 2.6-3.1) in neonatal ICUs.[6] The reasons for lower CLABSI rates observed in Egypt compared with other countries may be related to the limited use of central lines in some of the hospitals, especially in pediatric ICUs. An evaluation done in the past showed that even patients in ICUs are kept with peripheral intravenous access, which explains our findings that approximately 40% of the patients with ICU-onset primary BSI did not have a central line at the time of infection.

The predominance of gram-negative bacteria (*Klebsiella* spp, *Acinetobacter* spp, and *Pseudomonas* spp) in the hospital settings is similar to several surveillance studies in the United States,[26] Saudi Arabia,[27] and Brazil.[28] The rate of ESBL-producing *Klebsiella* (42.5%) was lower than the rates reported from Saudi Arabia (57%),[26] similar to Iran (47%),[29] and higher than Lebanon (30%).[30] The rate of multidrug resistance *Acinetobacter* (92.8%) was comparable with the rate reported from Pakistan[31] and Saudi Arabia.[27]

There are several limitations to the presented surveillance data. The reported infection rates could underestimate the true incidence because of difficulty in obtaining information from the medical records regarding clinical signs and symptoms; the lack of unified clinical standards for requesting clinical samples (eg, blood or urine culture), potentially leading to underdiagnosis of infections; and limited testing of clinical isolates in the hospital laboratories. Additionally, not all clinical isolates were sent to the NAMRU-3 laboratories, which might have contributed to decreased levels of reported resistance.

To institute a national HAI surveillance program, we applied a stepwise approach for surveillance implementation with regular evaluation that was useful in defining the optimal surveillance methodology before wide-scale implementation. It also allowed piloting of electronic data collection and reporting procedures, allowed time for less prepared surveillance hospitals to get training and improve laboratory capacity, and developed surveillance champions that advocated for the program at the national level. Several challenges were identified since the start of phase 1 surveillance implementation that had to be overcome.

The first was the limited hospital microbiology capacity. One of the major challenges affecting the surveillance program was the limited hospital microbiology laboratory capacity in pathogen identification and susceptibility testing. The main problems were nonavailability of essential supplies, high turnover of staff, and limited availability of external quality assurance programs. The GDD-Egypt and NAMRU-3 tried to minimize those issues through regular trainings for hospital laboratory staff, distribution of standard operating procedures, and provision of laboratory consumables and reagents. The confirmatory results from the NAMRU-3 laboratory were shared with hospital laboratories on a regular basis as a way to evaluate their performance.

The second was communication. In the initial phases of surveillance, the limited or lack of communication between the surveillance coordinators and the laboratory had a negative impact on case finding and reporting. However, regular hospital visits and feedback meetings strengthened the concept of teamwork.

The third was human resources and personnel challenges. Lack of motivation of the surveillance officers, ICU physicians, and laboratory focal persons were initially hindering the progress of surveillance. This was caused by the heavy workload, and they considered the surveillance program as extra to their daily assignments. Several advocacy workshops were conducted targeting ICU physicians to raise their awareness on the importance of surveillance in the prevention of HAIs.

The fourth was the quality of the patient medical records. The limited quality of patient medical records in some hospitals made it difficult for case finding or surveillance data validation. The presence of ICU link nurses, who were in the ICU every day and were responsible for the HAI surveillance, was critical to the surveillance program. Continuous awareness among clinicians on better clinical data and laboratory results documentation was done.

There were several lessons learned with this surveillance program. Phase 1 and phase 2 surveillance data helped to alert policymakers to the fact that HAIs and antimicrobial resistance represent a true problem in Egypt, with high burden on the Egyptian health care system. Strong political commitment was evidenced by a national launch of the HAI surveillance program in November 2015, which was attended by the Minister of Health of Egypt. As a result of the launch, increased awareness on the importance of surveillance and prevention of hospital infections was obvious.

The future vision for national HAI surveillance is to implement the standardized approach in all remaining hospitals including ICUs until September 2018 using the Web-based application.

Despite the challenges, Egypt is moving toward a national HAI surveillance program, which will generate data to guide and monitor prevention strategies and will improve patient safety.

References

1. World Health Organization. Health care-associated infections fact sheet; 2014. Available from: http://www.who.int/gpsc/country_work/gpsc_ccisc_fact_sheet_en.pdf. Accessed June 16, 2016.
2. Magill S, Edwards JR, Stat M, Bamberg W, Beldavs Z. Multistate point-prevalence survey of health care–associated infections. N Engl J Med 2014;370:1198-208.
3. US Department of Health and Human Services Centers of Disease Control and Prevention. Antibiotic resistance threats in the United States. Atlanta, GA: Centers for Disease and Control and Prevention; 2013.

4. Roca I, Akova M, Baquero F. The global threat of antimicrobial resistance: science for intervention. New Microbes New Infect 2015;6:22-9.
5. Allegranzi B, Nejad SB, Combescure C, Graafmans W, Attar H, Donaldson L, et al. Lancet 2010;377:228-41.
6. Dudeck MA, Weiner LM, Allen-Bridson K, Malpiedi PL, Peterson KD, Pollock DA, et al. National Healthcare Safety Network (NHSN) report, data summary for 2012, Device-associated module. Am J Infect Control 2013;41:1148-66.
7. Barrett SP. Infection control in Britain. J Hosp Infect 2002;50:106-9.
8. Reed CS, Corre G, Spelman D. Hospital infection control in Australia. J Hosp Infect 2003;54:267-71.
9. Cook DJ, Walter SD, Cook RJ, Griffith LE, Guyatt GH, Leasa D, et al. Incidence of and risk factors for ventilator-associated pneumonia in critically ill patients. Ann Intern Med 1998;129:433-40.
10. Gastmeier P, Hentschel J, de Veer I, Obladen M, Rüden H. Device-associated nosocomial infection surveillance in neonatal intensive care using specified criteria for neonates. J Hosp Infect 1998;38:51-60.
11. Rosenthal VD, Maki DG, Rodrigues C, Álvarez-Moreno C, Leblebicioglu H, Sobreyra-Oropeza M, et al.; International Nosocomial Infection Control Consortium Investigators. Impact of International Nosocomial Infection Control Consortium (INICC) Strategy on Central Line -Associated Bloodstream Infection Rates in the Intensive Care Units of 15 Developing Countries. Infect Control Hosp Epidemiol. 2010;31:1264-72.
12. Saied T, Elkholy A, Hafez SF, Basim H, Wasfy MO, El-Shoubary W, et al. Antimicrobial resistance in pathogens causing nosocomial bloodstream infections in university hospitals in Egypt. Am J Infect Control 2011;39: e61-5.
13. Hafez S, Saeid T, Hasan E, Elnawasany M, Ahmad E, Lloyd L, et al. Incidence and modifiable risk factors of surveillance of surgical site infections in Egypt: a prospective study. Am J Infect Control 2012;40:426-30.
14. El-Kholy A, Saied T, Gaber M, Younan MA, Haleim MM, El-Sayed H, et al. Device-associated nosocomial infection rates in intensive care units at Cairo University Hospitals: first step towards initiating surveillance programs in a resource-limited country. Am J Infect Control 2012;40:e216-20.
15. Gordts B, Vrijens F, Hulstaert F, Devriese S, Van de Sande S. The 2007 Belgian national prevalence survey for hospital-acquired infections. J Hosp Infect 2010;75:163-7.
16. Maki DG, Kluger DM, Crnich CJ. The risk of bloodstream infection in adults with different intravascular devices: a systematic review of 200 published prospective studies. Mayo Clin Proc 2006;81:1159-71.
17. Centers for Disease Control and Prevention/National Healthcare Safety Network. Surveillance definition of healthcare-associated infection and criteria for specific types of infections in the acute care setting. 2008. Available from: http://www.cdc.gov/nhsn/PDFs/pscManual/17pscNosInfDef_current.pdf. Accessed June 16, 2016.
18. See I, Lessa F. Incidence and pathogen distribution of healthcare-associated infections in pilot hospitals in Egypt. Infect Control Hosp Epidemiol 2013;34:1281-8.
19. Centers for Disease Control and Prevention. Surgical site infections (SSI) event. 2014. Available from: http://www.cdc.gov/nhsn/PDFs/pscManual/9pscSSIcurrent.pdf. Accessed June 16, 2016.
20. CLSI Guidelines. Clinical and Laboratory Standards Institute (CLSI) performance standards for antimicrobial susceptibility testing: twenty-fifth informational supplement M100-S25. Wayne (PA): CLSI; 2015.
21. Magiorakos A-P, Srinivasan A, Carey RB, Carmeli Y, Falagas ME, Giske CG, et al. Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: an international expert proposal for interim standard definitions for acquired resistance. Clin Microbiol Infect 2012;18:268-81.
22. Tao L, Hu B, Rosenthal VD, Gao X, He L. Device-associated infection rates in 398 intensive care units in Shanghai, China: International Nosocomial Infection Control Consortium (INICC) findings. Int J Infect Dis 2011;15:e774-80.
23. Richards M, Thursky K, Buising K. Epidemiology, prevalence, and sites of infections in intensive care units. Semin Respir Crit Care Med 2003;24:3-22.
24. Rosenthal D, Maki D, Jamulitrat S, Medeiros EA, Todi SK, Gomez DY, et al. International Nosocomial Infection Control Consortium (INICC) report, data summary for 2003-2008. Am J Infect Control 2010;38:95-104.e2.
25. Kohlenberg A, Schwab F, Behnke M, Geffers C, Gastmeier P. Pneumonia associated with invasive and noninvasive ventilation: an analysis of the German nosocomial infection surveillance system database. Intensive Care Med 2010;36:971-8.
26. Sievert DM, Ricks P, Edwards JR, Schneider A, Patel J, Srinivasan A, et al. Antimicrobial-resistant pathogens associated with healthcare-associated infections: summary of data reported to the national healthcare safety network at the centers for disease control and prevention, 2009-2010. Infect Control Hosp Epidemiol 2013;34:1-14.
27. Khan MA. Bacterial spectrum and susceptibility patterns of pathogens in ICU and IMCU of a secondary care hospital in Kingdom of Saudi Arabia. Int J Path 2012;10:64-70.
28. Rubio FG, Oliveira VD, Rangel RM, Nogueira MC, Almeida MT. Trends in bacterial resistance in a tertiary university hospital over one decade. Braz J Infect Dis 2013;17:480-2.
29. Zorgani A, Franka RA, Zaidi MM, Alshawaref UM, Elgmti M. Trends in nososcomial blood stream infections in a burn intensive care unit: an eight years survey. Ann Burns Fire Disasters 2010;23:88-94.
30. Araj GF, Kanj SS. Current status and changing trends of antimicrobial resistance in Lebanon. J Med Liban 2000;48:221-6.
31. Begum S, Hasan F, Hussain S, Ali A. Prevalence of multi drug resistant Acinetobacter baumannii in the clinical samples from Tertiary Care Hospital in Islamabad, Pakistan. Pak J Med Sci 2013;29:1253-8.