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Infection Prevention and Safety in Low and Middle Income Countries (C Bardossy, Section Editor)

Implementing Infection Prevention and Control Programs When Resources Are Limited

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Opinion Statement

There have been established at least four pillars of patient safety viz., healthcare-associated infection prevention and control (IPC), surgical safety, medication safety, and patient communication. It has always been challenging to design, implement, and monitor the functioning of such pillars especially when resources are limited. The trained human resource is most precious of all followed by infrastructure, consumables, and continuous training. The establishment of "IDEAL framework" recommended elsewhere is the approach to achieve "optimal minimal" patient safety goal; however, simple steps with the limited resources can help improve the patient outcomes and safe work environment in healthcare setting. The program may not be comprehensive initially, and step-wise expansion of program can be planned based on available resources and buying-in from various stakeholders in the healthcare units. Involvement of leadership in the implementation of the IPC program can be the key driver of the program. The program can be initiated in one of the key high-risk areas (e.g., intensive care units or operating room complex) and then can be expanded to other units. Meticulous capturing of healthcare-associated infection (HAI) indicators and their regular feedback brings credibility to the program and help other people to take ownership of the program. This review highlights the basic components of designing, implementation, and monitoring of IPC program when resources are limited.

Introduction

It is estimated that millions of patients are affected by healthcare-associated infections (HAIs) every year, leading to significant morbidity, mortality, and financial losses for healthcare systems. Among the 100 hospitalized patients at any given time, seven in developed and 15 in developing countries will acquire at least one HAI [1••]. The endemic burden of HAIs is also significantly (at least 2–3 times) higher in low- and middle-income countries (LMICs) than in high-income nations, particularly in patients admitted to critical care units and neonatal units [1••]. HAIs are among the most common adverse event reported worldwide.

Limitation of resources poses major obstacle in implementing effective infection prevention and control (IPC) program in LMICs. The challenge is more due to non-existent, poorly adapted, or insufficiently funded IPC policies by governments [2, 3••]. Inadequate allocation of funds, inadequate infrastructure and management, inappropriate use of antimicrobials, and inadequate trained staff are key constraints for effective infection control in the hospitals of resource-poor settings [4••].

Surgical site infections (SSIs) are the most frequent type of HAI in LMICs and affects up to one third of patients who have undergone a surgical procedure [5]. The pooled incidence of SSI was 11.8 per 100 surgical procedures in LMIC (range 1.2 to 23.6) [5, 6•]. Occurrence of device-associated infections (DAIs) varies widely among limited resource settings. For example, central line-associated blood stream infection (CLABSI) rates are reported to range from 1.6 to 44.6 cases per 1000 central line-days in adult and pediatric intensive care units (ICUs) and from 2.6 to 60.0 cases per 1000 central line-days in neonatal ICUs [7]. Studies from developed countries suggest that CLABSIs can be prevented by applying five measures—hand hygiene, using full barrier precautions during the insertion of central venous catheters, cleaning the skin with chlorhexidine, avoiding the femoral site if possible, and removing unnecessary catheters [8].

Challenges in resource-limited setting

The infection control programs in many countries with limited resources lack support through regulations. If regulations are in place in few such countries, the compliance with the rules is poor. Although accreditation programs for healthcare organizations are now being mandated in few countries, it will take considerable time for organization to develop the mindset for implementation of standards in true spirit. Recently, the "IDEAL" framework approach has been recommended to derive better outcomes and reduction in evolution and spread of multi drug Gram-negative bacteria in the resource-limited settings [6•]. This framework emphasizes upon implementation of IPC program along with development of antimicrobial and diagnostic stewardship, enhance interventions to improve outcomes of the IPC and stewardship programs, promote the concept of accreditation of healthcare institutions to enhance patient safety and quality of healthcare, and finally, all these steps being supported by legislations to empower people and ensure compliance to the various implementation steps.

A limited resource setting has insufficient funding by government and has infection control and prevention as low priority area. Limited resource settings are burdened with overcrowded ICUs, insufficient or altogether absent isolation rooms, lack of adequate number of sinks or if available, are at inappropriate

sites and poor supply chain management with lack of uninterrupted supplies. This leads to erratic supplies of hand rubs, soap, paper towels, and personal protective equipment (PPE). Additionally, non-availability of appropriate packing size of drugs leads to reuse of drugs available in ampules or vials with drugs without preservatives—increasing the risk of contamination and hence infection. Inappropriate processes and infection control practices—such as leaving needles inserted in multiple-use vials, reusing single-use vials, keeping punctured parenteral fluid bottles and preparing drug dilutions from that bottle for multiple shifts or even days, using similar bottles for flushing indwelling venous lines, using cotton balls impregnated with antiseptic contained in a un-cleaned/unsterile container, and using inappropriate materials for fixing and covering venous insertion sites. The common challenges in resource-limited settings are listed in Table 1. The effective IPC program is central to providing high-quality health care for patients, minimizing HAIs and safe working environment for health care personnel (HCP) [4••]. Prevention of HAIs in patients is a concern of everyone in the facility which requires participation between HCP, government, and community [5].

Steps of implementation of infection prevention and control program

The key steps required in the implementation of IPC program are summarized in Fig. 1. These steps are "optimal minimum;" however, the intensity of implementation and order of their implementation may vary depending on the resources available and specific challenges related to healthcare setting. Recently, Healthcare Infection Control Practices Advisory Committee (HICPAC) and WHO has released recommendations for "core infection prevention and control practices for safe healthcare delivery in all settings" [9••]. The various elements for implementation of IPC program include the following:

Engagement of leadership

The presence of political interest and commitment can provide thrust to the infection prevention program. The leadership engagement can be at national level, political level, and hospital level or even at departmental level. The departmental level leadership can bring in other levels over a period of time in stepwise approach. It brings in the technical expertise and resources. This will help to identify key personnel for implementation and monitoring of the program and brings in empowerment of all ranks of healthcare workers and patients to reach desirable IPC goals.

Development of program and prioritization of implementation areas

Once the leadership is involved, IPC program can be prepared and documented. The documented plan can bring in accountability and becomes an important tool to disseminate the policies and procedure. It can also be the base level

Table 1. List of common challenges and deficiencies in infection control programs in resource-limited healthcare settings

S. no.	Challenges
1.	Lack of regulation or poor compliance to regulation a. Absence of regulation b. Regulation is present but poor implementation
2.	National level policy and principles for implementation a. Non-existent national level policy of IPC b. Poor dissemination or lack of periodic updation of such policies
3.	Limitation of resources and insufficient funding by government a. Poor funding of state control healthcare setting b. Lack of specific allocation to IPC program c. Inadequate involvement of leadership
4.	Inadequate infrastructure and management of healthcare settings a. Debilitating infrastructure b. Inadequate maintenance of fittings and fixtures, e.g., heating, ventilation and air conditioning (HVAC) systems for operating rooms and ICUs, inappropriate flow of work in high risk areas with lots of criss-crossing c. Poor supply chain management—non-availability of hand rubs, personal protective equipment d. Non-availability of devices and instruments for disinfection and sterilization
5.	Surveillance of infection prevention and control practices a. Constrained with lack of trained staff and understanding of definitions b. Lack of bundle approach for minimizing HAIs c. Lack of data collection formats and clarity of methods of data collection d. Deficient information management system for data collation, analysis and dissemination
6.	Occupational health program a. Pre-exposure prophylaxis—lack of vaccines and drugs b. Post-exposure prophylaxis drugs
7.	Diagnostic facilities a. Limited microbiology laboratory and diagnostic facilities b. Limited availability or non-availability of point of care tests c. Where facilities are available lack of standard guidelines / investigative pathways for diagnosis of infectious diseases
8.	Antimicrobial usage a. Lack of national level antibiotic policies/recommendations based on microbiological data b. Poor implementation of the guidelines c. Lack of first line antimicrobials like benzyl penicillin, cloxacillin leading to usage of second line more potent antimicrobials, risking emergence of resistant against these drugs d. Deficient antimicrobial drugs usage data
9.	Shortage of trained health care staff a. Inadequate staff patient ratio including in high risk areas b. Dedicated staff of infection control (infection control nurses) lacking or are inadequate number c. Lack of uniform, structured infection control induction training and periodic training d. Lack of appropriate signages for patients, staff and visitors for improvement in IPC practices
10.	Biomedical waste management, housekeeping, and general hygiene a. Poor sanitary conditions due to inadequate number of staff b. Inadequate numbers and upkeep of waste bins c. Inappropriate biomedical waste transport and storage before final disposal d. Inappropriate disposal of biomedical waste e. Overcrowding, less educated society, and lack of general awareness among population

document for development of training program for all stakeholders. Mapping of critical processes within the program are imperative to get desired results and bring credibility to the IPC program. The program needs to be periodically updated (at least annually). The plan should also identify priority areas of healthcare to be taken in the phased manner and can also incorporate short

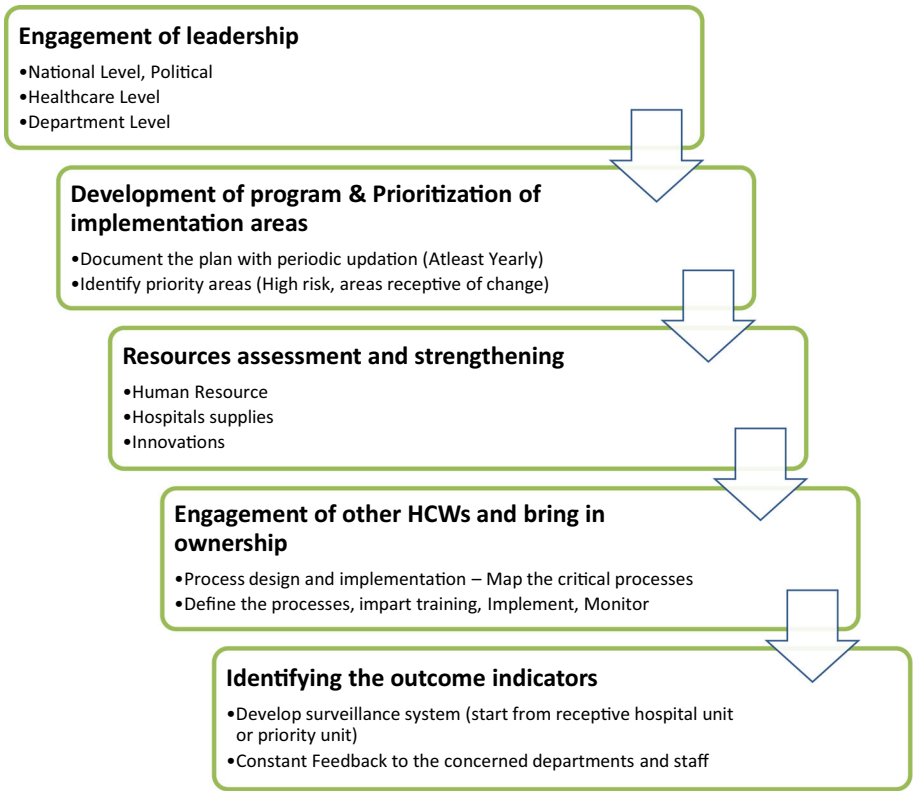

Fig. 1. Steps of implementation of IPC program (please refer to text for more details).

term (3 months), medium term (half yearly), and long-term (year or more) goals for the program. The progress towards such goals can be monitored on monthly basis in infection control meetings.

Resources assessment and strengthening

The resources required should be identified and documented. These include human resource, hospital supplies, and resources required to implement various processes and innovations. The augmentation of resources if not feasible immediately can be pooled forms other hospital areas to achieve goals in the priority areas of the hospital. Process to build up additional resources must go-on simultaneously for long-term sustenance of the IPC program.

Engagement of other HCWs and bring in ownership

While designing the program, involvement of different stakeholders from various clinical and support departments is critical for the success of the program. The involvement will help buying-in to the program and bring ownership for processes and procedures agreed and documented in the program. The critical processes identified should be used while defining the processes. The training of various healthcare workers should have incorporation of such processes and monitoring tools needed to be developed for such critical processes. The monitoring tools should be based on scientific data

requirements and preferable done in pre-template format to have meticulous documentation and uniform analysis of the monitoring activities.

Identifying the outcome indicators

Identifying the indicators shall be critical for monitoring the program. The indicators should then be defined along with clear definitions of numerators and denominators. The place and process of capturing these numerators should be documented. The people responsible for collection of data and performing surveillance should be identified and trained. The data collection methods need to be validated by sending different surveillance personnel in the same unit in periodic basis. Start from receptive hospital unit or priority area of the hospital. The data must be periodically analyzed (at least monthly) and constant feedback provided to the concerned departments and staff. The examples of common output indicators include but not limited to device-associated infection rates (central line-associated infection rates, catheter-associated urinary tract infections rates, ventilator-associated adverse events, etc.), surgical site infection rates (overall and surgery specific SSI rates), hand hygiene compliance rates, sharp injury reporting rates, percentage of HCWs given post-exposure prophylaxis (PEP), percentage of HCWs completing successfully PEP, and bundle compliance rates (separate for each bundle implemented).

Measures taken for implementation of the IPC program in limited resources

Organization and implementation of the IPC program

As a first step, identify existing hospital programs to fund the IPC activities, aligning with other initiatives. A set of defined policies and procedures for implementing and monitoring of HAIs should be formed and adhered to. The health care facility (HCF) should have guidelines for preventing and controlling HAIs that are consistent with the national guidelines and adapted to the local needs and resources. A designated qualified leadership should be identified. Authority of the leadership should be established. Hospital infection control committee and infection control team of qualified persons should be established. The IPC program responsibilities, goals, and functions should be clearly defined and regularly updated. There is an identified budget to guarantee functioning and activities related to implementation of the IPC program in HCF. Therefore, a strong political support and commitment is required to enable effective implementation.

Human resource development

Adequate number of staffs should be identified to play key roles for successful functioning of IPC program. The proper staffing ratio of IPC professionals and teams according to the national standards is maintained. The ratio to the number of ICN to the number of hospital beds, or admissions or any other indicator of workload should be maintained. The ratios described include 1 IPC professional per 250 beds. Several countries introduced better ratios (e.g., 1 per 80 or 100 beds), but the optimum ratios still need to be studied [9••].

Initial training for all newly recruited health care personnel is provided and periodical basic training for all health care personnel is provided regularly. In addition, specialized training for IPC professionals should be done periodically.

Job-specific training for all healthcare workers is implemented as part of an induction program and a periodic in-service training program (at least annually). Prevention and monitoring of occupational biological risks and HCW immunization program for hepatitis B, influenza, and rubella is implemented. The patient and the relatives must be given health education about the cause, spread, and prevention of the infection. The need for isolation and restriction of visitors are discussed with them and strictly enforced to minimize HAIs particularly in resource-limited settings [9••]. The information to patients and visitors through group discussions, posters, and for identified list of situations and conditions is provided. Healthcare workers, patients, and visitors are empowered to identify breach/lapses in infection control practices and report them feeling part of the IPC program.

Strengthening of infection control procedures and practices

The prevention and management of HAIs through the application of research-based knowledge to practices include standard precautions, hand hygiene, decontamination, waste management, surveillance, and audit. Standard precautions are the foundation for prevention and control of HAIs. According to HICPAC and the CDC, standard precautions are a group of infection prevention practices that apply to all patients and residents, regardless of suspected or confirmed infection status, in any setting in which healthcare is delivered [10••] and include the following:

1. Hand hygiene. This includes training for five moments and six steps of hand hygiene, providing resources for hand hygiene and monitoring the compliance in a standardized manner, e.g., usage of WHO hand hygiene monitoring tool. Hand hygiene shall also include appropriate usage of gloves and using hand rub before donning and after doffing of gloves.
2. Use of personal protective equipment (e.g., gloves, gowns, facemasks), depending on the risk assessment and anticipated exposure
3. Respiratory hygiene and cough etiquette
4. Management of spillage
5. Medication safety includes usage of appropriate puncturing techniques and devices to draw medicines, defining the age of multi-dose vials after their first use, appropriate labeling of vials and storage of medicine. This shall also include discard of medicine ampules meant for single use immediately after their first use or as per manufacturer's instructions.
6. Safe injection practices including prevention and management of injuries from sharp instruments. Safe and correct usage of intravenous infusion devices is also important part of safe injection practices.
7. Cleaning, disinfection, and sterilization of reusable health care equipment. Reprocessing of devices is done through documented and validated procedures. The list of devices and their reprocessing procedures may be prepared and disseminated. Periodic training to these procedures and monitoring of implementation of the same is required. Appropriate packing techniques and use of sterilization indicators are important part of safe sterilization practices.
8. Safe and appropriate waste management include disposing waste as per local laws and safe final disposal of the biomedical waste. This shall also

include use of personal protective equipment by the waste handlers and safe storage of waste at designated place before their final disposal as required.

9. Laundry management shall include the segregation of soiled and dirty linen at source, the safe storage and sorting practices, and safe transport to the laundry.
10. Environmental cleaning and disinfection. This includes identifying areas with frequency of cleaning and the various disinfectants being used for disinfection of various surfaces, e.g., the cleaning protocols and procedures before the first case being taken in operating room, in-between the cases and after the last surgery.

Two basic principles govern the main measures that should be taken in order to prevent the spread of HAIs in healthcare facilities: first is to identify and segregate the infection source from the rest of the hospital followed by steps towards cut off any route of transmission. It includes not only the isolation of infected patients but also all aseptic techniques that are intended to act as a barrier between infected or potentially contaminated tissue and the environment. Decontamination, disinfection and sterilization of environment, soiled instruments, and other items improve safety in operating rooms and other high-risk areas [11]. Hand hygiene is the single most important measure in reducing the spread of infection and very economical measure in resource-poor settings to curtail HAIs. Infection control assessment tools can be used in LMIC to establish baseline compliance with (a) hand hygiene and sanitation, (b) disinfection and sterilization, (c) safe drinking water, and (d) waste disposal [12]. Depending upon the findings, interventions should be prioritized and resources should be allocated by securing funding [6•]. Surveillance is conducted as an essential and well-defined component of IPC program for the outbreak identification, establishment of endemic baseline rates of infection, and the evaluation of control measures. Objectives and priorities for surveillance are defined according to the scope of care.

The mechanisms for constant periodic feedback for all IPC activities to the care providers and leadership help in improvement of the program.

Develop antimicrobial and diagnostic stewardship based on local data

Development of investigative pathways and clinical pathways for the management of patients is recommended. These pathways can be based on basic principle of laboratory testing and principles of treatment [13••]. While making investigative pathways due importance should be given to the available point of care tests and rapid tests. These pathways help in judicious use of laboratory resources, initiation of early appropriate antibiotic therapy and early discharge of patients.

In LMIC, inappropriate and uncontrolled use of antibiotics is very common due to frequent availability over the counter leading to resistance among common pathogens to cheap antimicrobials. The use of antimicrobials in the veterinary area has also an important impact in increasing antimicrobial resistance. Thus, necessary guidelines need to be set up on prudent use of antibiotics. The microbiology laboratory should prepare annual antibiograms to assist HCPs with the choice of empiric antibiotic therapy based on local susceptibility

patterns and de-escalation to definitive therapy as the microbiology results are known [14]. HCPs should be educated to distinguish between colonization and infection and to limit unnecessary continuation of prescribed antibiotics. Protocol on antimicrobial prophylaxis in surgery and policy on antimicrobials of restricted use should also be formed and implemented. Recent guidelines for prevention of surgical site infections recommend various steps for reduction of SSIs [15••]. The key recommendations include preoperative antibiotic prophylaxis, implement perioperative glycemic control and use blood glucose target levels less than 200 mg/dL in patients with and without diabetes, maintain perioperative normothermia, to optimize tissue oxygen delivery, maintain perioperative normothermia and adequate volume replacement, and perform intraoperative skin preparation with an alcohol-based antiseptic agent unless contraindicated [15••]. All the recommendations again may not be feasible to implement; however, the graded approach as per available resources and facilities may be implemented.

Bundle care approach in intensive care units

A bundle is a small set of evidence-based interventions for a defined patient segment/population and care setting that, when implemented together, will result in significantly better outcomes than when implemented individually [14]. Each bundle consists of three to five elements, all of which are well-established practices and evidence-based but are not usually, uniformly practiced at the bedside. These include ventilator-associated pneumonia prevention bundle, central line-associated blood stream infections prevention bundle, sepsis resuscitation bundle, sepsis management bundle, catheter-associated urinary tract infection prevention bundle, and SSI prevention bundle. Direct benefits of bundle approach are shorter intensive care unit stay, reduced financial cost and improved resource utilization, which is very economical in resource-poor settings to improve patient outcome and curtailing HAIs.

Good quality and responsive microbiological laboratory services to be made available

The HCF has access to microbiological laboratory services with trained lab specialists in clinical microbiology. Identification and characterization of the etiological agents is important to clinicians for informing decisions on treatment options and for the early detection of some outbreaks. It also provides data on the local epidemiology of HAIs and information relevant for policies on the use of antimicrobials and other infection prevention and control strategies. Microbiology activities were evaluated periodically by internal quality control and external quality control at least once a year. Laboratory biosafety standards were implemented [9••].

Enhance interventions based on relevant technical and behavioral factors to improve impact

Treatment of infectious diseases, antimicrobial stewardship, and IPC practices are rooted in the culture of a healthcare institution. Inter-professional collaboration is needed for effective IPC and stewardship program, which could be challenging in resource-limited settings [16]. Most evidence-based

interventions from developed countries can be implemented only in an outbreak crisis scenario in LMIC. For sustainable results, interventions need to be adapted within the context of underlying core cultural values. The common behavioral interventions that can be used include education, persuasion, and enablement [17].

Occupational health program

Prevention and monitoring of occupational biological risks and HCW immunization program for hepatitis B, influenza, rubella, and other vaccine preventable diseases is implemented. The patient and the relatives must be given health education about the cause, spread, and prevention of the infection. The need for isolation and restriction of visitors are discussed with them and strictly enforced to minimize HAIs particularly in resource-limited settings [9••].

Accreditation of healthcare institutions to improve quality and safety of care and legislation to ensure compliance

Accreditation has played an active role in improving patient safety, initiating surveillance of HAI and antimicrobial stewardship. Surveillance data can be used to identify preventable infections in high risk areas, so that resources are targeted to high priority areas. Health insurance (from both public sector and private sector) companies have taken initiatives through requirement of accreditation for enhanced payment, which has been a key driver in improving safety in this area [18]. Public sharing of HAI data is still a challenge in resource-limited countries that will require sensitization of broadcasting and print media along with other stakeholders including judiciary and public at large. Public-private partnerships should be encouraged for safe healthcare delivery in the inherently challenging situations prevailing in LMIC [6•].

Conclusions

Effective IPC is a pre-requisite towards providing high-quality healthcare for patients and a safe working environment in healthcare settings. Prevention of HAIs in patients is a responsibility of everyone in the facility including all levels of healthcare workers, patients and visitors. To reduce HAI rates in healthcare settings focus on education, surveillance of infection rates along with periodic feedback, and surveillance for compliance with infection control measures is important.

The IPC program requires collaboration between HCWs, government and community. A set of defined policies and procedures for implementing and monitoring of HAIs should be developed, implemented, and should have continuous intensive monitoring and feedback mechanisms. Regular education and training of healthcare workers, patients, and visitors regarding policies and procedures are important for an effective IPC program and reducing the morbidity and mortality in healthcare units and community.

Implementation of IPC program in resource-limited settings is a challenging task to perform. However, it is possible to achieve substantial progress in minimizing health care-associated infections within such challenging circumstances if effective measures are taken as outlined above. Focusing on

prevention of infection control policies in a cost-effective way, health care services could be improved even in a resource-poor setting.

Compliance with Ethical Standards

Conflict of Interest

Vikas Manchanda declares that he has no conflict of interest. Urvashi Suman declares that she has no conflict of interest. Nalini Singh declares that she has no conflict of interest.

Human and Animal Rights and Informed Consent

This article does not contain any studies with human or animal subjects performed by any of the authors.

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