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

Controlling infectious disease outbreaks in low-income and middle-income countries

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Abstract

When an infectious disease outbreak is detected or suspected, a healthcare facility's infection control personnel should be notified and an outbreak control team formed that is pertinent to the size and severity of the outbreak and healthcare facility. Management of an infectious disease outbreak in a middle- or low-income country is challenging. Cost-effective recommendations that are easy to carry out and that have been stratified according to the type of infection and prevention and control intervention used are provided in this paper and constitute basic practices.

Introduction

An infectious disease outbreak is defined as an excessive number of cases identified in a given area or among a particular group of people over a particular duration. Outbreaks occur frequently in hospitals and healthcare centers and pose a serious risk of colonization or illness to susceptible patients and healthcare staff. It was stated in a recent report that only six (three high-income and three low-income) countries are equipped to deal with a pandemic [1]. Carbapenem-resistant *Enterobacteriaceae* outbreaks occur in hospitals when the healthcare environment is compromised [2]. Outbreak control must be well planned, fast, and effective. The primary components of a management plan are risk assessment, case findings, patient evaluation and risk mitigation. The Rapid Isolation and Treatment of Infection strategy (RITE strategy) was recommended for the Ebola outbreak in Africa [3]. Infection control personnel expend considerable effort investigating outbreaks, leading to unexpectedly high costs for the affected hospital. Approximately 2–10% of all nosocomial infections are acquired during a nosocomial outbreak [4]. This review describes the major and minor components, and special measures for outbreak control in low- and middle-income countries.

Major components for outbreak control

The major components are the essential components that are recommended to be prioritized to control an outbreak (Table 1).

Hand hygiene

Hand hygiene remains the simplest and first-line measure used to prevent health care-associated infections (HAIs), outbreak and reduce the spread of multidrug-resistant (MDR) microorganisms. HAIs have a detrimental effect on individual quality of life and it is very costly to manage them. Although hand hygiene is a simple measure to employ, lack of compliance (averaging ≤ 40%) among healthcare workers (HCWs) is a major global challenge [5]. The World Health Organization's (WHO) Five Moments for Hand Hygiene approach, derived from the WHO's 2009 guidelines on hand hygiene, summarizes the mechanisms of microorganism cross-transmission as involving:

- The presence of microorganisms on the patient's skin and/or in the patient environment.
- The transfer of microorganisms to the hands of HCWs.
- The survival of microorganisms on the hands of HCWs.
- Incorrect hand cleansing by HCWs.
- Cross-transmission of the microorganisms to further patients [6].

The level of hand contamination was shown to increase progressively in a linear fashion over time, thereby favoring cross-transmission, in a study that explored the consequences of diminished or absent hand hygiene practices performed during patient care. A significant reduction in microorganism count was also reported in a limited number of studies in which handwashing and/or hand-rubbing was evaluated, although the data on MDR Gram-negative bacteria were scarce. Elsewhere, a significant reduction in Gram-negative bacteria count was observed when hand hygiene measures were performed using soap and water in conjunction with an alcohol hand-rub soap [7]. It was shown that an alcohol-based hand-rub reduced the *Acinetobacter baumannii* count by 98% on experimentally contaminated hands. Hand contamination, despite wearing gloves, was reported on the hands of 5% and 1% of HCWs after caring for MDR *A. baumannii* and MDR *Pseudomonas aeruginosa* colonized or infected patients, respectively [8].

Quantitative estimates of the cost savings that could be achieved (the potential savings from a reduction in the incidence of HAIs) were determined in several studies in relation to the establishment of hand hygiene promotion programs. The annual net cost to India and China from not performing handwashing was estimated to be US$ 23 billion and US$ 12 billion, respectively. The expected net return, following the introduction of nation-wide programs to effect a change in handwashing behavior, was estimated to be US$ 5.6 billion for India (at US$ 23/disability-adjusted life-year that was avoided, representing a 92-fold return on the investment), and US$ 2.64 billion for China (at US$ 22/disability-adjusted life-year that was avoided, a 35-fold return on the investment) [9]. Hand hygiene is probably the most effective

Table 1. Major components of infectious disease outbreak control in low- and middle-income countries

Infectious disease outbreak measures	Recommended action to be taken
Hand hygiene education programs	• Hand hygiene education programs should be implemented to reduce the transmission of extended-spectrum beta-lactamase-producing *Enterobacteriaceae*, multidrug-resistant *Klebsiella pneumoniae*, multidrug-resistant *Pseudomonas aeruginosa*, multidrug-resistant *Acinetobacter baumannii*, *Stenotrophomonas maltophilia* and *Burkholderia cepacia*. • Healthcare workers must be encouraged to perform hand hygiene with an alcohol-based hand rub before and after all patient contact. Soap and water washing is required when hands are visibly soiled, e.g., with body fluids or excretions. • Monitoring of hand hygiene compliance and feedback to healthcare workers should be performed to achieve greater compliance.
Contact precautions	• Contact precautions should be established for all patients colonized and/or infected with extended-spectrum beta-lactamase-producing *Enterobacteriaceae*, multidrug-resistant *Klebsiella pneumoniae*, multidrug-resistant *Acinetobacter baumannii*, *Clostridium difficile* and *Pseudomonas aeruginosa*. • Colonized and infected patients must be isolated in a single room to reduce the risk of transmitting extended-spectrum beta-lactamase-producing *Enterobacteriaceae*, multidrug-resistant *Klebsiella pneumoniae*, multidrug-resistant *Acinetobacter baumannii* and multidrug-resistant *Pseudomonas aeruginosa*. • Staff must be encouraged to ensure that the risk of acquiring multidrug-resistant *Klebsiella pneumoniae* is reduced. • Contact precautions must be established for all colonized and infected patients in the hospital setting, to reduce the risk of disease transmission. Healthcare workers caring for patients who are colonized or infected with extended-spectrum beta-lactamase-producing *Enterobacteriaceae* should wear gloves and gowns before entering the room, and should remove these promptly after the provision of care, and thereafter perform hand hygiene. • An audit of adherence to contact precautions must be carried out to make sure that the interventions are being performed correctly to increase the chances of a successful reduction in disease transmission.
Environmental surface cleaning and decontamination	• The routine cleaning and decontamination of environmental surfaces must be monitored to prevent the transmission of infection. The units should be vacated to perform intensive cleaning. • Routine environmental cleaning and disinfection procedures must be implemented and, when available, non-critical medical items should be dedicated for use in individual patients who are colonized or infected with extended-spectrum beta-lactamase-producing *Enterobacteriaceae* and multidrug-resistant *Acinetobacter baumannii*. • Regular environmental cleaning and disinfection procedures, including the use of detergents or disinfectants depending on local practice, should be affected to reduce the infection transmission rate. Patient care equipment and environmental surfaces must be regularly cleaned. • Shared equipment must be disinfected between use in different patients.
Antimicrobial stewardship	• An antimicrobial stewardship program should be instituted. Interventions regarding the restriction of antibiotic usage must launched to reduce the spread of extended-spectrum beta-lactamase-producing *Enterobacteriaceae*.

measure that can be used to control an outbreak, while being cost-effective. The introduction of an alcohol-based hand-rub was also demonstrated to lead to increased hand hygiene compliance among healthcare workers and fewer hospital-related infections in another study [6]. However, maintaining good hand hygiene practices in hospitals remains a challenge [10].

Institutional hygiene

Although environmental screening is often performed to control an infectious disease outbreak, its role remains contentious and the methodology has not been standardized. Unexpected environmental reservoirs are sometimes identified, suggesting that environmental screening should be considered, especially when control cannot effectively be accomplished using basic infection prevention and control (IPC) practices. The increased use of antibiotics is associated with the resistance profiles of organisms on floors and other surfaces within a defined local environment, such as a hospital ward, and previous room occupancy by a Gram-negative bacilli-colonized or Gram-negative bacteria-infected patient has been shown to be a risk for the acquisition of Gram-negative [11].

Methods to assess cleanliness are needed. Such methods can be classified within two main categories, namely a process evaluation, where the cleaning process is monitored by visual inspection or with a fluorescent gel marker, and an outcome evaluation, where it is assessed using an adenosine triphosphate (ATP) bioluminescence system or via the identification of microbial cultures. The use of ATP monitoring has been demonstrated to have a pronounced effect on the behavior of cleaners after they have received concomitant educational guidance [12]. Hospital environmental cleaning or disinfecting can be accomplished manually in low-income countries [13].

An infection prevention and control program

The overall objective of an IPC program is to minimize the risk of HAIs, the cross-contamination of environmental surfaces and cross-colonization between patients, and to minimize the risk of other negative effects by contributing to patient safety. This is achieved by protecting patients from infections in the most efficient manner possible, thereby reducing the economic impact of HAIs on healthcare facilities, healthcare systems, and the national healthcare industry. IPC is a critical patient safety issue as HAIs are by far the most common complication that affects hospitalized patients. IPC programs are considered to be one of the most cost-effective interventions in minimizing infectious disease transmission.

Personal protective equipment

As a minimum, basic infection control precautions (i.e. standard precautions) need to be applied during the care of patients. Personal protective equipment is a critical measure to protect healthcare workers, military and voluntary personnel assisting people from highly infectious diseases [14]. This is to ensure a reduction in the risk of transmission of blood-borne and other microorganisms from both recognized and unrecognized sources. In addition to standard precautions being taken, contact precautions should include wearing a gown and gloves upon entering the room of a patient who is colonized or infected with epidemiologically targeted bacteria, as well as using disposable, single-use or

patient-dedicated, non-critical care equipment (such as blood pressure cuffs and stethoscopes). Once MDR bacterial infection or carriage is detected in hospitalized patients, most international guidelines recommend the application of contact precautions to these patients to prevent the spread of infection, even if the quality of evidence is low [15]. There are multiple ways of implementing contact precautions:

- Special isolation wards can be allocated to infected patients, or a particular group of patients (for example, patients in whom infection has definitively been identified) can share an area.
- Colonized patients could be isolated in single or cohort nursing rooms on the general wards, with the need for designated personnel.
- Contact precautions should be applied when caring for colonized or infected patients.

The effectiveness of implementing contact precautions to control a MDR *A. baumannii* outbreak was reported in one study [16].

An antimicrobial stewardship program

HAIs are a leading cause of morbidity and mortality worldwide. The significant negative impact that HAIs have on both patient outcomes and the broader health economy has been demonstrated in multiple studies [17]. The understanding is that these infections extend beyond the risk to individual patients because they contribute to antimicrobial resistance, thereby potentially reducing the efficacy of treatment options for specific infections.

Effective therapy is becoming increasing difficult because of rate at which antimicrobial resistance is increasing in common HAI pathogens. Over the last decade, MDR Gram-negative bacteria, including MDR *P. aeruginosa*, MDR *A. baumannii* and extended-spectrum beta-lactamase and carbapenemase-producing *Enterobacteriaceae*, have been implicated in severe HAIs, and their occurrence is steadily increasing [6]. In addition, antibiotics have long been established as a crucial risk factor for *Clostridium difficile* infection. In patients colonized by *C. difficile*, antibiotics may promote *C. difficile* proliferation and the number of *C. difficile* spores that are shed in the local environment. Antibiotic use in *C. difficile*-infected patients can have a potentially negative effect on any other patient in the same environment who is not receiving them. In turn, this may result in a higher environmental *C. difficile* burden and greater risk for acquisition and infection in future patients who share the same environment as those infected with *C. difficile* [18].

It has been demonstrated in numerous studies that previous antimicrobial drug exposure is a strong risk factor for colonization and infection due to drug-resistant bacteria [19]. Different approaches are applied to the control and restriction of antibiotic consumption in hospitalized patients. Antibiotic restriction, i.e., the requirement that an infectious disease specialist must provide approval of the use of the antibiotic in a given person, is considered to be one of the most effective methods of control [20].

Antibiotic cycling or rotation refers to the scheduled alternation of various antibiotic classes and has been described as a strategy in decreasing antibiotic resistance. The goal of antibiotic cycling or rotation is sustainable decline or stabilization with respect to antimicrobial resistance, through successive, prospective alterations in antibiotic selection, in order to prevent the selection of

specific resistance traits and hence organisms. Indeed, antibiotic cycling in high-risk units has been shown to successfully modify resistance patterns [21]. Thus, this is a compelling approach.

The implementation of antibiotic guidelines or protocols has also been shown to be a formal means of realizing the goals of appropriate antibiotic use, limiting unnecessary antibiotic use and, as a result, improving antibiotic susceptibility profiles [22].

Minor components for outbreak control

Immunization

Influenza is a respiratory infection that causes substantial illness and death in the healthcare setting, while affecting healthcare providers every year. The immunization of healthcare personnel and long-term care facility residents against influenza can help to prevent outbreaks. Although immunization against influenza does not always prevent infection, it can prevent serious complications [23].

Ensuring that people who are capable of transmitting influenza to patients or residents are immunized is considered to be part of the duty of care for clients. This includes all personnel who carry out activities within the facility, i.e., employees, students, attending physicians, healthcare and non-healthcare contract workers, and volunteers.

Streptococcus pneumoniae, a bacterium, is an important contributor to deaths associated with influenza every winter. Vaccination against *S. pneumoniae* is recommended and unlike the influenza vaccine, does not have to be repeated annually [24]. Therefore, ensuring that eligible people who are at high risk of contracting influenza receive a free pneumococcal vaccine each winter will help to protect them.

The pneumococcal polysaccharide vaccine is recommended for and provided free to people who are at high risk of acquiring serious infection, i.e., the elderly, immunocompromised patients, and residential care residents. Visitors should be provided with information about the need for influenza and pneumococcal immunization and locations where they can receive it.

Special measures for outbreak control

Ward closure

Ward closure is defined as the restriction of new patient admissions, usually in conjunction with numerous infection control measures, such as enhanced environmental surface cleaning measures, rigorous hand hygiene practices, and heightened surveillance to control infectious disease transmission. Historically, ward closures have been employed to curtail the spread of disease, thereby shortening the overall duration of an outbreak. In recent years, the value and efficacy of applying ward closure to control hospital-acquired infection outbreaks has been questioned because it is one of the most expensive and disruptive IPC measures that can be used [25].

It is more likely that hospitals are able to avoid ward closure to contain the transmission of antibiotic-resistant organisms than it is for them to do so to

restrict the spread of respiratory viruses and noroviruses. Antibiotic-resistant organisms spread more slowly than respiratory or gastrointestinal pathogens, allowing for more available time to control transmission of the pathogen. In addition, it is more feasible to contain such outbreaks using strategies such as additional housekeeping and environmental surface cleaning measures, enhanced surveillance, patient isolation, and the use of personal protective equipment.

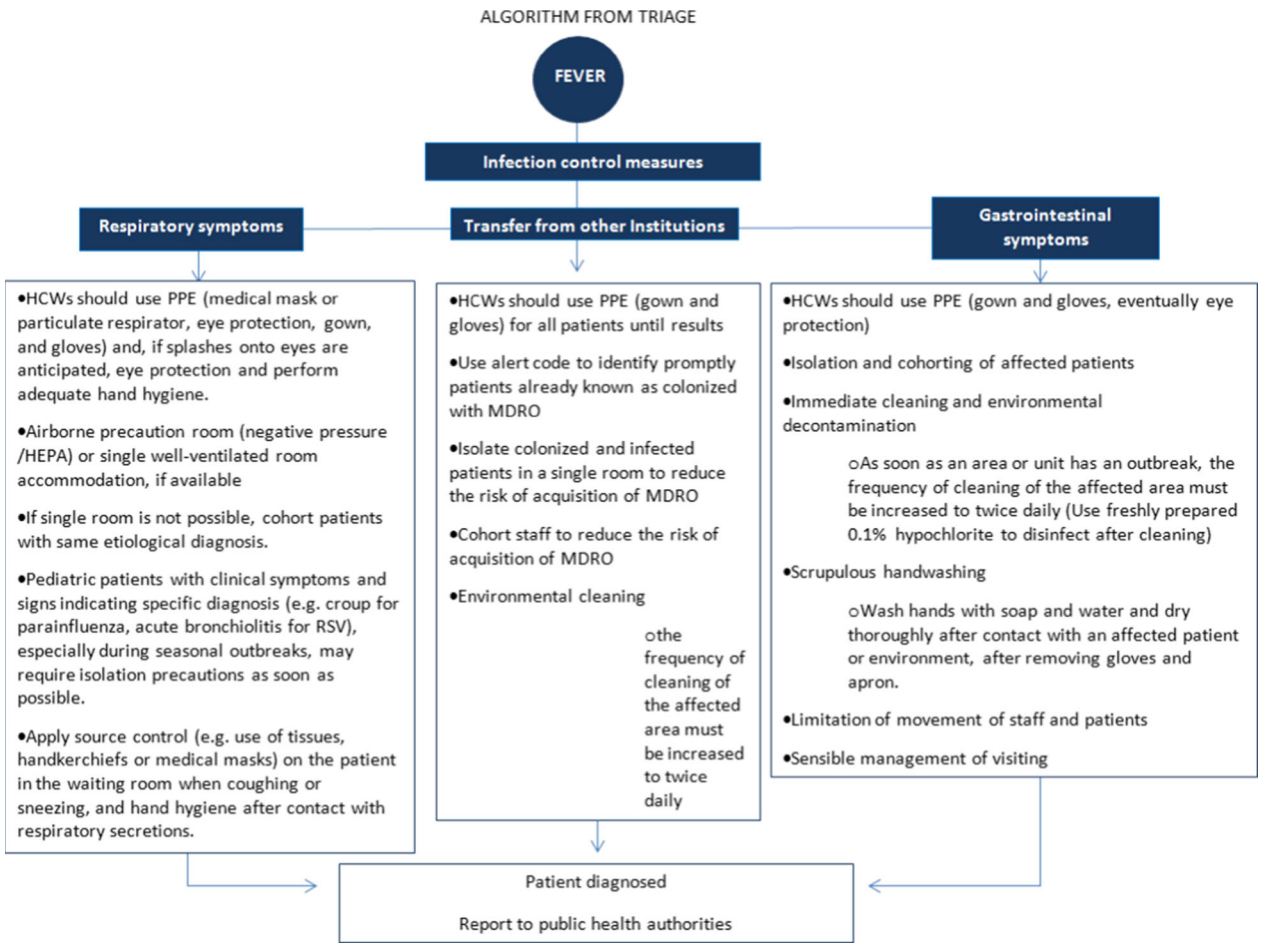
Capacity problems limit the use of optimal outbreak containment strategies. Often ward closure is not an option owing to continuous demand for overcapacity, or protocols that govern full capacity because of large patient volumes. It was established that ward closure may not be necessary, depending on the setting and the type of microorganism associated with the outbreak, in recent studies in which the efficiency of ward closure was compared with other, less expensive and less disruptive outbreak methods [25]. Thus, ward closure is considered to be last resort in the control infectious disease outbreaks.

Waste management

A waste management program is necessary to prevent the spread of highly infectious pathogens. Some sort of waste handling protocol should be in place at all institutions. A simple tool can be used to evaluate the management of health-care waste at each institution; the individualized rapid assessment tool was evaluated in a tertiary care hospital in Nepal [26].

Real-time reporting tools

Some infectious diseases, such as the acquired immune deficiency syndrome epidemic (late 1970s), followed by the severe acute respiratory syndrome coronavirus in Asia (2002–2003), the global H1N1 pandemic (2009), the Middle East respiratory syndrome coronavirus in Saudi Arabia (2012), the re-emergence of the Ebola virus in Africa (2014), and the Zika virus (2016), are very difficult to control as they require real-time reporting in order to timeously alert the relevant surveillance personnel. Social media and Internet-based data have also been shown to play a role in the ability to send early warning signals to public health authorities, enabling them to take an informed course of action to prevent and control the spread of disease [27]. The use of social media has also been pivotal in improving real-time reporting, utilized to inform the public and governments about possible health-related threats. It has been reported that, on average, there is a lag time of at least 2 weeks from receipt of information about an infectious disease event to the dissemination of the data via traditional surveillance systems. The distribution of data by means of the Internet and social media ensures acceleration of the process of informing the public and governments about threats to public health, especially infectious diseases. Technology, especially in the light of ongoing advancements, can be used as a platform to improve the quality of detection and reporting of infectious diseases threats, through exploitation of the sensitivity and timeliness capabilities of digital-based surveillance systems [28]. A mathematical model has recently been developed for use in predicting new infectious disease outbreaks in low- and middle-income countries [29].



HCW: healthcare workers, PPE: personal protective equipment, HEPA: high efficiency particulate air, MDRO: multidrug resistant organisms.

Fig. 1. Algorithm for Initial outbreak management.

Respiratory or surgical masks

Ideally, N95® particulate respirators or surgical masks should be used as a respiratory precaution in cases where patients are suspected to have pulmonary tuberculosis, a highly contagious respiratory virus or influenza infection [30]. The time from patient entering the facility until wearing a mask should be as short as possible since it is considered to be an important outbreak control measure [31].

Guidelines

New comprehensive US guidelines for infectious outbreak control were published. Although low-income countries may not have the resources to follow such guidelines, the full content may help to address most issues on controlling outbreaks [32].

Initial outbreak management

We developed a simple algorithm for use by triage personnel in the event of a possible infectious disease outbreak (Fig. 1). Monitoring patient symptoms has been shown to be effective in helping to control an outbreak [33].

Conclusion

It is possible to control infectious disease outbreaks in low- and middle-income countries by using simple and inexpensive measures, such as performing hand hygiene, and environmental surface cleaning and decontamination, wearing personal protective equipment, and implementing an antimicrobial stewardship program. Expeditious measures should be implemented as soon as possible whenever there is suspicion of the potential for infectious disease transmission.

Compliance with Ethical Standards

Conflict of Interest
Juan Pablo Caeiro declares that he has no competing interests. María I. Garzón declare that she has no competing interests.

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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