Principles of Infection Control in Asian Clinical Settings

AMR&S WORKING GROUP

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Management of healthcare-associated infections (HAIs) is a persistent challenge for hospitals worldwide, but the HAI burden in low- and middle-income Asian countries has been estimated to be at least double that in developed Western countries.[1,2] HAIs, which are often caused by multidrug-resistant (MDR) organisms, contribute to the emergence and spread of antimicrobial resistance (AMR), lead to poor patient outcomes, and impose considerable disease and financial burdens on hospitals and healthcare systems.[2-5]

HAIs are often avoidable if infection prevention and control (IPC) measures are effectively implemented.[2,3] Despite the importance of effective IPC to reduce the high burden of HAI and AMR in Asian healthcare facilities, IPC is inconsistent across the Asian region for a variety of reasons, including inadequate financial resources, suboptimal infrastructure, insufficient training, understaffing and overcrowding.[2,6-10]

Ideally, all healthcare facilities should strive to meet World Health Organisation (WHO) minimum requirements for IPC,[11] and we aim to help Asian hospitals achieve this. In this document, WHO-recommended core IPC components are outlined, and IPC implementation and improvement strategies that are feasible in low-resource settings are suggested. A table of links to useful IPC resources from the World Health Organisation (WHO) and the Asia Pacific Society for Infection Control (APSIC) are provided in **Appendix 1**.

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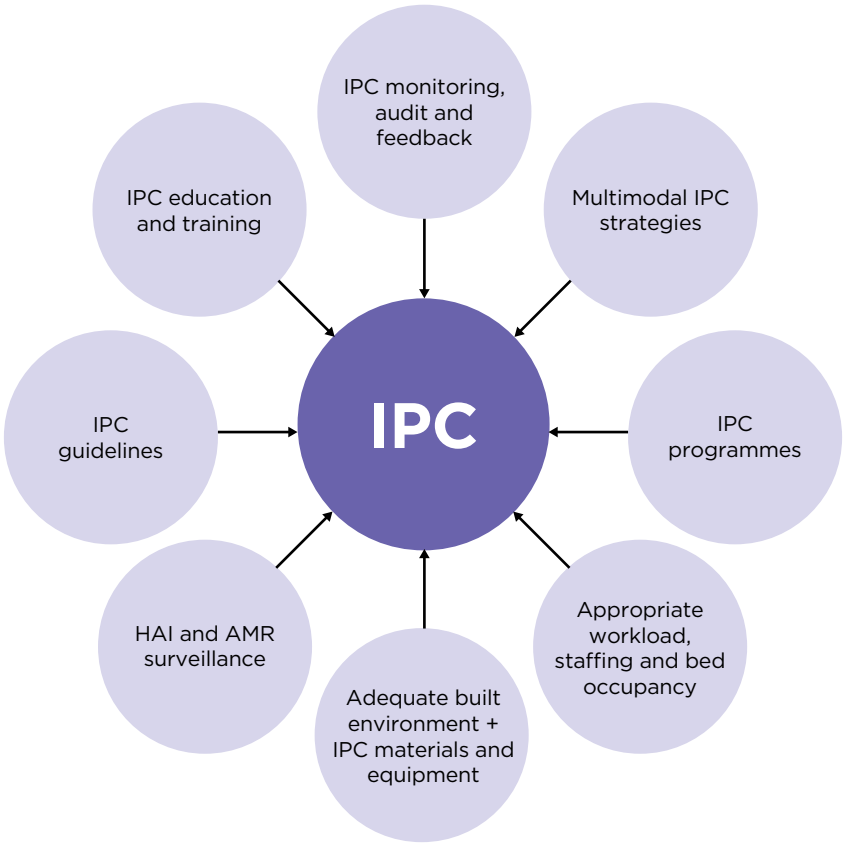
Figure 1

IPC core components.[3]



Core IPC components

The WHO Guidelines on Core Components of IPC Programmes[3] can be used to help establish or strengthen IPC initiatives in Asian hospitals and other healthcare settings.[7,8,12] These guidelines are applicable to any country and can be adapted according to the availability of supporting infrastructure and resources.[3] The WHO states that eight core IPC components are required to effectively manage infectious diseases within clinical care settings (**Figure 1**).[3]

1. IPC programmes

All healthcare facilities should develop an IPC programme, the goal of which is to improve IPC practices and thereby reduce HAIs and AMR, and improve patient outcomes.[3]

IPC programmes facilitate the implementation of other core IPC components:[3]

- IPC guideline development and implementation
- IPC education and training initiatives
- HAI and AMR surveillance
- IPC monitoring, audit and feedback

As part of a stepwise approach to IPC, initial IPC programme goals could be to provide alcohol-based hand rub (ABHR) at all ICU points of care and to implement hand hygiene educational, monitoring, audit and feedback initiatives.[14]

The following are required for IPC programme implementation:[3,11]

- IPC professionals, ideally with a minimum ratio of one full-time IPC-trained nurse or doctor per 250 beds, with dedicated time to carry out IPC activities, but when possible, a higher ratio should be considered (ie, 1 IPC professional/100 beds)
- A dedicated budget for IPC
- Good quality microbiological laboratory support.

Although establishment of comprehensive IPC programmes should be prioritised, this may be challenging in many poorly resourced clinical settings.[7,13,14] In such circumstances, a step-wise approach to IPC implementation and resource-building is recommended, starting with a small budget and a small group of committed staff who are able to dedicate at least 1 to 2 working days per week to IPC.[14] Using such an approach, simple, low-cost IPC measures can be implemented first, beginning in high-risk areas (eg, intensive care units [ICUs] and operating theatres).[13-17]

2. IPC guidelines

Evidence-based guidelines on IPC activities must be readily available to healthcare workers so that they are aware of standard processes that they must adhere to.[3] IPC guidelines should include directives on standard IPC and transmission-based precautions, aseptic techniques and device management for clinical procedures, and prevention of HAIs associated with invasive devices or procedures.[3,11] Pre-existing IPC best practice guidelines, such as those available online from the WHO and APSIC (see **Appendix 1**), can be used to develop facility-specific recommendations adapted to the local context.

Standard IPC precautions to be maintained at all times are:[18]

- Hand hygiene
- Sterilization and decontamination of medical devices
- Use of isolation rooms/cohorting
- Personal protective equipment (PPE)
- Aseptic technique
- Waste management
- Environmental cleaning.

Transmission-based precautions to be used in addition to standard precautions for patients with known or suspected infection with transmissible or epidemiologically significant pathogens (eg, MDR organisms) are:[19]

- Screening to identify colonized/infected patients
- Placement of infectious patients in isolation rooms and/or cohort areas (for groups of patients with similar symptoms or the same diagnosis)
- Staff cohorting (limit the number of healthworkers caring for isolated patients) and use of contact precautions and PPE when caring for infectious patients
- Additional environmental cleaning for isolation rooms and cohort areas, focusing on potential bacterial reservoirs such as sinks and high-touch surfaces (eg, bedside rails, tables, doorknobs) in close proximity to patients.

IPC guidelines can be linked to staff training and performance initiatives (eg, with regard to hand hygiene).[14]

IPC education and training can be incorporated into orientation programmes for all new healthcare workers, including cleaners;[3,24] consider integrating IPC training competencies into job descriptions and performance reviews.[14]

Prevalent HAIs associated with invasive devices or procedures are:[20]

- Central line-associated bloodstream infections (CLABSI)
- Catheter-associated urinary tract infection (CAUTI)
- Surgical site infection (SSI)
- Ventilator-associated pneumonia (VAP).

It is also important to have practical IPC guidelines specifically on how to control the spread of carbapenem-resistant Gram-negative bacteria, given that HAIs caused by these MDR bacteria are highly transmissible and extremely difficult to treat.[21] The WHO provides global guidelines for the prevention and control of carbapenem-resistant Gram-negative bacteria in healthcare facilities.[21]

3. IPC education and training

In addition to providing ongoing education and training opportunities for IPC specialists, all other workers involved in patient care require IPC education and training relevant to their roles at the start of employment and regularly thereafter (eg, yearly).[3,22] IPC education and training for those involved in patient care should involve participatory team- and task-based strategies, including bedside and simulation training.[3]

Freely available online training resources can be used to develop role-appropriate IPC training courses for different healthcare workers. For example, sound environmental cleaning practices are critical to minimizing HAIs,[7,23] so the WHO provides a training package that can be used to help deliver IPC training specifically for cleaners of healthcare facilities in low- and middle-income countries.[24]

4. Surveillance

HAI surveillance should provide information on HAI incidence, type and aetiology, early clusters and outbreaks, as well as patterns of AMR, and the impact of interventions.[3]

Surveillance of the following should be prioritized:[3]

- HAIs in vulnerable populations (ie, neonates, burn patients, ICU patients)
- Infections associated with invasive devices or procedures (CAUTI, CLABSI, SSI, VAP)
- Infections caused by MDR organisms (eg, carbapenem-resistant Gram-negative bacteria).

In the event of an outbreak, investigations are required to identify sources of infection and determine how the infectious agent is spreading (eg, environmental sampling of high-touch surfaces may identify an important source). Once sources of infection are identified, IPC measures can be implemented or strengthened to prevent transmission.[25,26] As well as providing an outbreak toolkit,[26] the WHO offers a course on how to identify HAI outbreaks and what to do after an outbreak is identified.[27]

As part of a stepwise approach to HAI surveillance, prioritise feasible but high-impact starting points or pilot projects (eg, SSI or device-associated infection in ICUs) and then slowly scale up.[14]

Carbapenem-resistant Gram-negative bacteria

Carbapenem-resistant enterobacteriaceae (CRE), carbapenem-resistant *Acinetobacter baumannii* (CRAB) and carbapenem-resistant *Pseudomonas aeruginosa* (CRPsA) are all prevalent in Asian countries.[16,28-34] Identification of carbapenem resistance from clinical cultures allows facilities to identify patterns of infection and allocate resources to areas of need (eg, ICUs).[21,23,35,36]

Active surveillance screening for asymptomatic colonization is not standard-of-care, but during outbreaks and in endemic settings, colonization status should be routinely determined on admission, especially to ICUs, which are high-risk areas for HAIs and AMR.[21,23,36] Active surveillance facilitates early detection and isolation/cohorting to reduce the risk of transmission, but in overcrowded settings where resources and facilities are limited, it may be advisable to prioritise improvement of IPC infrastructure and best practices over surveillance screening.[16,21] In non-outbreak and non-endemic settings, CRE surveillance screening (faecal culture or rectal swabs) should be based on patient risk assessment.[21] Optimal microbiological methods for CRAB and CRPsA surveillance screening are unclear, and although potentially beneficial in outbreak or endemic settings,[35] surveillance screening to prevent spread of CRAB and CRPsA is not currently formally recommended.[21,36]

High-risk groups to be considered for CRE surveillance screening:[21]

- Patients with a documented history of CRE colonisation or infection
- Epidemiologically-linked contacts of newly-identified patients with CRE colonisation or infection (eg, patients in the same room, unit or ward)
- Patients recently hospitalised in regions where the local epidemiology suggests an increased risk of CRE colonization (eg, hospitalisation in a facility with known or suspected CRE)
- Based on the epidemiology of their admission unit, patients who may be at increased risk of CRE colonization and infection (eg, those admitted to ICUs, transplantation units or haematology units)

5. Multimodal IPC strategies

Rather than relying on a single strategy, multimodal strategies should be used to improve IPC practices and reduce HAI and AMR.[3] A multimodal strategy comprises multiple elements implemented in an integrated way with the aim of changing behaviour and improving an outcome.[3]

Key elements of multimodal strategies are:[3]

1. System change needed to enable good IPC practices
2. Guidelines, education and training
3. Monitoring, audit and feedback
4. Reminders and communications promoting the desired actions at the right times
5. Fostering an organizational culture of safety that values IPC.

Multimodal strategies often include bundles: small sets of evidence-based practices proven to improve outcomes (eg, reduction of medical device-associated infections) when performed collectively and reliably.[3]

Case studies demonstrating use of multimodal IPC strategies to achieve different goals in Asian hospital settings are provided in **Appendix 2**. These include a programme to improve general IPC in a hospital in the Philippines,[12] a comprehensive hand hygiene campaign and an IPC response to an outbreak of carbapenem-resistant *Klebsiella pneumoniae* in Vietnamese hospitals,[25,37] an IPC response to endemic CRAB in a South Korean hospital's ICU,[35] and interventions to reduce the rate of CLABSI in the general wards of a Malaysian hospital.[38]

Examples of prevention bundles used to good effect in Thai hospitals[39]

CLABSI bundle:
- Hand hygiene
- Maximum sterile barrier precautions
- Use of chlorhexidine gluconate for antisepsis of the insertion site
- Choosing the optimal site for line insertion
- Daily reivew of line necessity

VAP bundle:
- Hand hygiene
- Semirecombent positioning of the patient
- Avoidance of frequent ventilator circuit changes
- Use of antimicrobial mouth rinse
- Feeding content check to prevent aspiration
- Cross-contamination prevention

6. Monitoring/audit of IPC practices and feedback

Regular monitoring and audit of compliance with IPC practices should be performed, with timely feedback provided to all audited staff and other stakeholders (ie, hospital administration), the aim being to promote appropriate action and behaviour change (individual and organizational).[3] Healthcare worker hand hygiene, which is widely considered to be the most important activity for the prevention of HAI and spread of MDR organisms,[3,36,40,41] serves as an excellent example of an essential process indicator to be monitored and assessed to identify opportunities for improvement.[7,11]

The 5 key moments of hand hygiene:[42]

1. Before touching a patient
2. Before a clean or aseptic task or procedure
3. After touching a patient
4. After body fluid exposure risk
5. After touching a patient's surroundings

Foster a positive rather than a punitive audit and feedback culture, and consider recognising performance with incentives (eg, ward or individual personnel awards).[14]

7. Workload, staffing and bed occupancy

To reduce the risk of disease transmission, the approved bed capacity of the facility should not be exceeded, with 1 patient per bed and spacing of ≥1 metre between the edges of beds recommended.[3,11] Staffing levels should also be adequate for patient workloads.[3] Implementing systems to manage triage (whereby patients are assessed when entering the facility, including for any infectious disease transmission risk) and subsequent flow of patients to different areas within the facility also reduces the risk of overcrowding conducive to disease transmission.[11]

It is recognised that avoidance of overcrowding might not be possible in all settings and that patients may wish to receive care in an overcrowded facility if this is the only option available.[3] This is particularly concerning in densely populated Asian cities, where MDR organisms are prevalent and there are insufficient hospital beds to meet the needs of patients.[6,16,43] In such instances, facilities should find interim solutions to provide the safest care possible.[3]

8. Built environment, and IPC materials and equipment

To prevent HAI and the spread of MDR organisms, patient care activities need to be undertaken in a clean and hygienic environment that has adequate water, sanitation and hygiene (WASH) services and appropriate materials and equipment for IPC.[3]

Facility requirements include the following:[3,811,35]

- Sufficient, continuous supply of safe water (no *Escherichia coli* detectable in 100 mL and/or 0.5 mg/L free chlorine residual) for water-related IPC activities including hand hygiene, environmental cleaning and reprocessing of medical devices
- Hand hygiene facilities equipped with ABHR and water, liquid soap and, ideally, single-use towels optimally placed at points of care and within 5 metres of sanitation facilities
- Sufficient and appropriately labelled bins to allow for healthcare waste segregation (<5 metres from point of generation), with safe disposal (i.e. incineration)
- A dedicated area for decontamination and sterilization of medical devices

If there are no or too few isolation rooms in a busy hospital, efforts can be made to cohort patients with the highest infectious disease transmission risk in separate ward areas.

Simple suggestions to reduce environmental-related infection in resource-limited settings include provision of the following: ABHR at all points of care (local or in-house production can reduce acquisition costs), easily cleanable plastic mattress coverings and chairs, PPE for cleaners (eg, disposable gloves), and combined cleaner and disinfectant solution.[22,37,44]

- Adequate ventilation to prevent transmission of pathogens, including positive mechanical ventilation for clean areas such as operating rooms, and (when required) negative pressure ventilation for isolation facilities (eg, for MDR tuberculosis)
- Sufficient and appropriate supplies and equipment for performing all IPC practices, including standard and transmission-based precautions
- Single isolation rooms (with private bath and toilet facilities) for suspected or confirmed infectious patients (recommended ratio of ≥1 per 20 beds in secondary care facilities and ≥1 per 10 beds in tertiary care facilities) and/or designated areas for cohorting patients with similar pathogens (ideally in areas with partitions or plastic curtains and a closed door, given that there is potential for airborne transmission of CRAB[35,45]).

The WHO WASHFIT tool is available to assist with WASH improvements in existing healthcare facilities in low- and middle-income countries.[14] When building new hospitals, it is important for IPC professionals to be actively involved in the planning stages.[14]

Partnering with AMS

AMS programmes aim to reduce AMR by eliminating inappropriate antibiotic use, but implementation of AMS programs alone are not sufficient to reduce rates of HAIs caused by MDR organisms.[46] Adherence to standard and transmission-based IPC precautions are critical for controlling the spread of MDR organisms in clinical settings.[46] IPC practices to prevent common HAIs are also important to reduce broad-spectrum antibiotic use and limit the development of AMR.[7,46] IPC and AMS team members should therefore work collaboratively to reduce the incidence of HAIs and to control the spread of MDR organisms in clinical settings.[7,8,35,36,44,46-49]

To help achieve overlapping goals, IPC and AMS teams should use their complementary skill sets to collaborate on IPC and AMS educational initiatives, MDR organism surveillance programmes and provision of facility-specific antibiograms.[47-49]

Take-Home Messages

- Aim to implement multimodal IPC strategies to reduce HAIs and AMR in clinical settings
- Use a stepwise approach to improve IPC in line with available infrastructure and resources
- Initially prioritise a continuous supply of basic supplies for IPC (eg, ABHR, environmental cleaning products and PPE)
- When resources allow, prioritise improvement of IPC infrastructure, including optimally placed WASH stations and provision of isolation facilities, and implement active screening for problematic MDR organisms, along with contact precautions and isolation or cohorting of colonised or infected patients to minimize transmission risk
- Don't fall into the 'no data, no problem' trap
- Don't underestimate the importance of simple, inexpensive interventions to improve standard IPC practices, such as adherence to proper hand hygiene and the maintenance of a clean environment and equipment, for preventing HAIs and controlling the spread of MDR organisms.

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Appendix 1

Online resources

This table provides links to useful online resources to help with implementation or strengthening of IPC practices.

Category	Resources	Link
General IPC	WHO • Core component guidelines • Minimum requirements • Implementation resources • Assessment tools	https://www.who.int/teams/integrated-health-services/infection-prevention-control/core-components
	APSIC infection control handbook	https://apsic-apac.org/wp-content/uploads/2022/06/Handbook-Compile-Final.pdf
	OpenWHO training courses	https://www.who.int/publications/m/item/openwho-ipc-training-courses-catalog
MDR organisms	WHO • CRE-CRAB-CRPsA IPC guidelines	https://www.who.int/publications/i/item/9789241550178
SSI	WHO • Prevention guidelines • Implementation tools • Training tools • Monitoring tools	https://www.who.int/teams/integrated-health-services/infection-prevention-control/surgical-site-infection
	APSIC prevention guidelines[a]	https://apsic-apac.org/guidelines-and-resources/apsic-guidelines/
Venous catheter-associated infection	WHO • Prevention guidelines (peripheral catheters)[b]	https://www.who.int/publications/i/item/9789240093829
	APSIC CLABSI prevention guidelines	https://apsic-apac.org/guidelines-and-resources/apsic-guidelines/
CAUTI	WHO training resources	https://www.who.int/teams/integrated-health-services/infection-prevention-control/ipc-training-resources
	APSIC prevention guidelines	https://apsic-apac.org/guidelines-and-resources/apsic-guidelines/

Hand hygiene	WHO • Guidelines • Action tool • Implementation tool • Training tool • Monitoring tool	https://www.who.int/teams/integrated-health-services/infection-prevention-control/hand-hygiene https://www.who.int/europe/publications/i/item/9789289055437
Disinfection and sterilisation of medical equipment	APSIC guidelines	https://apsic-apac.org/guidelines-and-resources/apsic-guidelines/
PPE	WHO action tool	https://www.who.int/europe/publications/i/item/9789289055437
Environmental cleaning	WHO • Training tool • Action tool	https://www.who.int/publications/i/item/9789240051041 https://www.who.int/europe/publications/i/item/9789289055437
	APSIC guidelines	https://apsic-apac.org/guidelines-and-resources/apsic-guidelines/

[a]Some Asian-language versions available.
[b]Part 1 of 2-part guidelines, with part 2 (central catheters) currently in development.

Appendix 2

Case examples of IPC interventions in Asian hospitals

St Luke's Medical Center - Quezon City (SLMC-QC), Philippines[12]

Problems

- No well-defined IPC policy
- Lack of IPC infrastructure and staff training
- Increasing HAIs

Intervention

Continually evolving multimodal IPC programme:

1. System change (availability of the appropriate infrastructure and supplies for IPC good practices)
   - Strategically-located handwashing stations and isolation rooms
   - Modular isolation rooms
2. Education and training of healthcare workers and key players (eg, managers)
   - Infection control basic certification course for all new healthcare workers
   - Re-certification courses for all existing workers
3. Monitoring infrastructure, practices, process, outcomes and providing data feedback
   - Audit and monitoring of IPC compliance (eg, hand hygiene)
   - Electronic monitoring via records, lab and diagnostics for HAIs
4. Reminders in the workplace/communications
   - Posters reminding staff of physical distancing, mask use and hand hygiene
5. Culture change within the facility/strengthening of the safety climate
   - Annual celebration of World Hand Hygiene Day
   - Commitment of executives to IPC, ensuring a dedicated budget and support
   - Quality improvement initiatives and infection control liaisons in each department

Results

	2012	2022
HAIs/1,000 patient days		
CAUTI	7	0.8
CLABSI	6	2.76
VAP	20	0.57
MRSA among all SA isolates	60%	48%
Hand hygiene compliance	NA	97%

CAUTI, catheter-associated urinary tract infection; CLABSI, central line-associated bloodstream infection; HAI, healthcare-associated infection; MRSA, methicillin-resistant *Staphylococcus aureus*; SA, *S. aureus*; NA, not available; VAP, ventilator-associated pneumonia

Appendix 2

Case examples of IPC interventions in Asian hospitals

Hung Vuong Hospital, Ho Chi Minh City, Vietnam[37]

Problem
• Poor hand hygiene compliance
 	
Interventions
• Implementation of the WHO multimodal hand hygiene promotion strategy, with strong support from hospital management
  - If not available in Vietnamese, tools were translated and adapted to the local context
• Cost-saving in-house ABHR production using the WHO ABHR formulation, with provision at all points of care
• Regular training workshops, including role-playing games, practical exercises and scientific lectures
• Workplace poster reminders
• Hand hygiene competitions with modest prizes
• Regular audit and feedback
• Award for the department with the best hand hygiene compliance
• Strategies for the prevention of CAUTI and SSI were also implemented during the study period
• Hospital-wide HAI surveillance
 	
Results
2010 to 2018:
• Hand hygiene compliance (either hand washing or hand rubbing) improved from 21.5% to 75.1%
  - Achieved as a consequence of a marked increase in hand rubbing with ABHR while hand washing with soap and water remained stable
• HAI incidence decreased from 1.10 to 0.45 episodes per 1000 patient-days

Appendix 2

Case examples of IPC interventions in Asian hospitals

Chungnam National University Hospital, Daejeon, South Korea[35]

Problems

- Endemic CRAB in multi-bed, open-ward ICUs, + CRAB isolated from computer and ECG monitors, infusion pumps, bedrails, computer keyboards, curtains, stethoscopes and tables, despite the following routine practices:
  - Wearing gloves and gowns when caring for colonised patients
  - Environmental cleaning using 0.01% sodium hypochlorite once a day
- Distance of <1 metre between ICU beds
- Only one isolation bed per ICU
- Inappropriate use of cabapenems

Interventions

1. Comprehensive intensified IPC strategy:

- Hand hygiene education, promotion and monitoring
  - Posters, flyers and videos used to promote hand hygiene performance
  - Hospital computer screensavers containing hand hygiene guidelines downloaded from the WHO website (https://www.who.int/teams/integrated-health-services/infection-prevention-control/hand-hygiene)
  - ABHR available at all ICU bedsides
- Education to improve understanding of the importance of stopping the spread of CRAB
- All patients admitted to ICUs screened for CRAB, with surveillance cultures twice weekly thereafter
- Patients with cultures positive for CRAB cohorted to a designated area and contact precautions implemented:
  - Gloves and gowns when touching the patient or surfaces in their immediate vicinity
  - When possible, exclusive use of medical equipment for the infected or colonised patients
  - Plastic curtains between each patient
  - Enhanced environmental cleaning and disinfection, including an extra 2 hours of environmental cleaning/day + wiping high-touch surfaces 3 times/day with a cloth soaked with 1:100 diluted bleach or quaternary ammonium chloride wipes

2. AMS interventions to reduce inappropriate use of carbapenems

Results

	April 2013	March 2014
CRAB incidence density rate, cases/1,000 patient-days	22.82	2.68*
CRAB among all AB isolates	93.16%	87.26%
Carbapenem consumption, DDD/1,000 patient-days	134.99	94.85
Hand hygiene adherence	71.4%	86.5%

AB, *Acinetobacter baumanii*; CRAB, carbapenem-resistant *A. baumannii*; DDD, daily defined doses

*p<0.001 vs April 2013

Appendix 2

Case examples of IPC interventions in Asian hospitals

Hospital Tuannko Ja'afar Seremban, Seremban, Malaysia[38]

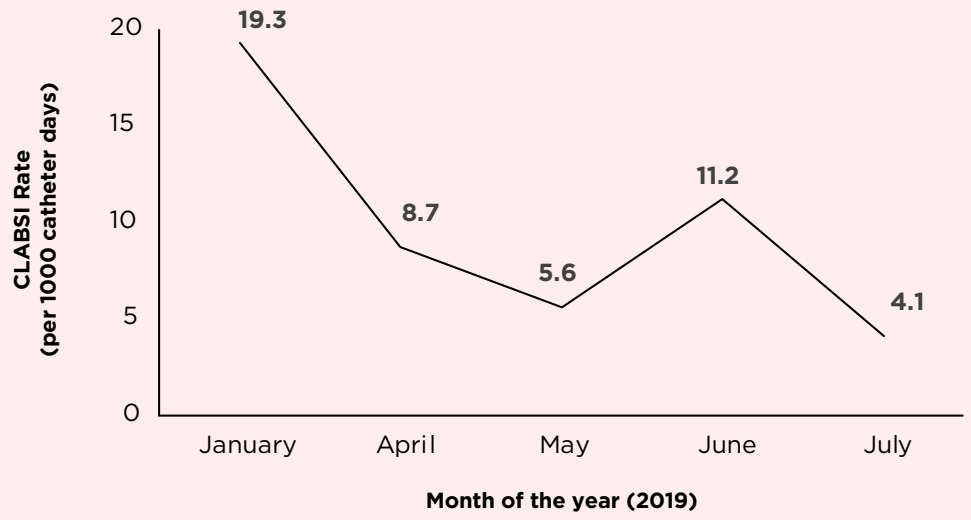
Problems

- Need to reduce CLABSI rates in general medical wards
- Low nurse-to-patient ratio (1:8)

Intervention

1. Creation of a multidisciplinary team including an infectious disease consultant, medical consultants, medical officers, staff nurses and infection control staff
2. Creation of a multimodal intervention bundle:
   - Educational programme for nurses and doctors focusing on central line care and identification of infection
   - Weekly audit and feedback
   - Implementation of a central line bundle of care
     - Hand hygiene
     - Maximal barrier precautions (mask and cap, gown, sterile gloves and sterile full body drape) during central line insertion
     - Use of chlorhexidine gluconate 2% for skin preparation before central line insertion
     - Daily inspection
     - Daily review for the need to continue central line placement
     - Care bundle checklist
     - Use of transparent dressing and proper aseptic technique when handling the central line

Results



Appendix 2

Case examples of IPC interventions in Asian hospitals

Hospital for Tropical Diseases, Ho Chi Minh City, Vietnam[25]

Problems

- High-mortality outbreaks of carbapenem-resistant *Klebsiella pneumoniae* in two separate wards identified during routine surveillance
  - Carbapenem-resistant *K. pneumoniae* isolates recovered from bronchoalveolar lavage (BAL) and blood samples from 3 patients in the adult ICU (outbreak 1)
  - Carbapenem-resistant *K. pneumoniae* recovered from urine, BAL, sputm, pus and blood samples from 5 patients in a ward for patients with CNS infections (outbreak 2)
- The AMR profiles of *K. pneumoniae* isolated from these wards were distinct, suggesting two simultaneous outbreaks

Interventions

- In response to notification of the outbreaks from the microbiology department, the hospital IPC team implemented measures to identify the sources and contain the spread of the bacteria, including:
  - Enhanced environmental sampling (patient monitors, haemodialysis machines, medical trolleys, bedside items, bedrails, ventilators, infusion pumps, stethoscopes, BP cuffs, suction catheters and sinks)
  - Informing clinicians, nurses and cleaners about the infected patients
  - Isolation of infected patients in private rooms with dedicated nurses and non-critical patient-care equipment (stethoscopes, BP cuffs, thermometers)
  - Cleaning all surfaces in the rooms (beds, trolleys, door handles, toilets etc.) with bleach 3 times/day
  - Strict enforcement of hand hygiene
  - Universal use of gowns for all healthcare personnel before entering and upon leaving isolation rooms
  - Decontamination of all rooms and equipment used for the infected patients with hydrogen peroxoide vapour after discharge
  - Enhanced cleaning and handwashing within the adult ICU and CNS infections wards

Results

- The outbreaks were rapidly characterized and contained
- Whole genome sequencing showed the outbreaks were caused by two distinct lineages of a carbapenem-resistant *K. pneumoniae* ST16 clone, which clustered with ST16 isolates previously described in the hospital and from other hospitals in the south of Vietnam, suggesting that the clone may have been maintained in the hospital and/or other hospitals, with transfer of severely ill patients across different wards and between hospitals likely an important factor for transmission
- *K. pneumoniae* isolates identified from a hospital bed and blood pressure cuff during the outbreak two were determined to be genetically linked to the outbreak two-case cluster, suggesting that such high-touch equipment may be an important source of *K. pneumoniae* maintenance in the hospital

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